Axions (A^0) and Other Very Light Bosons, Searches for

NODE=S029

See the related review(s):
Axions and Other Similar Particles

A^0 (Axion) MASS LIMITS from Astrophysics and Cosmology

NODE=S029AXA

These bounds depend on model-dependent assumptions (i.e. — on a combination of axion parameters).

NODE=S029AXA

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
>0.2	BARROSO	82	ASTR	Standard Axion
>0.25	[1] RAFFELT	82	ASTR	Standard Axion
>0.2	[2] DICUS	78C	ASTR	Standard Axion
	MIKAELIAN	78	ASTR	Stellar emission
>0.3	[2] SATO	78	ASTR	Standard Axion
>0.2	VYSOTSKII	78	ASTR	Standard Axion

NODE=S029AXA

[1] Lower bound from 5.5 MeV γ-ray line from the sun. NODE=S029AXA;LINKAGE=B

[2] Lower bound from requiring the red giants' stellar evolution not be disrupted by axion emission. NODE=S029AXA;LINKAGE=A

A^0 (Axion) and Other Light Boson (X^0) Searches in Hadron Decays

NODE=S029AD2

Limits are for branching ratios.

NODE=S029AD2

NODE=S029AD2

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] ABLIKIM	25AV	BES3	$\eta \to \pi^+\pi^- A^0$, $A^0 \to e^+e^-$
		[2] ADACHI	25AA	BEL2	$B \to K/K^* A^0$, $A^0 \to \gamma\gamma$
$<1 \times 10^{-12}$	90	[3] ALRAHMAN	25	ICRS	$K \to \pi A^0$, $A^0 \to \mu^+\mu^-$
$<5 \times 10^{-12}$	90	[4] CORTINA-GIL	25B	NA62	$K^+ \to \pi^+ X^0$
$<1 \times 10^{-4}$	90	[5] ABLIKIM	24AK	BES3	$\eta' \to \pi^+\pi^- A^0$, $A^0 \to e^+e^-$
		[6] ABLIKIM	24G	BES3	$J/\psi \to \mu^+\mu^- X^0$
$<0.5 \times 10^{-6}$	90	[7] ABLIKIM	24M	BES3	$\eta \to \gamma X^0$, $\eta' \to \gamma X^0$
$<2 \times 10^{-9}$	90	[8] CORTINA-GIL	24	NA62	$K^+ \to \pi^+ A^0$, $A^0 \to \gamma\gamma$
$<2 \times 10^{-7}$	90	[9] SADOVSKY	24	OKA	$K^+ \to \pi^+\pi^0 A^0$
$<4 \times 10^{-8}$	95	[10] ADACHI	23K	BEL2	$B^+ \to K^+ X^0$
$<9 \times 10^{-8}$	95	[11] ADACHI	23K	BEL2	$B^0 \to K^*(892)^0 X^0$ $(K^*(892)^0 \to K^+\pi^-)$
$<3.7 \times 10^{-10}$	95	[12] CORTINA-GIL	23B	NA62	$K^+ \to \pi^+ A^0 A^0$, $A^0 \to e^+e^-$
$<4.2 \times 10^{-8}$	90	[13] LEES	22B	BABR	$B^\pm \to K^\pm A^0$ $(A^0 \to \gamma\gamma)$
$<7 \times 10^{-13}$	95	[14] ABRATENKO	21	MCBN	$K^+ \to \pi^+ X^0$ $(X^0 \to e^+e^-)$
$<1.5 \times 10^{-7}$	90	[15] CORTINA-GIL	21	NA62	$K^+ \to \mu^+\nu X^0$
$<5 \times 10^{-11}$	90	[16] CORTINA-GIL	21A	NA62	$K^+ \to \pi^+ X^0$
$<9 \times 10^{-10}$	90	[17] CORTINA-GIL	21C	NA62	$K^+ \to \pi^+ X^0$
$<1.5 \times 10^{-8}$	90	[18] PARK	21	BELL	$B^0 \to X^0 X^0$ $(X^0 \to e^+e^-$, $\mu^+\mu^-$, $\pi^+\pi^-)$
$<2.4 \times 10^{-9}$	90	[19] AHN	19	KOTO	$K_L^0 \to \pi^0 X^0$, $m_{X^0} = 135$ MeV
$<2 \times 10^{-10}$	95	[20] AAIJ	17AQ	LHCB	$B^+ \to K^+ X^0$ $(X^0 \to \mu^+\mu^-)$
$<3.7 \times 10^{-8}$	90	[21] AHN	17	KOTO	$K_L^0 \to \pi^0 X^0$, $m_{X^0} = 135$ MeV
$<6 \times 10^{-11}$	90	[22] BATLEY	17	NA48	$K^\pm \to \pi^\pm X^0 (X^0 \to \mu^+\mu^-)$
		[23] WON	16	BELL	$\eta \to \gamma X^0$ $(X^0 \to \pi^+\pi^-)$
$<1 \times 10^{-9}$	95	[24] AAIJ	15AZ	LHCB	$B^0 \to K^{*0} X^0$ $(X^0 \to \mu^+\mu^-)$
$<1.5 \times 10^{-6}$	90	[25] ADLARSON	13	WASA	$\pi^0 \to \gamma X^0$ $(X^0 \to e^+e^-)$, $m_{X^0} = 100$ MeV
$<2 \times 10^{-8}$	90	[26] BABUSCI	13B	KLOE	$\phi \to \eta X^0$ $(X^0 \to e^+e^-)$
		[27] ARCHILLI	12	KLOE	$\phi \to \eta X^0$, $X^0 \to e^+e^-$
$<2 \times 10^{-15}$	90	[28] GNINENKO	12A	BDMP	$\pi^0 \to \gamma X^0$ $(X^0 \to e^+e^-)$
$<3 \times 10^{-14}$	90	[29] GNINENKO	12B	BDMP	$\eta(\eta') \to \gamma X^0$ $(X^0 \to e^+e^-)$
$<7 \times 10^{-10}$	90	[30] ADLER	04	B787	$K^+ \to \pi^+ X^0$
$<7.3 \times 10^{-11}$	90	[31] ANISIMOVSK...	04	B949	$K^+ \to \pi^+ X^0$
$<4.5 \times 10^{-11}$	90	[32] ADLER	02C	B787	$K^+ \to \pi^+ X^0$
$<4 \times 10^{-5}$	90	[33] ADLER	01	B787	$K^+ \to \pi^+\pi^0 A^0$
$<4.9 \times 10^{-5}$	90	AMMAR	01B	CLEO	$B^\pm \to \pi^\pm(K^\pm) X^0$

OCCUR=2

$<5.3 \times 10^{-5}$	90	AMMAR	01B	CLEO	$B^0 \to K^0_S X^0$	OCCUR=2
$<3.3 \times 10^{-5}$	90	[34] ALTEGOER	98	NOMD	$\pi^0 \to \gamma X^0$, $m_{X^0} < 120$ MeV	
$<5.0 \times 10^{-8}$	90	[35] KITCHING	97	B787	$K^+ \to \pi^+ X^0$ ($X^0 \to \gamma\gamma$)	
$<5.2 \times 10^{-10}$	90	[36] ADLER	96	B787	$K^+ \to \pi^+ X^0$	
$<2.8 \times 10^{-4}$	90	[37] AMSLER	96B	CBAR	$\pi^0 \to \gamma X^0$, $m_{X^0} < 65$ MeV	
$<3 \times 10^{-4}$	90	[37] AMSLER	96B	CBAR	$\eta \to \gamma X^0$, m_{X^0}= 50–200 MeV	OCCUR=2
$<4 \times 10^{-5}$	90	[37] AMSLER	96B	CBAR	$\eta' \to \gamma X^0$, m_{X^0}= 50–925 MeV	OCCUR=3
$<6 \times 10^{-5}$	90	[37] AMSLER	94B	CBAR	$\pi^0 \to \gamma X^0$, m_{X^0}=65–125 MeV	
$<6 \times 10^{-5}$	90	[37] AMSLER	94B	CBAR	$\eta \to \gamma X^0$, m_{X^0}=200–525 MeV	OCCUR=2
$<7 \times 10^{-3}$	90	[38] MEIJERDREES	94	CNTR	$\pi^0 \to \gamma X^0$, m_{X^0}=25 MeV	
$<2 \times 10^{-3}$	90	[38] MEIJERDREES	94	CNTR	$\pi^0 \to \gamma X^0$, m_{X^0}=100 MeV	OCCUR=2
$<2 \times 10^{-7}$	90	[39] ATIYA	93B	B787	Sup. by ADLER 04	
$<3 \times 10^{-13}$		[40] NG	93	COSM	$\pi^0 \to \gamma X^0$	
$<1.1 \times 10^{-8}$	90	[41] ALLIEGRO	92	SPEC	$K^+ \to \pi^+ X^0$ ($X^0 \to e^+ e^-$)	
$<5 \times 10^{-4}$	90	[42] ATIYA	92	B787	$\pi^0 \to \gamma X^0$	
$<1 \times 10^{-12}$	95	[43] BARABASH	92	BDMP	$\pi^\pm \to e^\pm \nu X^0$($X^0 \to e^+ e^-$, $\gamma\gamma$), $m_{X^0} = 8$ MeV	
$<1 \times 10^{-12}$	95	[44] BARABASH	92	BDMP	$K^\pm \to \pi^\pm X^0$($X^0 \to e^+ e^-$, $\gamma\gamma$), $m_{X^0} = 10$ MeV	OCCUR=2
$<1 \times 10^{-11}$	95	[45] BARABASH	92	BDMP	$K^0_L \to \pi^0 X^0$($X^0 \to e^+ e^-$, $\gamma\gamma$), $m_{X^0} = 10$ MeV	OCCUR=3
$<1 \times 10^{-14}$	95	[46] BARABASH	92	BDMP	$\eta' \to \eta X^0$($X^0 \to e^+ e^-$, $\gamma\gamma$), $m_{X^0} = 10$ MeV	OCCUR=4
$<4 \times 10^{-6}$	90	[47] MEIJERDREES	92	SPEC	$\pi^0 \to \gamma X^0$ ($X^0 \to e^+ e^-$), m_{X^0}= 100 MeV	
$<1 \times 10^{-7}$	90	[48] ATIYA	90B	B787	Sup. by KITCHING 97	
$<1.3 \times 10^{-8}$	90	[49] KORENCHE...	87	SPEC	$\pi^+ \to e^+ \nu A^0$ ($A^0 \to e^+ e^-$)	
$<1 \times 10^{-9}$	90	[50] EICHLER	86	SPEC	Stopped $\pi^+ \to e^+ \nu A^0$	OCCUR=2
$<2 \times 10^{-5}$	90	[51] YAMAZAKI	84	SPEC	For 160$<m<$260 MeV	
$<(1.5–4) \times 10^{-6}$	90	[51] YAMAZAKI	84	SPEC	K decay, $m_{X^0} \ll 100$ MeV	OCCUR=2
		[52] ASANO	82	CNTR	Stopped $K^+ \to \pi^+ X^0$	
		[53] ASANO	81B	CNTR	Stopped $K^+ \to \pi^+ X^0$	
		[54] ZHITNITSKII	79		Heavy axion	

[1] ABLIKIM 25AV search for η decays to A^0 subsequently decaying to an electron positron pair in the BESIII detector. They set limits down to 3×10^{-3} on the relative branching fraction for the decay process compared to $\eta \to \pi^+ \pi^- e^+ e^-$ for axion masses between 5 and 200 MeV - see their Fig. 7 for mass-dependent limits. NODE=S029AD2;LINKAGE=UA

[2] ADACHI 25AA search for axion-like particles produced from decays of B to K or K^* mesons in the Belle detector, with the axion-like particle subsequently decaying to two photons. See their Fig. 5 for mass-dependent limits on the axion coupling to the W boson in the mass range 0.16–4.5 GeV. NODE=S029AD2;LINKAGE=WA

[3] ALRAHMAN 25 present a search for scalars and axions produced from the kaon decays that then decay to two muons using the ICARUS detector at Fermilab. In their Fig. 2, they present a constraint on axions with masses up to 350 MeV for a particular choice of gauge field and muon couplings. The quoted value is from their model-independent branching ratio limit shown in Fig. 3 at $c\tau_{A^0} = 200$ m. NODE=S029AD2;LINKAGE=VA

[4] CORTINA-GIL 25B report a search for an invisibly decaying X^0 produced in decays of K^+ in the NA62 detector, for masses up to 260 MeV. The quoted branching ratio limit is for $K^+ \to \pi^+ X^0$ for an invisibly decaying X^0. See their Fig. 2 for mass-dependent limits. NODE=S029AD2;LINKAGE=XA

[5] ABLIKIM 24AK search for η' decays to axions in the mass range 0 to 500 MeV using the BESIII detector at the Beijing Electron-Positron Collider. See Fig. 9b for mass-dependent limits. NODE=S029AD2;LINKAGE=NA

[6] ABLIKIM 24G search for muonphilic vector or scalar X^0 particles with masses between 1 and 1000 MeV in J/ψ decays at the BESIII detector. See their Fig. 3 for mass-dependent limits on the scalar/vector couplings under three different models. NODE=S029AD2;LINKAGE=OA

[7] ABLIKIM 24M search for η and η' decays to dark photons in the mass range 0 to 0.7 GeV using the BESIII detector at the Beijing Electron-Positron Collider. The quoted limit is for $\eta' \to \gamma X^0$. See Fig. 7 a and b for mass-dependent limits. NODE=S029AD2;LINKAGE=QA

[8] CORTINA-GIL 24 use $K^+ \to \pi^+ \gamma\gamma$ events in NA62 to constrain 210 to 350 MeV-mass axions coupled to gluons, which promptly decay to $\gamma\gamma$. See their Fig. 8 for mass-dependent limits. NODE=S029AD2;LINKAGE=RA

[9] SADOVSKY 24 report results from the OKA collaboration on a missing-mass search for invisible axions in K^+ decays to pions. The quoted limit applies at $m_{A^0} \simeq 200$ MeV. See their Fig. 6 for mass-dependent limits up to 200 MeV. NODE=S029AD2;LINKAGE=SA

[10] ADACHI 23K quoted limit is for $m_{X^0} \simeq 3$ GeV, $c\tau_{X^0} = 1$ cm, and the decay channel $X^0 \to e^+e^-$. See their Fig. 2 for limits with different lifetimes and decay channels, $X^0 \to \mu^+\mu^-$, $\pi^+\pi^-$, K^+K^-. NODE=S029AD2;LINKAGE=KA

[11] ADACHI 23K quoted limit is for $m_{X^0} \simeq 2$ GeV, $c\tau_{X^0} = 1$ cm, and the decay channel $X^0 \to e^+e^-$. See their Fig. 2 for limits with different lifetimes and decay channels, $X^0 \to \mu^+\mu^-$, $\pi^+\pi^-$, K^+K^-. NODE=S029AD2;LINKAGE=LA

[12] CORTINA-GIL 23B limit extends over 10–170 MeV in mass. Quoted limit is at 155 MeV. NODE=S029AD2;LINKAGE=MA

[13] LEES 22B quoted limit is for $m_{A^0} = 3.9$ GeV, assuming the promptly decaying axion. Limits of O(10^{-7}) are obtained for $m_{A^0} = 0.175$–4.78 GeV. See their Figs.3 and 4 for mass and lifetime dependent limits. NODE=S029AD2;LINKAGE=JA

[14] ABRATENKO 21 quoted limit is for $m_{X^0} = 150$ MeV and the lifetime $c\tau_{X^0} = 80$ m. See their Fig. 4 for the limits in the range of $m_{X^0} = 10$–210 MeV. NODE=S029AD2;LINKAGE=IA

[15] CORTINA-GIL 21 quoted limit is for $m_{X^0} = 370$ MeV. Limits from O(10^{-5}) and O(10^{-6}) are obtained for $m_{X^0} = 10$–370 MeV (see their Fig. 7). NODE=S029AD2;LINKAGE=EA

[16] CORTINA-GIL 21A quoted limit is for $m_{X^0} = 160$–250 MeV. Limits between 5×10^{-11} and 2×10^{-10} are obtained in the range of $m_{X^0} = 0$–110 and 154–260 MeV, assuming stable or invisibly decaying X^0. See their Fig. 4 for mass- and lifetime-dependent limits. NODE=S029AD2;LINKAGE=GA

[17] CORTINA-GIL 21C quoted limit is for $m_{X^0} = 130$–140 MeV, and limits of 9×10^{-10}–6×10^{-7} are obtained in the mass range of $m_{X^0} = 110$–155 MeV, assuming X^0 escapes detection. See their Fig. 6 for mass- and lifetime-dependent limits. NODE=S029AD2;LINKAGE=HA

[18] PARK 21 look for dark photons produced by decays of B^0 through off-shell Higgs-dark Higgs mixing. See their Fig. 5 for limits in the range of $m_{X^0} = 0.01$–2.62 GeV. NODE=S029AD2;LINKAGE=FA

[19] AHN 19 is an update of AHN 17 from a new data set. See their Fig. 4 for the limits in the range of $m_{X^0} = 0$–250 MeV. NODE=S029AD2;LINKAGE=DA

[20] AAIJ 17AQ limit is for $\tau_{X^0} = 10$ ps. See their Fig. 4 for limits in the range of $m_{X^0} =$ 250–4700 MeV and $\tau_{X^0} = 0.1$–1000 ps. NODE=S029AD2;LINKAGE=Z

[21] AHN 17 limit as a function of m_{X^0} from 0 to 250 MeV is provided in their Fig. 5. NODE=S029AD2;LINKAGE=Y

[22] BATLEY 17 limit is for $m_{X^0} = 216$ MeV and $\tau_{X^0} \leq 10$ ps. See their Fig. 4(c) for limits in the range of $m_{X^0} = 211$–354 MeV and longer lifetimes. NODE=S029AD2;LINKAGE=CA

[23] WON 16 look for a vector boson coupled to baryon number. Derived limits on $\alpha' < 10^{-3}$–10^{-2} for $m_{X^0} = 290$–520 MeV at 95% CL. See their Fig. 4 for mass-dependent limits. NODE=S029AD2;LINKAGE=W

[24] AAIJ 15AZ limit is for $\tau_{X^0} = 10$ ps and $m_{X^0} = 214$–4350 MeV. See their Fig. 4 for mass- and lifetime-dependent limits. NODE=S029AD2;LINKAGE=P

[25] ADLARSON 13 limits between 2.0×10^{-5} and 1.5×10^{-6} are obtained for $m_{X^0} =$ 20–100 MeV (see their Fig. 8). Angular momentum conservation requires that X^0 has spin ≥ 1. NODE=S029AD2;LINKAGE=N

[26] BABUSCI 13B limit is for B($\phi \to \eta X^0$)·B($X^0 \to e^+e^-$) and applies to $m_{X^0} = 410$ MeV. It is derived by analyzing $\eta \to \pi^0\pi^0\pi^0$ and $\pi^-\pi^+\pi^0$. Limits between 1×10^{-6} and 2×10^{-8} are obtained for $m_{X^0} \leq 450$ MeV (see their Fig. 6). NODE=S029AD2;LINKAGE=O

[27] ARCHILLI 12 analyzed $\eta \to \pi^+\pi^-\pi^0$ decays. Derived limits on $\alpha'/\alpha < 2 \times 10^{-5}$ for $m_{X^0} = 50$–420 MeV at 90% CL. See their Fig. 8 for mass-dependent limits. NODE=S029AD2;LINKAGE=AR

[28] GNINENKO 12A limit is for B($\pi^0 \to \gamma X^0$)·B($X^0 \to e^+e^-$) and applies for $m_{X^0} =$ 90 MeV and $\tau_{X^0} \simeq 1 \times 10^{-8}$ sec. Limits between 10^{-8} and 2×10^{-15} are obtained for $m_{X^0} = 3$–120 MeV and $\tau_{X^0} = 1 \times 10^{-11}$–1 sec. See their Fig. 3 for limits at different masses and lifetimes. NODE=S029AD2;LINKAGE=GN

[29] GNINENKO 12B limit is for B($\eta \to \gamma X^0$)·B($X^0 \to e^+e^-$) and applies for $m_{X^0} =$ 100 MeV and $\tau_{X^0} \simeq 6\times10^{-9}$ sec. Limits between 10^{-5} and 3×10^{-14} are obtained for $m_{X^0} \lesssim 550$ MeV and $\tau_{X^0} = 10^{-10}$–10 sec. See their Fig. 5 for limits at different mass and lifetime and for η' decays. NODE=S029AD2;LINKAGE=GI

[30] ADLER 04 limit applies for a mass near 180 MeV. For other masses in the range $m_{X^0} =$ 150–250 MeV the limit is less restrictive, but still improves ADLER 02C and ATIYA 93B. NODE=S029AD2;LINKAGE=AL

[31] ANISIMOVSKY 04 bound is for m_{X^0}=0. NODE=S029AD2;LINKAGE=AN

[32] ADLER 02C bound is for m_{X^0} <60 MeV. See Fig. 2 for limits at higher masses. NODE=S029AD2;LINKAGE=LC

[33] The quoted limit is for $m_{X^0} = 0$–80 MeV. See their Fig. 5 for the limit at higher mass. The branching fraction limit assumes pure phase space decay distributions. NODE=S029AD2;LINKAGE=AD

[34] ALTEGOER 98 looked for X^0 from π^0 decay which penetrate the shielding and convert to π^0 in the external Coulomb field of a nucleus. NODE=S029AD2;LINKAGE=M

[35] KITCHING 97 limit is for B($K^+ \to \pi^+X^0$)·B($X^0 \to \gamma\gamma$) and applies for $m_{X^0} \simeq 50$ MeV, $\tau_{X^0} < 10^{-10}$ s. Limits are provided for 0<$m_{X^0} < 100$ MeV, $\tau_{X^0} < 10^{-8}$ s. NODE=S029AD2;LINKAGE=TK

[36] ADLER 96 looked for a peak in missing-mass distribution. This work is an update of ATIYA 93. The limit is for massless stable X^0 particles and extends to m_{X^0}=80 MeV at the same level. See paper for dependence on finite lifetime. NODE=S029AD2;LINKAGE=K4

[37] AMSLER 94B and AMSLER 96B looked for a peak in missing-mass distribution. NODE=S029AD2;LINKAGE=K

[38] MEIJERDREES 94 limit is based on inclusive photon spectrum and is independent of X^0 decay modes. It applies to $\tau(X^0) > 10^{-23}$ sec. NODE=S029AD2;LINKAGE=L

[39] ATIYA 93B looked for a peak in missing mass distribution. The bound applies for stable X^0 of m_{X^0}=150–250 MeV, and the limit becomes stronger (10^{-8}) for m_{X^0}=180–240 MeV. NODE=S029AD2;LINKAGE=I2

[40] NG 93 studied the production of X^0 via $\gamma\gamma \rightarrow \pi^0 \rightarrow \gamma X^0$ in the early universe at $T \simeq 1$ MeV. The bound on extra neutrinos from nucleosynthesis $\Delta N_\nu < 0.3$ (WALKER 91) is employed. It applies to $m_{X^0} \ll 1$ MeV in order to be relativistic down to nucleosynthesis temperature. See paper for heavier X^0. NODE=S029AD2;LINKAGE=J

[41] ALLIEGRO 92 limit applies for m_{X^0}=150–340 MeV and is the branching ratio times the decay probability. Limit is $< 1.5 \times 10^{-8}$ at 99%CL. NODE=S029AD2;LINKAGE=F

[42] ATIYA 92 looked for a peak in missing mass distribution. The limit applies to m_{X^0}=0–130 MeV in the narrow resonance limit. See paper for the dependence on lifetime. Covariance requires X^0 to be a vector particle. NODE=S029AD2;LINKAGE=H

[43] BARABASH 92 is a beam dump experiment that searched for a light Higgs. Limits between 1×10^{-12} and 1×10^{-7} are obtained for $3 < m_{X^0} < 40$ MeV. NODE=S029AD2;LINKAGE=Q

[44] Limits between 1×10^{-12} and 1 are obtained for $4 < m_{X^0} < 69$ MeV. NODE=S029AD2;LINKAGE=S

[45] Limits between 1×10^{-11} and 5×10^{-3} are obtained for $4 < m_{X^0} < 63$ MeV. NODE=S029AD2;LINKAGE=U

[46] Limits between 1×10^{-14} and 1 are obtained for $3 < m_{X^0} < 82$ MeV. NODE=S029AD2;LINKAGE=V

[47] MEIJERDREES 92 limit applies for $\tau_{X^0} = 10^{-23}$–10^{-11} sec. Limits between 2×10^{-4} and 4×10^{-6} are obtained for m_{X^0} = 25–120 MeV. Angular momentum conservation requires that X^0 has spin ≥ 1. NODE=S029AD2;LINKAGE=E

[48] ATIYA 90B limit is for B($K^+ \rightarrow \pi^+ X^0$)·B($X^0 \rightarrow \gamma\gamma$) and applies for m_{X^0} = 50 MeV, $\tau_{X^0} < 10^{-10}$ s. Limits are also provided for $0 < m_{X^0} < 100$ MeV, $\tau_{X^0} < 10^{-8}$ s. NODE=S029AD2;LINKAGE=K2

[49] KORENCHENKO 87 limit assumes m_{A^0} = 1.7 MeV, $\tau_{A^0} \lesssim 10^{-12}$ s, and B($A^0 \rightarrow e^+ e^-$) = 1. NODE=S029AD2;LINKAGE=A

[50] EICHLER 86 looked for $\pi^+ \rightarrow e^+ \nu A^0$ followed by $A^0 \rightarrow e^+ e^-$. Limits on the branching fraction depend on the mass and and lifetime of A^0. The quoted limits are valid when $\tau(A^0) \gtrsim 3. \times 10^{-10}$s if the decays are kinematically allowed. NODE=S029AD2;LINKAGE=T

[51] YAMAZAKI 84 looked for a discrete line in $K^+ \rightarrow \pi^+$X. Sensitive to wide mass range (5–300 MeV), independent of whether X decays promptly or not. NODE=S029AD2;LINKAGE=R

[52] ASANO 82 at KEK set limits for B($K^+ \rightarrow \pi^+ X^0$) for m_{X^0} <100 MeV as BR $< 4. \times 10^{-8}$ for $\tau(X^0 \rightarrow n\gamma$'s$) > 1. \times 10^{-9}$ s, BR $< 1.4 \times 10^{-6}$ for $\tau < 1. \times 10^{-9}$s. NODE=S029AD2;LINKAGE=G

[53] ASANO 81B is KEK experiment. Set B($K^+ \rightarrow \pi^+ X^0$) $< 3.8 \times 10^{-8}$ at CL = 90%. NODE=S029AD2;LINKAGE=C

[54] ZHITNITSKII 79 argue that a heavy axion predicted by YANG 78 (3 <m <40 MeV) contradicts experimental muon anomalous magnetic moments. NODE=S029AD2;LINKAGE=B

A^0 (Axion) Searches in Quarkonium Decays

NODE=S029AXQ

Decay or transition of quarkonium. Limits are for branching ratio. NODE=S029AXQ

NODE=S029AXQ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$<8.3 \times 10^{-8}$	95	[1] ABLIKIM	23E	BES3	$J/\psi \rightarrow A^0\gamma$ ($A^0 \rightarrow \gamma\gamma$)	
$<3.1 \times 10^{-7}$	90	[2] JIA	22	BELL	$\Upsilon(1S) \rightarrow A^0\gamma$($A^0 \rightarrow \mu^+\mu^-$)	
$<2.8 \times 10^{-8}$	90	[3] ABLIKIM	16E	BES3	$J/\psi \rightarrow A^0\gamma$ ($A^0 \rightarrow \mu^+\mu^-$)	OCCUR=2
$<4 \times 10^{-7}$	90	[4] ABLIKIM	12	BES3	$J/\psi \rightarrow A^0\gamma$ ($A^0 \rightarrow \mu^+\mu^-$)	
$<4.0 \times 10^{-5}$	90	[5] ANTREASYAN	90C	CBAL	$\Upsilon(1S) \rightarrow A^0\gamma$	
$<5 \times 10^{-5}$	90	[6] DRUZHININ	87	ND	$\phi \rightarrow A^0\gamma$ ($A^0 \rightarrow e^+e^-$)	
$<2 \times 10^{-3}$	90	[7] DRUZHININ	87	ND	$\phi \rightarrow A^0\gamma$ ($A^0 \rightarrow \gamma\gamma$)	OCCUR=2
$<7 \times 10^{-6}$	90	[8] DRUZHININ	87	ND	$\phi \rightarrow A^0\gamma$ ($A^0 \rightarrow$ missing)	OCCUR=3
$<1.4 \times 10^{-5}$	90	[9] EDWARDS	82	CBAL	$J/\psi \rightarrow A^0\gamma$	

[1] ABLIKIM 23E obtained limits in the range of 8.3×10^{-8}–1.8×10^{-6} for 0.165 GeV $\leq m_{A^0} \leq$ 2.84 GeV. See their Fig. 5 for mass-dependent limits. NODE=S029AXQ;LINKAGE=F

[2] JIA 22 limits between 3.1×10^{-7}–1.6×10^{-5} were obtained for 0.22 GeV $< m_{A^0} <$ 9.2 GeV. See their Fig. 4 for mass-dependent limits. NODE=S029AXQ;LINKAGE=E

[3] ABLIKIM 16E limits between 2.8–495.3×10^{-8} were obtained for 0.212 GeV $< m_{A^0} <$ 3.0 GeV. See their Fig. 5 for mass-dependent limits. NODE=S029AXQ;LINKAGE=C

[4] ABLIKIM 12 derived limits between 4×10^{-7}–2.1×10^{-5} for 0.212 GeV $< m_{A^0} <$ 3.0 GeV. See their Fig. 2(c) for mass-dependent limits. NODE=S029AXQ;LINKAGE=D

[5] ANTREASYAN 90C assume that A^0 does not decay in the detector. NODE=S029AXQ;LINKAGE=AN

[6] The first DRUZHININ 87 limit is valid when $\tau_{A^0}/m_{A^0} < 3 \times 10^{-13}$ s/MeV and $m_{A^0} < 20$ MeV. NODE=S029AXQ;LINKAGE=E1

[7] The second DRUZHININ 87 limit is valid when $\tau_{A^0}/m_{A^0} < 5 \times 10^{-13}$ s/MeV and $m_{A^0} < 20$ MeV. NODE=S029AXQ;LINKAGE=F1

[8] The third DRUZHININ 87 limit is valid when $\tau_{A^0}/m_{A^0} > 7 \times 10^{-12}$ s/MeV and $m_{A^0} < 200$ MeV. NODE=S029AXQ;LINKAGE=H1

[9] EDWARDS 82 looked for $J/\psi \rightarrow \gamma A^0$ decays by looking for events with a single γ [of energy $\sim 1/2$ the $J/\psi(1S)$ mass], plus nothing else in the detector. The limit is inconsistent with the axion interpretation of the FAISSNER 81B result. NODE=S029AXQ;LINKAGE=J

A^0 (Axion) Searches in Positronium Decays

NODE=S029AXD

Decay or transition of positronium. Limits are for branching ratio.

NODE=S029AXD
NODE=S029AXD

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<4.4 \times 10^{-5}$	90	[1] BADERT...	02	CNTR	o-Ps $\rightarrow \gamma X_1 X_2$, $m_{X_1}+m_{X_2} \leq$ 900 keV
$<2 \times 10^{-4}$	90	MAENO	95	CNTR	o-Ps $\rightarrow A^0 \gamma$ m_{A^0}=850–1013 keV
$<3.0 \times 10^{-4}$	90	[2] ASAI	94	CNTR	o-Ps $\rightarrow A^0 \gamma$ m_{A^0}=30–500 keV
$<2.8 \times 10^{-5}$	90	[3] AKOPYAN	91	CNTR	o-Ps $\rightarrow A^0 \gamma$ ($A^0 \rightarrow \gamma\gamma$), $m_{A^0} < 30$ keV
$<1.1 \times 10^{-6}$	90	[4] ASAI	91	CNTR	o-Ps $\rightarrow A^0 \gamma$, $m_{A^0} < 800$ keV
$<3.8 \times 10^{-4}$	90	GNINENKO	90	CNTR	o-Ps $\rightarrow A^0 \gamma$, $m_{A^0} < 30$ keV
$<(1–5) \times 10^{-4}$	95	[5] TSUCHIAKI	90	CNTR	o-Ps $\rightarrow A^0 \gamma$, m_{A^0} = 300–900 keV
$<6.4 \times 10^{-5}$	90	[6] ORITO	89	CNTR	o-Ps $\rightarrow A^0 \gamma$, $m_{A^0} < 30$ keV
		[7] AMALDI	85	CNTR	Ortho-positronium
		[8] CARBONI	83	CNTR	Ortho-positronium

[1] BADERTSCHER 02 looked for a three-body decay of ortho-positronium into a photon and two penetrating (neutral or milli-charged) particles. NODE=S029AXD;LINKAGE=DB

[2] The ASAI 94 limit is based on inclusive photon spectrum and is independent of A^0 decay modes. NODE=S029AXD;LINKAGE=C

[3] The AKOPYAN 91 limit applies for a short-lived A^0 with $\tau_{A^0} < 10^{-13}\, m_{A^0}$ [keV] s. NODE=S029AXD;LINKAGE=B

[4] ASAI 91 limit translates to $g^2_{A^0 e^+ e^-}/4\pi < 1.1 \times 10^{-11}$ (90% CL) for $m_{A^0} < 800$ keV. NODE=S029AXD;LINKAGE=A1

[5] The TSUCHIAKI 90 limit is based on inclusive photon spectrum and is independent of A^0 decay modes. NODE=S029AXD;LINKAGE=A

[6] ORITO 89 limit translates to $g^2_{A^0 e e}/4\pi < 6.2 \times 10^{-10}$. Somewhat more sensitive limits are obtained for larger m_{A^0}: $B < 7.6 \times 10^{-6}$ at 100 keV. NODE=S029AXD;LINKAGE=GX

[7] AMALDI 85 set limits B($A^0\gamma$) / B($\gamma\gamma\gamma$) $< (1–5) \times 10^{-6}$ for m_{A^0} = 900–100 keV which are about 1/10 of the CARBONI 83 limits. NODE=S029AXD;LINKAGE=AM

[8] CARBONI 83 looked for orthopositronium $\rightarrow A^0\gamma$. Set limit for A^0 electron coupling squared, $g(eeA^0)^2/(4\pi) < 6. \times 10^{-10}$–$7. \times 10^{-9}$ for m_{A^0} from 150–900 keV (CL = 99.7%). This is about 1/10 of the bound from $g-2$ experiments. NODE=S029AXD;LINKAGE=O

A^0 (Axion) Search in Photoproduction

NODE=S029AXG
NODE=S029AXG

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] ADHIKARI	22C	GLUX	m_{A^0} = 180–480, 600–720 MeV
	[2] BASSOMPIE...	95		$m_{A^0} = 1.8 \pm 0.2$ MeV

[1] ADHIKARI 22C search for $A^0 \rightarrow \gamma\gamma$ and $A^0 \rightarrow \pi^+\pi^-\pi^0$ decays, and set limits of $f_{A^0} \lesssim$ 0.5–14 GeV at 90% CL. See their Fig. 4 for mass-dependent limits. NODE=S029AXG;LINKAGE=B

[2] BASSOMPIERRE 95 is an extension of BASSOMPIERRE 93. They looked for a peak in the invariant mass of e^+e^- pairs in the region $m_{e^+e^-} = 1.8 \pm 0.2$ MeV. They obtained bounds on the production rate A^0 for $\tau(A^0) = 10^{-18}$–10^{-9} sec. They also found an excess of events in the range $m_{e^+e^-}$ = 2.1–3.5 MeV. NODE=S029AXG;LINKAGE=BB

A^0 (Axion) Production in Hadron Collisions

NODE=S029AXP

Limits are for $\sigma(A^0)$ / $\sigma(\pi^0)$.

NODE=S029AXP
NODE=S029AXP

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] AAD	25AN	ATLS	$pp \rightarrow t\bar{t}A^0$, $A^0 \rightarrow b\bar{b}$

		[2] AAD	25AT ATLS	$H \to ZA^0$, $A^0 \to gg$, $q\overline{q}$	
		[3] AAD	25AY ATLS	$Z^* \to ZA^0$, $A^0 \to gg$	
		[4] CHEKHOVSKY	25 CMS	$q\overline{q} \to Wa$, $a \to Z\gamma$	
		[5] AAD	24AT ATLS	$H \to A^0 A^0 \to 4\gamma$	
		[6] AAD	24BN ATLS	$q\overline{q} \to VA^0$, $t \to A^0 q$, $A^0 \to gg$, $c\overline{c}$	
		[7] AAD	24BZ ATLS	$V \to VA^0$, $A^0 \to gg$	
		[8] AAD	24CD ATLS	$V \to VA^0$	
		[9] AAD	24K ATLS	$H \to ZA^0$	
		[10] HAYRAPETY...	24AZ CMS	$H \to A^0 A^0$, $A^0 \to \mu^+\mu^-$	
		[11] HAYRAPETY...	24I CMS	$H \to A^0 Z \to \gamma\gamma\ell^+\ell^-$	
		[12] TUMASYAN	24C CMS	$\gamma\gamma \to A^0 \to \gamma\gamma$	
		[13] ACCIARRI	23 ARNT	$A^0 \to \mu^+\mu^-$	
		[14] BERTUZZO	23 ARNT	$A^0 \to \mu^+\mu^-$	
		[15] AAD	22J ATLS	$H \to A^0 A^0$, ZA^0 ($A^0 \to \mu^+\mu^-$)	
		[16] TUMASYAN	22AH CMS	$H \to A^0 A^0$, $A^0 \to e^+e^-$, $\mu^+\mu^-$	
		[17] TUMASYAN	22R CMS	$pp \to A^{*0} \to ZZ$, ZH	
		[18] AAD	21F ATLS	Monojet + missing p_T	
		[19] AAD	21K ATLS	Mono-γ + missing p_T	
		[20] AAD	21N ATLS	$\gamma\gamma$ scatt. in Pb+Pb	
		[21] CARRA	21 ATLS	$pp \to A^{*0} \to WW$, $Z\gamma$	
		[22] AAIJ	20AL LHCB	$pp \to X^0 \to \mu^+\mu^-$	
		[23] GAVELA	20 CMS	$pp \to A^{*0} \to \gamma\gamma$, ZZ	
		[24] SIRUNYAN	19BQ CMS	$X^0 \to \mu^+\mu^-$	
		[25] JAIN	07 CNTR	$A^0 \to e^+e^-$	
		[26] AHMAD	97 SPEC	e^+ production	
		[27] LEINBERGER	97 SPEC	$A^0 \to e^+e^-$	
		[28] GANZ	96 SPEC	$A^0 \to e^+e^-$	
		[29] KAMEL	96 EMUL	^{32}S emulsion, $A^0 \to e^+e^-$	
		[30] BLUEMLEIN	92 BDMP	$A^0 N_Z \to \ell^+\ell^- N_Z$	
		[31] MEIJERDREES	92 SPEC	$\pi^- p \to nA^0$, $A^0 \to e^+e^-$	
		[32] BLUEMLEIN	91 BDMP	$A^0 \to e^+e^-$, 2γ	
		[33] FAISSNER	89 OSPK	Beam dump, $A^0 \to e^+e^-$	
		[34] DEBOER	88 RVUE	$A^0 \to e^+e^-$	
		[35] EL-NADI	88 EMUL	$A^0 \to e^+e^-$	
		[36] FAISSNER	88 OSPK	Beam dump, $A^0 \to 2\gamma$	
		[37] BADIER	86 BDMP	$A^0 \to e^+e^-$	
$<2. \times 10^{-11}$	90	[38] BERGSMA	85 CHRM	CERN beam dump	
$<1. \times 10^{-13}$	90	[38] BERGSMA	85 CHRM	CERN beam dump	OCCUR=2
		[39] FAISSNER	83 OSPK	Beam dump, $A^0 \to 2\gamma$	
		[40] FAISSNER	83B RVUE	LAMPF beam dump	
		[41] FRANK	83B RVUE	LAMPF beam dump	
		[42] HOFFMAN	83 CNTR	$\pi p \to nA^0$ ($A^0 \to e^+e^-$)	
		[43] FETSCHER	82 RVUE	See FAISSNER 81B	
		[44] FAISSNER	81 OSPK	CERN PS ν wideband	
		[45] FAISSNER	81B OSPK	Beam dump, $A^0 \to 2\gamma$	
		[46] KIM	81 OSPK	26 GeV $pN \to A^0 X$	
		[47] FAISSNER	80 OSPK	Beam dump, $A^0 \to e^+e^-$	
$<1. \times 10^{-8}$	90	[48] JACQUES	80 HLBC	28 GeV protons	
$<1. \times 10^{-14}$	90	[48] JACQUES	80 HLBC	Beam dump	OCCUR=2
		[49] SOUKAS	80 CALO	28 GeV p beam dump	
		[50] BECHIS	79 CNTR		
$<1. \times 10^{-8}$	90	[51] COTEUS	79 OSPK	Beam dump	
$<1. \times 10^{-3}$	95	[52] DISHAW	79 CALO	400 GeV pp	
$<1. \times 10^{-8}$	90	ALIBRAN	78 HYBR	Beam dump	
$<6. \times 10^{-9}$	95	ASRATYAN	78B CALO	Beam dump	
$<1.5 \times 10^{-8}$	90	[53] BELLOTTI	78 HLBC	Beam dump	
$<5.4 \times 10^{-14}$	90	[53] BELLOTTI	78 HLBC	m_{A^0}=1.5 MeV	OCCUR=2

$<4.1 \times 10^{-9}$	90	[53] BELLOTTI	78	HLBC	m_{A^0}=1 MeV	OCCUR=3
$<1. \times 10^{-8}$	90	[54] BOSETTI	78B	HYBR	Beam dump	
		[55] DONNELLY	78			
$<0.5 \times 10^{-8}$	90	HANSL	78D	WIRE	Beam dump	
		[56] MICELMAC...	78			
		[57] VYSOTSKII	78			

[1] AAD 25AN search for axion-like particle production in proton-proton collisions in association with single top and a W or top quark pair, with the subsequent A^0 decaying to $b\overline{b}$. They search for axion-like particles with masses between 12 and 100 GeV as shown in the mass-dependent limits on the production cross section times branching fraction in their Fig. 9. NODE=S029AXP;LINKAGE=VA

[2] AAD 25AT set limits on the branching fraction of Higgs boson decays to a Z boson and a 0.5–3.5 GeV-mass axion-like particle decaying to either a gluon or quark pair. See their Fig. 4 for detailed limits. NODE=S029AXP;LINKAGE=XA

[3] AAD 25AY set limits on long-lived axion-like particles produced in proton-proton collisions via an intermediate off-shell Z boson, with the axion-like particle decaying to a gluon pair in association with a lepton pair in the final state. See their Fig. 15 for limits on the Z + axion cross section multiplied by the axion-to-2-gluon branching ratio as a function of the proper decay length for the axion. They search across axion masses 0.1–40 GeV. NODE=S029AXP;LINKAGE=YA

[4] CHEKHOVSKY 25 constrain the production of heavy axion-like particles via a search for $WZ\gamma$ events in proton-proton collisions recorded by the CMS detector. They consider a process in which an ALP is produced alongside a W, and then decays to a Z and γ. See Fig. 3 for mass-dependent limits on the branching ratio multiplied by the cross section (or in terms of the ALP energy scale) across the 110 to 400 GeV ALP mass region. NODE=S029AXP;LINKAGE=WA

[5] AAD 24AT search for Higgs decays to axions, constraining the effective coupling to photons between 100 MeV and 62 GeV axion mass. Limit strength is dependent on the effective axion-Higgs coupling and is strongest at the highest mass. See their Fig. 8 for full limits. NODE=S029AXP;LINKAGE=NA

[6] AAD 24BN search for the production of long-lived axion-like particles produced in proton-proton collisions at the ATLAS detector. See their Fig. 2 for cross-section limits on benchmark ALP masses between 40 and 55 GeV, as a function of their proper decay length. Limits are presented for both ALP production from $q\overline{q}$ in association with the production of a vector boson, and ALP production from top decays. NODE=S029AXP;LINKAGE=RA

[7] AAD 24BZ set limits on photo-phobic axion-like particles with masses between 0.1 and 40 GeV that are radiated from vector bosons and decay into gluons. See their Figs. 11 and 12 for limits on the ALP couplings to W, Z and gluons. An erratum for this publication can be found at AAD 25BF, which impacts the ALP branching ratio limit plots: Figures 9(a) and 10(a). NODE=S029AXP;LINKAGE=SA

[8] AAD 24CD search for the production of axion-like particles in association with a hadronically decaying W or Z and large missing transverse energy in proton-proton collisions at the ATLAS detector. See their Fig. 7 for upper limits on the vector boson coupling for an ALP mass of 1 MeV as a function of f_{A^0}. NODE=S029AXP;LINKAGE=TA

[9] AAD 24K search for Higgs decays to a Z and an axion-like particle in the mass range 0.1 to 33 GeV. They constrain the axion coupling to photons. See Fig. 3b for mass-dependent limits, which also depend on the coupling of the Higgs to ZA^0. NODE=S029AXP;LINKAGE=OA

[10] HAYRAPETYAN 24AZ present results from CMS's search for axion-like particles produced from Higgs decays then promptly decaying to a dimuon. See their Fig. 6 for limits on the effective ALP coupling to the SM-like Higgs. NODE=S029AXP;LINKAGE=UA

[11] HAYRAPETYAN 24I report a search by CMS for an exotic Higgs decay to an axion-like particle and a Z, which decay to two photons and two leptons respectively. See Fig. 7 and 8 for mass-dependent limits on the cross-section for the process and the effective axion coupling in the mass range 1 to 30 GeV. NODE=S029AXP;LINKAGE=QA

[12] TUMASYAN 24C reports results from the CMS and TOTEM collaborations' search for photon-photon fusion events in proton collisions and the subsequent diphoton events which may occur via the production of axions. Constraints on the axion to two-photon coupling are presented at the 10^{-5} GeV^{-1} level for axion masses between 500 and 2000 GeV. NODE=S029AXP;LINKAGE=PA

[13] ACCIARRI 23 search for axions in the NuMI neutrino beam target, which are produced through mixings with mesons due to the coupling with gluons, and exclude f_{A^0} around tens of TeV for m_{A^0} = 0.2–0.9 GeV. They assume a slightly suppressed axion coupling to muons. See their Fig. 4 for the limits. NODE=S029AXP;LINKAGE=KA

[14] BERTUZZO 23 employs an analysis analogous to ACCIARRI 23. They search for leptophilic axions primarily produced via $\tau \rightarrow \mu A^0$ and $\tau \rightarrow eA^0$, and exclude f_{A^0} around 1×10^6–6×10^7 GeV for m_{A^0} = 0.2–1.7 GeV. See their Fig. 2 for the limits. NODE=S029AXP;LINKAGE=MA

[15] AAD 22J set upper limits for the cross sections of $H \rightarrow A^0 A^0 \rightarrow 4\mu$ and $H \rightarrow ZA^0 \rightarrow 2\ell 2\mu$. See their Figs. 14 and 17 for the respective mass-dependent limits. NODE=S029AXP;LINKAGE=IA

[16] TUMASYAN 22AH set the limits of $O(10^{-6})$ with respect to the product of the branching fractions of $H \rightarrow A^0 A^0$ and $A^0 \rightarrow e^+ e^-$, $\mu^+ \mu^-$. They also derive limits on the effective axion couplings contributing to $H \rightarrow A^0 A^0$ and $H \rightarrow ZA^0$. See their Figs. 5 and 7 for the limits. NODE=S029AXP;LINKAGE=GA

[17] TUMASYAN 22R is analogous to GAVELA 20, and set a limit on the products of the axion couplings to gluons and Z bosons as $G_{AZZ}\ G_{Agg} < 6.64 \times 10^{-7}$ GeV^{-2} at NODE=S029AXP;LINKAGE=HA

95% CL for $f_{A^0} = 3$ TeV and $m_{A^0} < 100$ GeV. Here we use $c_{\widetilde{G}} = G_{Agg}\ f_{A^0}/4$ and $c_{\widetilde{Z}} = G_{AZZ}\ f_{A^0}/4$ to translate their limits. They also set a limit on the product of the axion couplings to gluons and ZH. See their Fig. 9 for the f_{A^0}-dependent limits.

[18] AAD 21F look for axion production with an energetic jet and large missing p_T, and set a limit on the axion coupling to gluons, $c_{\widetilde{G}}/f_{A^0} < 8 \times 10^{-6}$ GeV^{-1} at 95 % CL for $m_{A^0} = 1$ MeV. Using $c_{\widetilde{G}} = \alpha_s/8\pi$, we interpret the limit as $f_{A^0} > 0.4$ TeV for $\alpha_s \simeq 0.08$. NODE=S029AXP;LINKAGE=CA

[19] AAD 21K look for axion production with an energetic photon and large missing p_T, and set a limit on the axion coupling to a Z boson and photon, $G_{AZ\gamma} < 5.1 \times 10^{-4}$ GeV^{-1} at 95 % CL for $m_{A^0} = 1$ MeV and assuming $G_{A\gamma\gamma} = 0$. NODE=S029AXP;LINKAGE=DA

[20] AAD 21N look for axion production using the measurement of light-by-light scattering based on Pb+Pb collision data. They set the limit on the axion-photon coupling, $G_{A\gamma\gamma} < 5.3 \times 10^{-5}$–$3.4 \times 10^{-4}$ GeV^{-1} at 95 % CL for $m_{A^0} = 6$–100 GeV. Here we use $\Lambda_a = G_{A\gamma\gamma}{}^{-1}$ to translate their limits. See their Fig. 9 for mass-dependent limits. NODE=S029AXP;LINKAGE=EA

[21] CARRA 21 is analogous to GAVELA 20, and they use the differential cross sections for WW and $Z\gamma$ production measured with the ATLAS detector to set limits on the product of the axion couplings to gauge bosons as $G_{AWW}\ G_{Agg} < 6.2 \times 10^{-7}$ GeV^{-2} and $G_{AZ\gamma}\ G_{Agg} < 3.7 \times 10^{-7}$ GeV^{-2} at 95 % CL for $m_{A^0} \lesssim 100$ GeV. NODE=S029AXP;LINKAGE=FA

[22] AAIJ 20AL look for a light new boson decaying into a pair of muons using the LHCb data with an integrated luminosity of 5.1 fb^{-1}, and set limits on the cross section over a range of $m_{X^0} = 0.22$–3 and 20–60 GeV. See Figs. 8 and 9 for mass-dependent limits. NODE=S029AXP;LINKAGE=AA

[23] GAVELA 20 focus on the axion production as an s-channel off shell mediator, and use the Run 2 CMS public data to set limits on the product of the axion couplings to gluons and photons as well as Z bosons as $G_{A\gamma\gamma}\ G_{Agg} < 2.8 \times 10^{-7}$ GeV^{-2} and $G_{AZZ}\ G_{Agg} < 9.8 \times 10^{-7}$ GeV^{-2} for $m_{A^0} \lesssim 200$ GeV. See their Fig.3 for the limits. NODE=S029AXP;LINKAGE=V

[24] SIRUNYAN 19BQ look for the pair production of a new light boson decaying into a pair of muons, and set limits on the product of the production cross section times branching fraction to dimuons squared times acceptance over a range of $m_{X^0} = 0.25$–8.5 GeV. See the right panel of their Fig. 1 for mass-dependent limits. NODE=S029AXP;LINKAGE=U

[25] JAIN 07 claims evidence for $A^0 \rightarrow e^+ e^-$ produced in ^{207}Pb collision on nuclear emulsion (Ag/Br) for $m(A^0) = 7 \pm 1$ or 19 ± 1 MeV and $\tau(A^0) \leq 10^{-13}$ s. NODE=S029AXP;LINKAGE=JA

[26] AHMAD 97 reports a result of APEX Collaboration which studied positron production in ^{238}U+^{232}Ta and ^{238}U+^{181}Ta collisions, without requiring a coincident electron. No narrow lines were found for 250 $< E_{e^+} <$ 750 keV. NODE=S029AXP;LINKAGE=LA

[27] LEINBERGER 97 (ORANGE Collaboration) at GSI looked for a narrow sum-energy e^+e^--line at $\sim$ 635 keV in ^{238}U+^{181}Ta collision. Limits on the production probability for a narrow sum-energy e^+e^- line are set. See their Table 2. NODE=S029AXP;LINKAGE=LL

[28] GANZ 96 (EPos II Collaboration) has placed upper bounds on the production cross section of e^+e^- pairs from ^{238}U+^{181}Ta and ^{238}U+^{232}Th collisions at GSI. See Table 2 for limits both for back-to-back and isotropic configurations of e^+e^- pairs. These limits rule out the existence of peaks in the e^+e^- sum-energy distribution, reported by an earlier version of this experiment. NODE=S029AXP;LINKAGE=G1

[29] KAMEL 96 looked for e^+e^- pairs from the collision of ^{32}S (200 GeV/nucleon) and emulsion. No evidence of mass peaks is found in the region of sensitivity $m_{ee} >$2 MeV. NODE=S029AXP;LINKAGE=KL

[30] BLUEMLEIN 92 is a proton beam dump experiment at Serpukhov with a secondary target to induce Bethe-Heitler production of e^+e^- or $\mu^+\mu^-$ from the produce A^0. See Fig. 5 for the excluded region in m_{A^0}-x plane. For the standard axion, 0.3 $<x<$25 is excluded at 95% CL. If combined with BLUEMLEIN 91, 0.008 $<x<$32 is excluded. NODE=S029AXP;LINKAGE=NN

[31] MEIJERDREES 92 give $\Gamma(\pi^- p \rightarrow nA^0)\cdot B(A^0 \rightarrow e^+e^-)/\Gamma(\pi^- p \rightarrow \text{all}) < 10^{-5}$ (90% CL) for $m_{A^0} = 100$ MeV, $\tau_{A^0} = 10^{-11}$–10^{-23} sec. Limits ranging from 2.5×10^{-3} to 10^{-7} are given for $m_{A^0} = 25$–136 MeV. NODE=S029AXP;LINKAGE=Z

[32] BLUEMLEIN 91 is a proton beam dump experiment at Serpukhov. No candidate event for $A^0 \rightarrow e^+e^-$, 2γ are found. Fig. 6 gives the excluded region in m_{A^0}-x plane ($x = \tan\beta = v_2/v_1$). Standard axion is excluded for $0.2 < m_{A^0} < 3.2$ MeV for most $x > 1$, 0.2–11 MeV for most $x < 1$. NODE=S029AXP;LINKAGE=A2

[33] FAISSNER 89 searched for $A^0 \rightarrow e^+e^-$ in a proton beam dump experiment at SIN. No excess of events was observed over the background. A standard axion with mass $2m_e$–20 MeV is excluded. Lower limit on f_{A^0} of $\simeq 10^4$ GeV is given for $m_{A^0} = 2m_e$–20 MeV. NODE=S029AXP;LINKAGE=F2

[34] DEBOER 88 reanalyze EL-NADI 88 data and claim evidence for three distinct states with mass $\sim$ 1.1, $\sim$ 2.1, and $\sim$ 9 MeV, lifetimes 10^{-16}–10^{-15} s decaying to e^+e^- and note the similarity of the data with those of a cosmic-ray experiment by Bristol group (B.M. Anand, Proc. of the Royal Society of London, Section A **A22** 183 (1953)). For a criticism see PERKINS 89, who suggests that the events are compatible with π^0 Dalitz decay. DEBOER 89B is a reply which contests the criticism. NODE=S029AXP;LINKAGE=X

[35] EL-NADI 88 claim the existence of a neutral particle decaying into $e^+ e^-$ with mass 1.60 ± 0.59 MeV, lifetime $(0.15 \pm 0.01) \times 10^{-14}$ s, which is produced in heavy ion interactions with emulsion nuclei at ~ 4 GeV/c/nucleon. NODE=S029AXP;LINKAGE=W

[36] FAISSNER 88 is a proton beam dump experiment at SIN. They found no candidate event for $A^0 \rightarrow \gamma\gamma$. A standard axion decaying to 2γ is excluded except for a region $x \simeq 1$. Lower limit on f_{A^0} of 10^2–10^3 GeV is given for $m_{A^0} = 0.1$–1 MeV. NODE=S029AXP;LINKAGE=F1

[37] BADIER 86 did not find long-lived A^0 in 300 GeV π^- Beam Dump Experiment that decays into $e^+ e^-$ in the mass range $m_{A^0} = (20$–$200)$ MeV, which excludes the A^0 decay constant $f(A^0)$ in the interval (60–600) GeV. See their figure 6 for excluded region on $f(A^0)$-m_{A^0} plane. NODE=S029AXP;LINKAGE=A1

[38] BERGSMA 85 look for $A^0 \rightarrow 2\gamma$, $e^+ e^-$, $\mu^+ \mu^-$. First limit above is for $m_{A^0} = 1$ MeV; second is for 200 MeV. See their figure 4 for excluded region on $f_{A^0}-m_{A^0}$ plane, where f_{A^0} is A^0 decay constant. For Peccei-Quinn PECCEI 77 A^0, $m_{A^0} < 180$ keV and $\tau > 0.037$ s. (CL = 90%). For the axion of FAISSNER 81B at 250 keV, BERGSMA 85 expect 15 events but observe zero. NODE=S029AXP;LINKAGE=T

[39] FAISSNER 83 observed 19 1-γ and 12 2-γ events where a background of 4.8 and 2.3 respectively is expected. A small-angle peak is observed even if iron wall is set in front of the decay region. NODE=S029AXP;LINKAGE=P

[40] FAISSNER 83B extrapolate SIN γ signal to LAMPF ν experimental condition. Resulting 370 γ's are not at variance with LAMPF upper limit of 450 γ's. Derived from LAMPF limit that $\left[d\sigma(A^0)/d\omega \text{ at } 90^\circ\right] m_{A^0}/\tau_{A^0} < 14 \times 10^{-35}$ cm^2 sr^{-1} MeV ms^{-1}. See comment on FRANK 83B. NODE=S029AXP;LINKAGE=Q

[41] FRANK 83B stress the importance of LAMPF data bins with negative net signal. By statistical analysis say that LAMPF and SIN-A0 are at variance when extrapolation by phase-space model is done. They find LAMPF upper limit is 248 not 450 γ's. See comment on FAISSNER 83B. NODE=S029AXP;LINKAGE=R

[42] HOFFMAN 83 set CL = 90% limit $d\sigma/dt$ B$(e^+ e^-) < 3.5 \times 10^{-32}$ cm^2/GeV^2 for $140 < m_{A^0} < 160$ MeV. Limit assumes $\tau(A^0) < 10^{-9}$ s. NODE=S029AXP;LINKAGE=S

[43] FETSCHER 82 reanalyzes SIN beam-dump data of FAISSNER 81. Claims no evidence for axion since 2-γ peak rate remarkably decreases if iron wall is set in front of the decay region. NODE=S029AXP;LINKAGE=O

[44] FAISSNER 81 see excess μe events. Suggest axion interactions. NODE=S029AXP;LINKAGE=L

[45] FAISSNER 81B is SIN 590 MeV proton beam dump. Observed 14.5 ± 5.0 events of 2γ decay of long-lived neutral penetrating particle with $m_{2\gamma} \lesssim 1$ MeV. Axion interpretation with η-A^0 mixing gives $m_{A^0} = 250 \pm 25$ keV, $\tau_{(2\gamma)} = (7.3 \pm 3.7) \times 10^{-3}$ s from above rate. See critical remarks below in comments of FETSCHER 82, FAISSNER 83, FAISSNER 83B, FRANK 83B, and BERGSMA 85. Also see in the next subsection ALEKSEEV 82B, CAVAIGNAC 83, and ANANEV 85. NODE=S029AXP;LINKAGE=M

[46] KIM 81 analyzed 8 candidates for $A^0 \rightarrow 2\gamma$ obtained by Aachen-Padova experiment at CERN with 26 GeV protons on Be. Estimated axion mass is about 300 keV and lifetime is $(0.86 \sim 5.6) \times 10^{-3}$ s depending on models. Faissner (private communication), says axion production underestimated and mass overestimated. Correct value around 200 keV. NODE=S029AXP;LINKAGE=N

[47] FAISSNER 80 is SIN beam dump experiment with 590 MeV protons looking for $A^0 \rightarrow e^+ e^-$ decay. Assuming $A^0/\pi^0 = 5.5 \times 10^{-7}$, obtained decay rate limit $20/(A^0$ mass) MeV/s (CL = 90%), which is about 10^{-7} below theory and interpreted as upper limit to $m_{A^0} < 2m_{e^-}$. NODE=S029AXP;LINKAGE=I

[48] JACQUES 80 is a BNL beam dump experiment. First limit above comes from nonobservation of excess neutral-current-type events $\left[\sigma(\text{production})\sigma(\text{interaction}) < 7. \times 10^{-68}\right.$ cm^4, CL = 90%$\left.\right]$. Second limit is from nonobservation of axion decays into 2γ's or $e^+ e^-$, and for axion mass a few MeV. NODE=S029AXP;LINKAGE=J

[49] SOUKAS 80 at BNL observed no excess of neutral-current-type events in beam dump. NODE=S029AXP;LINKAGE=K

[50] BECHIS 79 looked for the axion production in low energy electron Bremsstrahlung and the subsequent decay into either 2γ or $e^+ e^-$. No signal found. CL = 90% limits for model parameter(s) are given. NODE=S029AXP;LINKAGE=F

[51] COTEUS 79 is a beam dump experiment at BNL. NODE=S029AXP;LINKAGE=G

[52] DISHAW 79 is a calorimetric experiment and looks for low energy tail of energy distributions due to energy lost to weakly interacting particles. NODE=S029AXP;LINKAGE=H

[53] BELLOTTI 78 first value comes from search for $A^0 \rightarrow e^+ e^-$. Second value comes from search for $A^0 \rightarrow 2\gamma$, assuming mass $< 2m_{e^-}$. For any mass satisfying this, limit is above value$\times$(mass^{-4}). Third value uses data of PL 60B 401 and quotes $\sigma(\text{production})\sigma(\text{interaction}) < 10^{-67}$ cm^4. NODE=S029AXP;LINKAGE=A

[54] BOSETTI 78B quotes $\sigma(\text{production})\sigma(\text{interaction}) < 2. \times 10^{-67}$ cm^4. NODE=S029AXP;LINKAGE=B

[55] DONNELLY 78 examines data from reactor neutrino experiments of REINES 76 and GURR 74 as well as SLAC beam dump experiment. Evidence is negative. NODE=S029AXP;LINKAGE=C

[56] MICELMACHER 78 finds no evidence of axion existence in reactor experiments of REINES 76 and GURR 74. (See reference under DONNELLY 78 below). NODE=S029AXP;LINKAGE=D

[57] VYSOTSKII 78 derived lower limit for the axion mass 25 keV from luminosity of the sun and 200 keV from red supergiants. NODE=S029AXP;LINKAGE=E

A^0 (Axion) Searches in Reactor Experiments

NODE=S029AXR

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] CHANG	07		Primakoff or Compton
	[2] ALTMANN	95	CNTR	Reactor; $A^0 \rightarrow e^+e^-$
	[3] KETOV	86	SPEC	Reactor, $A^0 \rightarrow \gamma\gamma$
	[4] KOCH	86	SPEC	Reactor; $A^0 \rightarrow \gamma\gamma$
	[5] DATAR	82	CNTR	Light water reactor
	[6] VUILLEUMIER	81	CNTR	Reactor, $A^0 \rightarrow 2\gamma$

NODE=S029AXR

[1] CHANG 07 looked for monochromatic photons from Primakoff or Compton conversion of axions from the Kuo-Sheng reactor due to axion coupling to photon or electron, respectively. The search places model-independent limits on the products $G_{A\gamma\gamma}G_{ANN}$ and $G_{Aee}G_{ANN}$ for $m(A^0)$ less than the MeV range. NODE=S029AXR;LINKAGE=CH

[2] ALTMANN 95 looked for A^0 decaying into e^+e^- from the Bugey 5 nuclear reactor. They obtain an upper limit on the A^0 production rate of $\omega(A^0)/\omega(\gamma)$ $\times$B($A^0 \rightarrow e^+e^-$)$< 10^{-16}$ for $m_{A^0} = 1.5$ MeV at 90% CL. The limit is weaker for heavier A^0. In the case of a standard axion, this limit excludes a mass in the range $2m_e < m_{A^0} < 4.8$ MeV at 90% CL. See Fig. 5 of their paper for exclusion limits of axion-like resonances Z^0 in the (m_{X^0}, f_{X^0}) plane. NODE=S029AXR;LINKAGE=C

[3] KETOV 86 searched for A^0 at the Rovno nuclear power plant. They found an upper limit on the A^0 production probability of 0.8 $\left[100 \text{ keV}/m_{A^0}\right]^6 \times 10^{-6}$ per fission. In the standard axion model, this corresponds to m_{A^0} >150 keV. Not valid for $m_{A^0} \gtrsim$ 1 MeV. NODE=S029AXR;LINKAGE=A

[4] KOCH 86 searched for $A^0 \rightarrow \gamma\gamma$ at nuclear power reactor Biblis A. They found an upper limit on the A^0 production rate of $\omega(A^0)/\omega(\gamma(M1)) < 1.5 \times 10^{-10}$ (CL=95%). Standard axion with $m_{A^0} = 250$ keV gives 10^{-5} for the ratio. Not valid for m_{A^0} >1022 keV. NODE=S029AXR;LINKAGE=B

[5] DATAR 82 looked for $A^0 \rightarrow 2\gamma$ in neutron capture ($np \rightarrow dA^0$) at Tarapur 500 MW reactor. Sensitive to sum of $I = 0$ and $I = 1$ amplitudes. With ZEHNDER 81 $\left[(I = 0) - (I = 1)\right]$ result, assert nonexistence of standard A^0. NODE=S029AXR;LINKAGE=I

[6] VUILLEUMIER 81 is at Grenoble reactor. Set limit m_{A^0} <280 keV. NODE=S029AXR;LINKAGE=D

A^0 (Axion) and Other Light Boson (X^0) Searches in Nuclear Transitions

NODE=S029ANT

Limits are for branching ratio.

NODE=S029ANT

VALUE	CL%	DOCUMENT ID		TECN	COMMENT	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$< 8.89 \times 10^{-6}$	90	[1] DERBIN	23	CNTR	M1 transition of ^{169}Tm	
$< 8.5 \times 10^{-6}$	90	[2] DERBIN	02	CNTR	^{125m}Te decay	
		[3] DEBOER	97C	RVUE	M1 transitions	
$< 5.5 \times 10^{-10}$	95	[4] TSUNODA	95	CNTR	^{252}Cf fission, $A^0 \rightarrow ee$	
$< 1.2 \times 10^{-6}$	95	[5] MINOWA	93	CNTR	$^{139}\text{La}^* \rightarrow {}^{139}\text{La}\,A^0$	
$< 2 \times 10^{-4}$	90	[6] HICKS	92	CNTR	^{35}S decay, $A^0 \rightarrow \gamma\gamma$	
$< 1.5 \times 10^{-9}$	95	[7] ASANUMA	90	CNTR	^{241}Am decay	
$<(0.4\text{–}10) \times 10^{-3}$	95	[8] DEBOER	90	CNTR	$^8\text{Be}^* \rightarrow {}^8\text{Be}\,A^0$, $A^0 \rightarrow e^+e^-$	
$<(0.2\text{–}1) \times 10^{-3}$	90	[9] BINI	89	CNTR	$^{16}\text{O}^* \rightarrow {}^{16}\text{O}\,X^0$, $X^0 \rightarrow e^+e^-$	
		[10] AVIGNONE	88	CNTR	$\text{Cu}^* \rightarrow \text{Cu}\,A^0$ ($A^0 \rightarrow 2\gamma$, $A^0 e \rightarrow \gamma e$, $A^0 Z \rightarrow \gamma Z$)	
$< 1.5 \times 10^{-4}$	90	[11] DATAR	88	CNTR	$^{12}\text{C}^* \rightarrow {}^{12}\text{C}\,A^0$, $A^0 \rightarrow e^+e^-$	
$< 5 \times 10^{-3}$	90	[12] DEBOER	88C	CNTR	$^{16}\text{O}^* \rightarrow {}^{16}\text{O}\,X^0$, $X^0 \rightarrow e^+e^-$	
$< 3.4 \times 10^{-5}$	95	[13] DOEHNER	88	SPEC	$^2\text{H}^*$, $A^0 \rightarrow e^+e^-$	
$< 4 \times 10^{-4}$	95	[14] SAVAGE	88	CNTR	Nuclear decay (isovector)	
$< 3 \times 10^{-3}$	95	[14] SAVAGE	88	CNTR	Nuclear decay (isoscalar)	OCCUR=2
$<10.6 \times 10^{-2}$	90	[15] HALLIN	86	SPEC	^{6}Li isovector decay	
<10.8	90	[15] HALLIN	86	SPEC	^{10}B isoscalar decays	OCCUR=2
< 2.2	90	[15] HALLIN	86	SPEC	^{14}N isoscalar decays	OCCUR=3
$< 4 \times 10^{-4}$	90	[16] SAVAGE	86B	CNTR	$^{14}\text{N}^*$	
		[17] ANANEV	85	CNTR	Li*, deut* $A^0 \rightarrow 2\gamma$	
		[18] CAVAIGNAC	83	CNTR	^{97}Nb*, deut* transition $A^0 \rightarrow 2\gamma$	
		[19] ALEKSEEV	82B	CNTR	Li*, deut* transition $A^0 \rightarrow 2\gamma$	

[20] LEHMANN	82	CNTR	$Cu^* \to Cu A^0$ ($A^0 \to 2\gamma$)
[21] ZEHNDER	82	CNTR	Li^*, Nb^* decay, n-capt.
[22] ZEHNDER	81	CNTR	$Ba^* \to Ba A^0$ ($A^0 \to 2\gamma$)
[23] CALAPRICE	79		Carbon

[1] DERBIN 23 use a thallium garnet bolometric detector to search for the 8.4 keV solar axion line emitted from the M1 nuclear transition of ^{169}Tm. Their limits are equivalent to an upper bound on the KSVZ and DFSZ axion masses of 141 eV and 244 eV, respectively. NODE=S029ANT;LINKAGE=L

[2] DERBIN 02 looked for the axion emission in an M1 transition in ^{125m}Te decay. They looked for a possible presence of a shifted energy spectrum in gamma rays due to the undetected axion. NODE=S029ANT;LINKAGE=ER

[3] DEBOER 97C reanalyzed the existent data on Nuclear M1 transitions and find that a 9 MeV boson decaying into $e^+ e^-$ would explain the excess of events with large opening angles. See also DEBOER 01 for follow-up experiments. NODE=S029ANT;LINKAGE=W

[4] TSUNODA 95 looked for axion emission when ^{252}Cf undergoes a spontaneous fission, with the axion decaying into $e^+ e^-$. The bound is for m_{A^0}=40 MeV. It improves to 2.5×10^{-5} for m_{A^0}=200 MeV. NODE=S029ANT;LINKAGE=J

[5] MINOWA 93 studied chain process, ^{139}Ce $\to$ ^{139}La* by electron capture and M1 transition of ^{139}La* to the ground state. It does not assume decay modes of A^0. The bound applies for $m_{A^0} < 166$ keV. NODE=S029ANT;LINKAGE=D

[6] HICKS 92 bound is applicable for $\tau_{X^0} < 4 \times 10^{-11}$ sec. NODE=S029ANT;LINKAGE=V

[7] The ASANUMA 90 limit is for the branching fraction of X^0 emission per ^{241}Am α decay and valid for $\tau_{X^0} < 3 \times 10^{-11}$ s. NODE=S029ANT;LINKAGE=I

[8] The DEBOER 90 limit is for the branching ratio ^{8}Be* (18.15 MeV, 1^+) $\to$ ^{8}BeA^0, $A^0 \to e^+ e^-$ for the mass range m_{A^0} = 4–15 MeV. NODE=S029ANT;LINKAGE=BB

[9] The BINI 89 limit is for the branching fraction of ^{16}O*(6.05 MeV, 0^+) $\to$ ^{16}OX^0, $X^0 \to e^+ e^-$ for m_X = 1.5–3.1 MeV. $\tau_{X^0} \lesssim 10^{-11}$ s is assumed. The spin-parity of X is restricted to 0^+ or 1^-. NODE=S029ANT;LINKAGE=H

[10] AVIGNONE 88 looked for the 1115 keV transition $C^* \to Cu A^0$, either from $A^0 \to 2\gamma$ in-flight decay or from the secondary A^0 interactions by Compton and by Primakoff processes. Limits for axion parameters are obtained for $m_{A^0} < 1.1$ MeV. NODE=S029ANT;LINKAGE=G

[11] DATAR 88 rule out light pseudoscalar particle emission through its decay $A^0 \to e^+ e^-$ in the mass range 1.02–2.5 MeV and lifetime range 10^{-13}–10^{-8} s. The above limit is for $\tau = 5 \times 10^{-13}$ s and m = 1.7 MeV; see the paper for the τ-m dependence of the limit. NODE=S029ANT;LINKAGE=T

[12] The limit is for the branching fraction of ^{16}O*(6.05 MeV, 0^+) $\to$ ^{16}OX^0, $X^0 \to e^+ e^-$ against internal pair conversion for m_{X^0} = 1.7 MeV and $\tau_{X^0} < 10^{-11}$ s. Similar limits are obtained for m_{X^0} = 1.3–3.2 MeV. The spin parity of X^0 must be either 0^+ or 1^-. The limit at 1.7 MeV is translated into a limit for the X^0-nucleon coupling constant: $g^2_{X^0 NN}/4\pi < 2.3 \times 10^{-9}$. NODE=S029ANT;LINKAGE=DX

[13] The DOEHNER 88 limit is for m_{A^0} = 1.7 MeV, $\tau(A^0) < 10^{-10}$ s. Limits less than 10^{-4} are obtained for m_{A^0} = 1.2–2.2 MeV. NODE=S029ANT;LINKAGE=C

[14] SAVAGE 88 looked for A^0 that decays into $e^+ e^-$ in the decay of the 9.17 MeV $J^P = 2^+$ state in ^{14}N, 17.64 MeV state $J^P = 1^+$ in ^{8}Be, and the 18.15 MeV state $J^P = 1^+$ in ^{8}Be. This experiment constrains the isovector coupling of A^0 to hadrons, if m_{A^0} = (1.1 $\to$ 2.2) MeV and the isoscalar coupling of A^0 to hadrons, if m_{A^0} = (1.1 $\to$ 2.6) MeV. Both limits are valid only if $\tau(A^0) \lesssim 1 \times 10^{-11}$ s. NODE=S029ANT;LINKAGE=B

[15] Limits are for $\Gamma(A^0(1.8\text{ MeV}))/\Gamma(\pi M1)$; i.e., for 1.8 MeV axion emission normalized to the rate for internal emission of $e^+ e^-$ pairs. Valid for $\tau_{A^0} < 2 \times 10^{-11}$s. ^{6}Li isovector decay data strongly disfavor PECCEI 86 model I, whereas the ^{10}B and ^{14}N isoscalar decay data strongly reject PECCEI 86 model II and III. NODE=S029ANT;LINKAGE=AA

[16] SAVAGE 86B looked for A^0 that decays into $e^+ e^-$ in the decay of the 9.17 MeV $J^P = 2^+$ state in ^{14}N. Limit on the branching fraction is valid if $\tau_{A^0} \lesssim 1. \times 10^{-11}$s for m_{A^0} = (1.1–1.7) MeV. This experiment constrains the iso-vector coupling of A^0 to hadrons. NODE=S029ANT;LINKAGE=U

[17] ANANEV 85 with IBR-2 pulsed reactor exclude standard A^0 at CL = 95% masses below 470 keV (Li^* decay) and below $2m_e$ for deuteron* decay. NODE=S029ANT;LINKAGE=S

[18] CAVAIGNAC 83 at Bugey reactor exclude axion at any $m_{^{97}Nb^* decay}$ and axion with m_{A^0} between 275 and 288 keV (deuteron* decay). NODE=S029ANT;LINKAGE=P

[19] ALEKSEEV 82 with IBR-2 pulsed reactor exclude standard A^0 at CL = 95% mass-ranges m_{A^0} <400 keV (Li^* decay) and 330 keV $< m_{A^0}$ <2.2 MeV. (deuteron* decay). NODE=S029ANT;LINKAGE=F

[20] LEHMANN 82 obtained $A^0 \to 2\gamma$ rate $< 6.2 \times 10^{-5}$/s (CL = 95%) excluding m_{A^0} between 100 and 1000 keV. NODE=S029ANT;LINKAGE=K

[21] ZEHNDER 82 used Gosgen 2.8GW light-water reactor to check A^0 production. No 2γ peak in Li^*, Nb^* decay (both single p transition) nor in n capture (combined with NODE=S029ANT;LINKAGE=M

previous Ba* negative result) rules out standard A^0. Set limit m_{A^0} <60 keV for any A^0.

[22] ZEHNDER 81 looked for $\mathrm{Ba}^* \to A^0\,\mathrm{Ba}$ transition with $A^0 \to 2\gamma$. Obtained 2γ coincidence rate $< 2.2 \times 10^{-5}$/s (CL = 95%) excluding m_{A^0} >160 keV (or 200 keV depending on Higgs mixing). However, see BARROSO 81. NODE=S029ANT;LINKAGE=E

[23] CALAPRICE 79 saw no axion emission from excited states of carbon. Sensitive to axion mass between 1 and 15 MeV. NODE=S029ANT;LINKAGE=A

A^0 (Axion) Limits from Its Electron Coupling

NODE=S029AXE

Limits are for $\tau(A^0 \to e^+e^-)$.

NODE=S029AXE
NODE=S029AXE

VALUE (s)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[1] ANDREEV	21	NA64	$eN \to eA^0N$ ($A^0 \to$ invisibles)
		[2] ANDREEV	21B	NA64	$eN \to eA^0N$ ($A^0 \to ee$)
none 4×10^{-16}–4.5×10^{-12}	90	[3] BROSS	91	BDMP	$eN \to eA^0N$ ($A^0 \to ee$)
		[4] GUO	90	BDMP	$eN \to eA^0N$ ($A^0 \to ee$)
		[5] BJORKEN	88	CALO	$A \to e^+e^-$ or 2γ
		[6] BLINOV	88	MD1	$ee \to eeA^0$ ($A^0 \to ee$)
none 1×10^{-14}–1×10^{-10}	90	[7] RIORDAN	87	BDMP	$eN \to eA^0N$ ($A^0 \to ee$)
none 1×10^{-14}–1×10^{-11}	90	[8] BROWN	86	BDMP	$eN \to eA^0N$ ($A^0 \to ee$)
none 6×10^{-14}–9×10^{-11}	95	[9] DAVIER	86	BDMP	$eN \to eA^0N$ ($A^0 \to ee$)
none 3×10^{-13}–1×10^{-7}	90	[10] KONAKA	86	BDMP	$eN \to eA^0N$ ($A^0 \to ee$)

[1] ANDREEV 21 look for invisible decays of axions coupled to electrons, and set limits on $g_{Aee} < 4.6 \times 10^{-6}$–$3.1 \times 10^{-3}$ for $m_{A^0} = 10^{-3}$–1 GeV. This limits the axion contribution to the electron $g-2$ to an order of magnitude less than the current experimental uncertainty. See their Figs. 3 and 4 for mass-dependent limits. NODE=S029AXE;LINKAGE=E

[2] ANDREEV 21B set limits on g_{Aee} in the range of 6.3×10^{-6}–1.6×10^{-3} for m_{A^0} = 2–17 MeV at 90% CL. This excludes $6.6 \times 10^{-5} < g_{Aee} < 1 \times 10^{-4}$ at m_{A^0} = 16.7 MeV corresponding to the ATOMKI anomaly. See their Fig. 2 for mass-dependent limits. NODE=S029AXE;LINKAGE=I

[3] The listed BROSS 91 limit is for m_{A^0} = 1.14 MeV. $B(A^0 \to e^+e^-) = 1$ assumed. Excluded domain in the τ_{A^0}–m_{A^0} plane extends up to $m_{A^0} \approx 7$ MeV (see Fig. 5). Combining with electron $g-2$ constraint, axions coupling only to e^+e^- ruled out for $m_{A^0} < 4.8$ MeV (90% CL). NODE=S029AXE;LINKAGE=G

[4] GUO 90 use the same apparatus as BROWN 86 and improve the previous limit in the shorter lifetime region. Combined with $g-2$ constraint, axions coupling only to e^+e^- are ruled out for $m_{A^0} < 2.7$ MeV (90% CL). NODE=S029AXE;LINKAGE=F

[5] BJORKEN 88 reports limits on axion parameters (f_A, m_A, τ_A) for $m_{A^0} < 200$ MeV from electron beam-dump experiment with production via Primakoff photoproduction, bremsstrahlung from electrons, and resonant annihilation of positrons on atomic electrons. NODE=S029AXE;LINKAGE=V

[6] BLINOV 88 assume zero spin, m = 1.8 MeV and lifetime < 5×10^{-12} s and find $\Gamma(A^0 \to \gamma\gamma)B(A^0 \to e^+e^-) < 2$ eV (CL=90%). NODE=S029AXE;LINKAGE=BL

[7] Assumes $A^0\gamma\gamma$ coupling is small and hence Primakoff production is small. Their figure 2 shows limits on axions for $m_{A^0} < 15$ MeV. NODE=S029AXE;LINKAGE=D

[8] Uses electrons in hadronic showers from an incident 800 GeV proton beam. Limits for $m_{A^0} < 15$ MeV are shown in their figure 3. NODE=S029AXE;LINKAGE=C

[9] m_{A^0} = 1.8 MeV assumed. The excluded domain in the $\tau_{A^0}-m_{A^0}$ plane extends up to $m_{A^0} \approx 14$ MeV, see their figure 4. NODE=S029AXE;LINKAGE=A

[10] The limits are obtained from their figure 3. Also given is the limit on the $A^0\gamma\gamma$–$A^0e^+e^-$ coupling plane by assuming Primakoff production. NODE=S029AXE;LINKAGE=B

Search for A^0 (Axion) Resonance in Bhabha Scattering

NODE=S029AEE

The limit is for $\Gamma(A^0)[B(A^0 \to e^+e^-)]^2$.

NODE=S029AEE
NODE=S029AEE

VALUE (10^{-3} eV)	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				

$<$ 1.3	97	[1] HALLIN	92	CNTR	m_{A^0} = 1.75–1.88 MeV	
none 0.0016–0.47	90	[2] HENDERSON	92C	CNTR	m_{A^0}= 1.5–1.86 MeV	
$<$ 2.0	90	[3] WU	92	CNTR	m_{A^0}= 1.56–1.86 MeV	
$<$ 0.013	95	TSERTOS	91	CNTR	m_{A^0} = 1.832 MeV	
none 0.19–3.3	95	[4] WIDMANN	91	CNTR	m_{A^0}= 1.78–1.92 MeV	
$<$ 5	97	BAUER	90	CNTR	m_{A^0} = 1.832 MeV	
none 0.09–1.5	95	[5] JUDGE	90	CNTR	m_{A^0} = 1.832 MeV, elastic	
$<$ 1.9	97	[6] TSERTOS	89	CNTR	m_{A^0} = 1.82 MeV	
$<$(10–40)	97	[6] TSERTOS	89	CNTR	m_{A^0} = 1.51–1.65 MeV	OCCUR=2
$<$(1–2.5)	97	[6] TSERTOS	89	CNTR	m_{A^0} = 1.80–1.86 MeV	OCCUR=3
$<$ 31	95	LORENZ	88	CNTR	m_{A^0} = 1.646 MeV	
$<$ 94	95	LORENZ	88	CNTR	m_{A^0} = 1.726 MeV	OCCUR=2
$<$ 23	95	LORENZ	88	CNTR	m_{A^0} = 1.782 MeV	OCCUR=3
$<$ 19	95	LORENZ	88	CNTR	m_{A^0} = 1.837 MeV	OCCUR=4
$<$ 3.8	97	[7] TSERTOS	88	CNTR	m_{A^0} = 1.832 MeV	
		[8] VANKLINKEN	88	CNTR		
		[9] MAIER	87	CNTR		
$<$2500	90	MILLS	87	CNTR	m_{A^0} = 1.8 MeV	
		[10] VONWIMMER...	87	CNTR		

[1] HALLIN 92 quote limits on lifetime, 8×10^{-14} – 5×10^{-13} sec depending on mass, assuming B($A^0 \rightarrow e^+ e^-$) = 100%. They say that TSERTOS 91 overstated their sensitivity by a factor of 3. NODE=S029AEE;LINKAGE=H

[2] HENDERSON 92C exclude axion with lifetime τ_{A^0}=1.4×10^{-12} – 4.0×10^{-10} s, assuming B($A^0 \rightarrow e^+ e^-$)=100%. HENDERSON 92C also exclude a vector boson with τ=1.4×10^{-12} – 6.0×10^{-10} s. NODE=S029AEE;LINKAGE=K

[3] WU 92 quote limits on lifetime $> 3.3 \times 10^{-13}$ s assuming B($A^0 \rightarrow e^+ e^-$)=100%. They say that TSERTOS 89 overestimate the limit by a factor of $\pi/2$. WU 92 also quote a bound for vector boson, $\tau > 8.2 \times 10^{-13}$ s. NODE=S029AEE;LINKAGE=J

[4] WIDMANN 91 bound applies exclusively to the case B($A^0 \rightarrow e^+ e^-$)=1, since the detection efficiency varies substantially as $\Gamma(A^0)_{\text{total}}$ changes. See their Fig. 6. NODE=S029AEE;LINKAGE=I

[5] JUDGE 90 excludes an elastic pseudoscalar $e^+ e^-$ resonance for 4.5×10^{-13} s $< \tau(A^0) <$ 7.5×10^{-12} s (95% CL) at m_{A^0} = 1.832 MeV. Comparable limits can be set for m_{A^0} = 1.776–1.856 MeV. NODE=S029AEE;LINKAGE=G

[6] See also TSERTOS 88B in references. NODE=S029AEE;LINKAGE=F

[7] The upper limit listed in TSERTOS 88 is too large by a factor of 4. See TSERTOS 88B, footnote 3. NODE=S029AEE;LINKAGE=E

[8] VANKLINKEN 88 looked for relatively long-lived resonance ($\tau = 10^{-10}$–10^{-12} s). The sensitivity is not sufficient to exclude such a narrow resonance. NODE=S029AEE;LINKAGE=D

[9] MAIER 87 obtained limits $R\Gamma \lesssim$ 60 eV (100 eV) at $m_{A^0} \simeq$ 1.64 MeV (1.83 MeV) for energy resolution $\Delta E_{\text{cm}} \simeq$ 3 keV, where R is the resonance cross section normalized to that of Bhabha scattering, and $\Gamma = \Gamma^2_{ee}/\Gamma_{\text{total}}$. For a discussion implying that $\Delta E_{\text{cm}} \simeq$ 10 keV, see TSERTOS 89. NODE=S029AEE;LINKAGE=A

[10] VONWIMMERSPERG 87 measured Bhabha scattering for E_{cm} = 1.37–1.86 MeV and found a possible peak at 1.73 with $\int \sigma dE_{\text{cm}} = 14.5 \pm 6.8$ keV·b. For a comment and a reply, see VANKLINKEN 88B and VONWIMMERSPERG 88. Also see CONNELL 88. NODE=S029AEE;LINKAGE=C

Search for A^0 (Axion) Resonance in $e^+ e^- \rightarrow \gamma\gamma$

NODE=S029AEG

The limit is for $\Gamma(A^0 \rightarrow e^+ e^-) \cdot \Gamma(A^0 \rightarrow \gamma\gamma)/\Gamma_{\text{total}}$ NODE=S029AEG

NODE=S029AEG

VALUE (10^{-3} eV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$<$ 0.18	95	VO	94	CNTR	m_{A^0}=1.1 MeV	
$<$ 1.5	95	VO	94	CNTR	m_{A^0}=1.4 MeV	OCCUR=2
$<$12	95	VO	94	CNTR	m_{A^0}=1.7 MeV	OCCUR=3
$<$ 6.6	95	[1] TRZASKA	91	CNTR	m_{A^0} = 1.8 MeV	
$<$ 4.4	95	WIDMANN	91	CNTR	m_{A^0}= 1.78–1.92 MeV	
		[2] FOX	89	CNTR		
$<$ 0.11	95	[3] MINOWA	89	CNTR	m_{A^0} = 1.062 MeV	
$<$33	97	CONNELL	88	CNTR	m_{A^0} = 1.580 MeV	
$<$42	97	CONNELL	88	CNTR	m_{A^0} = 1.642 MeV	OCCUR=2
$<$73	97	CONNELL	88	CNTR	m_{A^0} = 1.782 MeV	OCCUR=3
$<$79	97	CONNELL	88	CNTR	m_{A^0} = 1.832 MeV	OCCUR=4

[1] TRZASKA 91 also give limits in the range (6.6–30) $\times 10^{-3}$ eV (95%CL) for m_{A^0} = 1.6–2.0 MeV. NODE=S029AEG;LINKAGE=C

[2] FOX 89 measured positron annihilation with an electron in the source material into two photons and found no signal at 1.062 MeV ($< 9 \times 10^{-5}$ of two-photon annihilation at rest). NODE=S029AEG;LINKAGE=B

[3] Similar limits are obtained for m_{A^0} = 1.045–1.085 MeV. NODE=S029AEG;LINKAGE=A

Search for X^0 (Light Boson) Resonance in $e^+e^- \to \gamma\gamma\gamma$

NODE=S029XEG

The limit is for $\Gamma(X^0 \to e^+e^-)\cdot\Gamma(X^0 \to \gamma\gamma\gamma)/\Gamma_{total}$. C invariance forbids spin-0 X^0 coupling to both e^+e^- and $\gamma\gamma\gamma$. NODE=S029XEG

NODE=S029XEG

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE (10^{-3} eV)	CL%	DOCUMENT ID		TECN	COMMENT	
$<$ 0.2	95	[1] VO	94	CNTR	m_{X^0}=1.1–1.9 MeV	
$<$ 1.0	95	[2] VO	94	CNTR	m_{X^0}=1.1 MeV	OCCUR=2
$<$ 2.5	95	[2] VO	94	CNTR	m_{X^0}=1.4 MeV	OCCUR=3
$<$120	95	[2] VO	94	CNTR	m_{X^0}=1.7 MeV	OCCUR=4
$<$ 3.8	95	[3] SKALSEY	92	CNTR	m_{X^0}= 1.5 MeV	

[1] VO 94 looked for $X^0 \to \gamma\gamma\gamma$ decaying at rest. The precise limits depend on m_{X^0}. See Fig. 2(b) in paper. NODE=S029XEG;LINKAGE=B

[2] VO 94 looked for $X^0 \to \gamma\gamma\gamma$ decaying in flight. NODE=S029XEG;LINKAGE=C

[3] SKALSEY 92 also give limits 4.3 for m_{X^0} = 1.54 and 7.5 for 1.64 MeV. The spin of X^0 is assumed to be one. NODE=S029XEG;LINKAGE=A

Light Boson (X^0) Search in Nonresonant e^+e^- Annihilation at Rest

NODE=S029XGE

Limits are for the ratio of $n\gamma + X^0$ production relative to $\gamma\gamma$. NODE=S029XGE

NODE=S029XGE

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE (units 10^{-6})	CL%	DOCUMENT ID		TECN	COMMENT	
$<$ 4.2	90	[1] MITSUI	96	CNTR	γX^0	
$<$ 4	68	[2] SKALSEY	95	CNTR	γX^0	
$<$40	68	[3] SKALSEY	95	RVUE	γX^0	OCCUR=2
$<$ 0.18	90	[4] ADACHI	94	CNTR	$\gamma\gamma X^0$, $X^0 \to \gamma\gamma$	
$<$ 0.26	90	[5] ADACHI	94	CNTR	$\gamma\gamma X^0$, $X^0 \to \gamma\gamma$	OCCUR=2
$<$ 0.33	90	[6] ADACHI	94	CNTR	γX^0, $X^0 \to \gamma\gamma\gamma$	OCCUR=3

[1] MITSUI 96 looked for a monochromatic γ. The bound applies for a vector X^0 with C=-1 and m_{X^0} <200 keV. They derive an upper bound on eeX^0 coupling and hence on the branching ratio B(o-Ps $\to \gamma\gamma X^0$)$< 6.2 \times 10^{-6}$. The bounds weaken for heavier X^0. NODE=S029XGE;LINKAGE=F

[2] SKALSEY 95 looked for a monochromatic γ without an accompanying γ in e^+e^- annihilation. The bound applies for scalar and vector X^0 with $C = -1$ and m_{X^0} = 100–1000 keV. NODE=S029XGE;LINKAGE=A

[3] SKALSEY 95 reinterpreted the bound on γA^0 decay of o-Ps by ASAI 91 where 3% of delayed annihilations are not from $^3S_1$ states. The bound applies for scalar and vector X^0 with $C = -1$ and m_{X^0} = 0–800 keV. NODE=S029XGE;LINKAGE=B

[4] ADACHI 94 looked for a peak in the $\gamma\gamma$ invariant mass distribution in $\gamma\gamma\gamma\gamma$ production from e^+e^- annihilation. The bound applies for m_{X^0} = 70–800 keV. NODE=S029XGE;LINKAGE=C

[5] ADACHI 94 looked for a peak in the missing-mass mass distribution in $\gamma\gamma$ channel, using $\gamma\gamma\gamma\gamma$ production from e^+e^- annihilation. The bound applies for m_{X^0} <800 keV. NODE=S029XGE;LINKAGE=D

[6] ADACHI 94 looked for a peak in the missing mass distribution in $\gamma\gamma\gamma$ channel, using $\gamma\gamma\gamma\gamma$ production from e^+e^- annihilation. The bound applies for m_{X^0} = 200–900 keV. NODE=S029XGE;LINKAGE=E

Searches for Goldstone Bosons (X^0)

NODE=S029GB

(Including Horizontal Bosons and Majorons.) Limits are for branching ratios. NODE=S029GB

NODE=S029GB

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
		[1] IVANEZ-BAL...	25	ASTR	Majoron, SN 1987A
$<0.2 \times 10^{-4}$	95	[2] UNO	25	BEL2	$\tau \to \mu X^0$, $\tau \to e X^0$
		[3] ADACHI	23A	BEL2	$\tau^- \to e^- X^0$, Familon

		[4] ADACHI	23A	BEL2	$\tau^- \to \mu^- X^0$, Familon	OCCUR=2
		[5] FIORILLO	23	ASTR	Majoron, SN 1987A	
		[6] SANDNER	23	COSM	Majoron, CMB	
		[7] COLOMA	22A	BORX	νe non-standard interactions	
$<4.3 \times 10^{-6}$	90	[8] AGUILAR-AR...	21A	PIEN	$\pi \to \mu \nu X^0$, Majoron	
$<5.2 \times 10^{-8}$	90	[9] AGUILAR-AR...	21A	PIEN	$\pi \to e \nu X^0$, Majoron	OCCUR=2
$<9 \times 10^{-6}$	90	[10] AGUILAR-AR...	20	PIEN	$\mu^+ \to e^+ X^0$, Familon	
$<7 \times 10^{-12}$	90	[11] BALDINI	20	MEG	$\mu^+ \to e^+ X^0$ ($X^0 \to \gamma\gamma$), Familon	
$<9 \times 10^{-6}$	90	[12] BAYES	15	TWST	$\mu^+ \to e^+ X^0$, Familon	
		[13] LATTANZI	13	COSM	Majoron dark matter decay	
		[14] LESSA	07	RVUE	Meson, ℓ decays to Majoron	
		[15] FARZAN	03	ASTR	Majoron, SN cooling	
		[16] DIAZ	98	THEO	$H^0 \to X^0 X^0$, $A^0 \to X^0 X^0 X^0$, Majoron	
		[17] BOBRAKOV	91		Electron quasi-magnetic interaction	
$<3.3 \times 10^{-2}$	95	[18] ALBRECHT	90E	ARG	$\tau \to \mu X^0$. Familon	
$<1.8 \times 10^{-2}$	95	[18] ALBRECHT	90E	ARG	$\tau \to e X^0$. Familon	OCCUR=2
$<6.4 \times 10^{-9}$	90	[19] ATIYA	90	B787	$K^+ \to \pi^+ X^0$. Familon	
$<1.4 \times 10^{-5}$	90	[20] BALKE	88	CNTR	$\mu^+ \to e^+ X^0$. Familon	
$<1.1 \times 10^{-9}$	90	[21] BOLTON	88	CBOX	$\mu^+ \to e^+ \gamma X^0$. Familon	
		[22] CHANDA	88	ASTR	Sun, Majoron	
		[23] CHOI	88	ASTR	Majoron, SN 1987A	
$<5 \times 10^{-6}$	90	[24] PICCIOTTO	88	CNTR	$\pi \to e \nu X^0$, Majoron	
$<1.3 \times 10^{-9}$	90	[25] GOLDMAN	87	CNTR	$\mu \to e \gamma X^0$. Familon	
$<3 \times 10^{-4}$	90	[26] BRYMAN	86B	RVUE	$\mu \to e X^0$. Familon	
$<1 \times 10^{-10}$	90	[27] EICHLER	86	SPEC	$\mu^+ \to e^+ X^0$. Familon	
$<2.6 \times 10^{-6}$	90	[28] JODIDIO	86	SPEC	$\mu^+ \to e^+ X^0$. Familon	
		[29] BALTRUSAIT...	85	MRK3	$\tau \to \ell X^0$. Familon	
		[30] DICUS	83	COSM	$\nu(\text{hvy}) \to \nu(\text{light}) X^0$	

[1] IVANEZ-BALLESTEROS 25 set new bounds on majorons coupled to neutrinos using the 24 neutrino events from SN 1987A, based on a three-neutrino likelihood analysis including nonradiative neutrino decay in matter and the resulting distortion of the neutrino energy spectrum. See their Figs. 1–3 for bounds on the majoron-neutrino coupling as a function of the lightest neutrino mass. NODE=S029GB;LINKAGE=Y

[2] UNO 25 search for the production of a 0–1.6 GeV mass spin-0 particle in lepton-flavour violating tau decays at Belle II. See Fig. 4 for mass-dependent limits on the branching ratio of tau decays to X^0 and electrons or muons. NODE=S029GB;LINKAGE=X

[3] ADACHI 23A set limits in the range of 1.1×10^{-3}–9.7×10^{-3} for $0 < m_{X^0} < 1.6$ GeV on $B(\tau^- \to e^- X^0)/B(\tau^- \to e^- \overline{\nu}_e \nu_\tau)$. See their Fig. 2 for mass-dependent limits. NODE=S029GB;LINKAGE=U

[4] ADACHI 23A set limits in the range of 7×10^{-4}–1.22×10^{-2} for $0 < m_{X^0} < 1.6$ GeV on $B(\tau^- \to \mu^- X^0)/B(\tau^- \to \mu^- \overline{\nu}_\mu \nu_\tau)$. See their Fig. 2 for mass-dependent limits. NODE=S029GB;LINKAGE=V

[5] FIORILLO 23 used data from Kamiokande-II and IMB on the neutrino flux from SN1987A to constrain the universal neutrino Majoron Yukawa coupling, g. They set an upper limit of $g\, m_{X^0} \lesssim 10^{-9}$ MeV for Majoron masses 100 eV $\lesssim m_{X^0} \lesssim$ 100 MeV, using neutrino coalescence as production of Majorons which then decay back to neutrinos. See their Fig. 1 for the mass-dependent limits. NODE=S029GB;LINKAGE=R

[6] SANDNER 23 study Majoron production via neutrino inverse decay and use Planck data to constrain the neutrino Majoron Yukawa coupling to $g \lesssim 2 \times 10^{-13}$–$1 \times 10^{-12}$ for Majoron masses m_{X^0} = 1–10 eV. See their Fig. 1 for mass-dependent limits. NODE=S029GB;LINKAGE=S

[7] COLOMA 22A used the spectral data of Borexino Phase II to constrain the neutrino non-standard interaction with electrons mediated by a scalar or a pseudoscalar. Limits on the universal coupling to neutrinos and electrons between 2×10^{-6} and 10^{-4} are obtained for $m_{X^0} \lesssim$ 30–40 MeV. See their Fig. 6 for mass-dependent limits. NODE=S029GB;LINKAGE=Q

[8] AGUILAR-AREVALO 21A quoted limit applies to m_{X^0} = 33.9 MeV. Limits between 4.3×10^{-6} and 7.5×10^{-5} are obtained for $0 < m_{X^0} < 33.9$ MeV. The lifetime of X^0 is assumed to be long enough. See their Fig. 6 for mass-dependent limits. NODE=S029GB;LINKAGE=O

[9] AGUILAR-AREVALO 21A quoted limit applies to m_{X^0} = 85 MeV. Limits between 5.2×10^{-8} and 1.4×10^{-6} are obtained for $0 < m_{X^0} < 120$ MeV, which improve the limits of PICCIOTTO 88 by an order of magnitude. The lifetime of X^0 is assumed to be long enough. See their Fig. 4 for mass-dependent limits. NODE=S029GB;LINKAGE=P

[10] AGUILAR-AREVALO 20 obtained limits of order 10^{-5} for m_{X^0} = 47.8–95.1 MeV. The quoted limit applies to m_{X^0} = 75 MeV. See their Fig. 1 for mass-dependent limits. NODE=S029GB;LINKAGE=M

[11] BALDINI 20 obtained limits for m_{X^0} = 20–45 MeV and $\tau_{X^0} < 40$ ps, and supersedes BOLTON 88 for m_{X^0} = 20–40 MeV. See their Fig. 17 for mass-dependent limits. NODE=S029GB;LINKAGE=N

[12] BAYES 15 limits are the average over m_{X^0} = 13–80 MeV for the isotropic decay distribution of positrons. See their Fig. 4 and Table II for the mass-dependent limits as well as the dependence on the decay anisotropy. In particular, they find a limit $< 58 \times 10^{-6}$ at 90% CL for massless familons and for the same asymmetry as normal muon decay, a case not covered by JODIDIO 86. NODE=S029GB;LINKAGE=K

[13] LATTANZI 13 use WMAP 9 year data as well as X-ray and γ-ray observations to derive limits on decaying majoron dark matter. A limit on the decay width $\Gamma(X^0 \to \nu\overline{\nu})$ $< 6.4 \times 10^{-19}$ s^{-1} at 95% CL is found if majorons make up all of the dark matter. NODE=S029GB;LINKAGE=B

[14] LESSA 07 consider decays of the form Meson $\to \ell\nu$ Majoron and $\ell \to \ell'\nu\overline{\nu}$ Majoron and use existing data to derive limits on the neutrino-Majoron Yukawa couplings $g_{\alpha\beta}$ (α,β=e,μ,τ). Their best limits are $|g_{e\alpha}|^2 < 5.5 \times 10^{-6}$, $|g_{\mu\alpha}|^2 < 4.5 \times 10^{-5}$, $|g_{\tau\alpha}|^2 < 5.5 \times 10^{-2}$ at CL = 90%. NODE=S029GB;LINKAGE=LE

[15] FARZAN 03 set limits on the neutrino Majoron Yukawa coupling, $|g_{ee}| < 4 \times 10^{-7}$, by considering the SN cooling due to the massless Majoron emission via neutrino coalescence. They also exclude values around 10^{-5} for both $g_{e\mu}$ and $g_{\mu\mu}$ using the process $\nu\nu \to X^0 X^0$. See also their Figs. 3 and 4 for mass-dependent limits. NODE=S029GB;LINKAGE=W

[16] DIAZ 98 studied models of spontaneously broken lepton number with both singlet and triplet Higgses. They obtain limits on the parameter space from invisible decay $Z \to H^0 A^0 \to X^0 X^0 X^0 X^0 X^0$ and $e^+ e^- \to Z H^0$ with $H^0 \to X^0 X^0$. NODE=S029GB;LINKAGE=J

[17] BOBRAKOV 91 searched for anomalous magnetic interactions between polarized electrons expected from the exchange of a massless pseudoscalar boson (arion). A limit $x_e^2 < 2 \times 10^{-4}$ (95%CL) is found for the effective anomalous magneton parametrized as $x_e(G_F/8\pi\sqrt{2})^{1/2}$. NODE=S029GB;LINKAGE=A2

[18] ALBRECHT 90E limits are for $B(\tau \to \ell X^0)/B(\tau \to \ell\nu\overline{\nu})$. Valid for $m_{X^0} < 100$ MeV. The limits rise to 7.1% (for μ), 5.0% (for e) for m_{X^0} = 500 MeV. NODE=S029GB;LINKAGE=I

[19] ATIYA 90 limit is for $m_{X^0} = 0$. The limit B $< 1 \times 10^{-8}$ holds for $m_{X^0} < 95$ MeV. For the reduction of the limit due to finite lifetime of X^0, see their Fig. 3. NODE=S029GB;LINKAGE=H

[20] BALKE 88 limits are for $B(\mu^+ \to e^+ X^0)$. Valid for $m_{X^0} < 80$ MeV and $\tau_{X^0} > 10^{-8}$ sec. NODE=S029GB;LINKAGE=L

[21] BOLTON 88 limit corresponds to $F > 3.1 \times 10^9$ GeV, which does not depend on the chirality property of the coupling. NODE=S029GB;LINKAGE=G

[22] CHANDA 88 find $v_T < 10$ MeV for the weak-triplet Higgs vacuum expectation value in Gelmini-Roncadelli model, and $v_S > 5.8 \times 10^6$ GeV in the singlet Majoron model. NODE=S029GB;LINKAGE=Z

[23] CHOI 88 used the observed neutrino flux from the supernova SN 1987A to exclude the neutrino Majoron Yukawa coupling h in the range $2 \times 10^{-5} < h < 3 \times 10^{-4}$ for the interaction $L_{\text{int}} = \frac{1}{2} ih\overline{\psi}^c_\nu \gamma_5 \psi_\nu \phi_X$. For several families of neutrinos, the limit applies for $(\Sigma h_i^4)^{1/4}$. NODE=S029GB;LINKAGE=E

[24] PICCIOTTO 88 limit applies when $m_{X^0} < 55$ MeV and $\tau_{X^0} > 2$ns, and it decreases to 4×10^{-7} at m_{X^0} = 125 MeV, beyond which no limit is obtained. NODE=S029GB;LINKAGE=F

[25] GOLDMAN 87 limit corresponds to $F > 2.9 \times 10^9$ GeV for the family symmetry breaking scale from the Lagrangian $L_{\text{int}} = (1/F)\overline{\psi}_\mu \gamma^\mu\ (a + b\gamma_5)\ \psi_e \partial_\mu \phi_{X^0}$ with $a^2 + b^2 = 1$. This is not as sensitive as the limit $F > 9.9 \times 10^9$ GeV derived from the search for $\mu^+ \to e^+ X^0$ by JODIDIO 86, but does not depend on the chirality property of the coupling. NODE=S029GB;LINKAGE=A

[26] Limits are for $\Gamma(\mu \to e X^0)/\Gamma(\mu \to e\nu\overline{\nu})$. Valid when m_{X^0} = 0–93.4, 98.1–103.5 MeV. NODE=S029GB;LINKAGE=B1

[27] EICHLER 86 looked for $\mu^+ \to e^+ X^0$ followed by $X^0 \to e^+ e^-$. Limits on the branching fraction depend on the mass and and lifetime of X^0. The quoted limits are valid when $\tau_{X^0} \lesssim 3. \times 10^{-10}$ s if the decays are kinematically allowed. NODE=S029GB;LINKAGE=T

[28] JODIDIO 86 corresponds to $F > 9.9 \times 10^9$ GeV for the family symmetry breaking scale with the parity-conserving effective Lagrangian $L_{\text{int}} = (1/F)\ \overline{\psi}_\mu \gamma^\mu \psi_e \partial^\mu \phi_{X^0}$. NODE=S029GB;LINKAGE=D

[29] BALTRUSAITIS 85 search for light Goldstone boson(X^0) of broken U(1). CL = 95% limits are $B(\tau \to \mu^+ X^0)/B(\tau \to \mu^+ \nu\nu) < 0.125$ and $B(\tau \to e^+ X^0)/B(\tau \to e^+ \nu\nu)$ <0.04. Inferred limit for the symmetry breaking scale is $m >$3000 TeV. NODE=S029GB;LINKAGE=C

[30] The primordial heavy neutrino must decay into ν and familon, f_A, early so that the red-shifted decay products are below critical density, see their table. In addition, $K \to \pi f_A$ and $\mu \to e f_A$ are unseen. Combining these excludes $m_{\text{heavy}\nu}$ between 5×10^{-5} and 5×10^{-4} MeV (μ decay) and $m_{\text{heavy}\nu}$ between 5×10^{-5} and 0.1 MeV (K-decay). NODE=S029GB;LINKAGE=A1

Majoron Searches in Neutrinoless Double β Decay

NODE=S029MT

Limits are for the half-life of neutrinoless $\beta\beta$ decay with a Majoron emission. NODE=S029MT

No experiment currently claims any such evidence. Only the best or comparable limits for each isotope are reported.

NODE=S029MT

$t_{1/2}(10^{21}$ yr)	CL%	ISOTOPE	TRANSITION	METHOD	DOCUMENT ID
>7200	**90**	**^{128}Te**		**CNTR**	[1] BERNATOW... 92

• • • We do not use the following data for averages, fits, limits, etc. • • •

> 16–24	90	^{100}Mo	$0\nu1\chi$	CUPID-Mo	[2] AUGIER	24	
> 120	90	^{82}Se	$0\nu1\chi$	CUPID-0	[3] AZZOLINI	23	
> 640	90	^{76}Ge	$0\nu1\chi$	GERDA	[4] AGOSTINI	22	
>4300	90	^{136}Xe	$0\nu1\chi$	EXO-200	[5] AL-KHARUSI	21	
> 4.4	90	^{100}Mo	$0\nu1\chi$	NEMO-3	[6] ARNOLD	19	
> 37	90	^{82}Se	$0\nu1\chi$	NEMO-3	[7] ARNOLD	18	OCCUR=2
> 420	90	^{76}Ge	$0\nu1\chi$	GERDA	[8] AGOSTINI	15A	
> 400	90	^{100}Mo	$0\nu1\chi$	NEMO-3	[9] ARNOLD	15	
>1200	90	^{136}Xe	$0\nu1\chi$	EXO-200	[10] ALBERT	14A	OCCUR=2
>2600	90	^{136}Xe	$0\nu1\chi$	KamLAND-Zen	[11] GANDO	12	
> 16	90	^{130}Te	$0\nu1\chi$	NEMO-3	[12] ARNOLD	11	
> 1.9	90	^{96}Zr	$2\nu1\chi$	NEMO-3	[13] ARGYRIADES	10	
> 1.52	90	^{150}Nd	$0\nu1\chi$	NEMO-3	[14] ARGYRIADES	09	
> 27	90	^{100}Mo	$0\nu1\chi$	NEMO-3	[15] ARNOLD	06	
> 15	90	^{82}Se	$0\nu1\chi$	NEMO-3	[16] ARNOLD	06	OCCUR=2
> 14	90	^{100}Mo	$0\nu1\chi$	NEMO-3	[17] ARNOLD	04	
> 12	90	^{82}Se	$0\nu1\chi$	NEMO-3	[18] ARNOLD	04	OCCUR=2
> 2.2	90	^{130}Te	$0\nu1\chi$	Cryog. det.	[19] ARNABOLDI	03	
> 0.9	90	^{130}Te	$0\nu2\chi$	Cryog. det.	[20] ARNABOLDI	03	OCCUR=2
> 8	90	^{116}Cd	$0\nu1\chi$	$CdWO_4$ scint.	[21] DANEVICH	03	
> 0.8	90	^{116}Cd	$0\nu2\chi$	$CdWO_4$ scint.	[22] DANEVICH	03	OCCUR=2
> 500	90	^{136}Xe	$0\nu1\chi$	Liquid Xe Scint.	[23] BERNABEI	02D	
> 5.8	90	^{100}Mo	$0\nu1\chi$	ELEGANT V	[24] FUSHIMI	02	
> 0.32	90	^{100}Mo	$0\nu1\chi$	Liq. Ar ioniz.	[25] ASHITKOV	01	
> 0.0035	90	^{160}Gd	$0\nu1\chi$	$^{160}Gd_2SiO_5$:Ce	[26] DANEVICH	01	
> 0.013	90	^{160}Gd	$0\nu2\chi$	$^{160}Gd_2SiO_5$:Ce	[27] DANEVICH	01	OCCUR=2
> 2.3	90	^{82}Se	$0\nu1\chi$	NEMO 2	[28] ARNOLD	00	
> 0.31	90	^{96}Zr	$0\nu1\chi$	NEMO 2	[29] ARNOLD	00	OCCUR=2
> 0.63	90	^{82}Se	$0\nu2\chi$	NEMO 2	[30] ARNOLD	00	OCCUR=5
> 0.063	90	^{96}Zr	$0\nu2\chi$	NEMO 2	[30] ARNOLD	00	OCCUR=6
> 0.16	90	^{100}Mo	$0\nu2\chi$	NEMO 2	[30] ARNOLD	00	OCCUR=7
> 2.4	90	^{82}Se	$0\nu1\chi$	NEMO 2	[31] ARNOLD	98	
> 7.2	90	^{136}Xe	$0\nu2\chi$	TPC	[32] LUESCHER	98	
> 7.91	90	^{76}Ge		SPEC	[33] GUENTHER	96	
> 17	90	^{76}Ge		CNTR	BECK	93	

[1] BERNATOWICZ 92 studied double-β decays of ^{128}Te and ^{130}Te, and found the ratio $\tau(^{130}\text{Te})/\tau(^{128}\text{Te}) = (3.52 \pm 0.11) \times 10^{-4}$ in agreement with relatively stable theoretical predictions. The bound is based on the requirement that Majoron-emitting decay cannot be larger than the observed double-beta rate of ^{128}Te of $(7.7 \pm 0.4) \times 10^{24}$ year. We calculated 90% CL limit as $(7.7–1.28 \times 0.4=7.2) \times 10^{24}$. NODE=S029MT;LINKAGE=A

[2] AUGIER 24 make use of 1.47 kg·yr of ^{100}Mo exposure of the CUPID-Mo scintillating cryogenic calorimeter, operated at the Laboratoire Souterrain de Modane to place a range of limits on the single Majoron mode of the $0\nu\beta\beta$ decay of ^{100}Mo. The range is due to the use of two different analysis strategies. Various limits on modes involving the emission of multiple Majorons are given too. The derived range of constraints on the Majoron-neutrino coupling constant is $g_{\nu\chi} < 4.0–8.5 \times 10^{-5}$, reflecting the variability of the used nuclear matrix elements and of the two data analysis strategies. NODE=S029MT;LINKAGE=M

[3] AZZOLINI 23 use 9.95 kg·yr of data, collected by the CUPID-0 experiment, to place a limit on the single Majoron mode of the $0\nu\beta\beta$ decay of ^{82}Se. Various limits on modes involving the emission of multiple Majorons are given too. The resulting constraint on the Majoron-neutrino coupling constant is $g_{\nu\chi} < 1.8–4.4 \times 10^{-5}$. The range is due to the variability of the used nuclear matrix elements. NODE=S029MT;LINKAGE=L

[4] AGOSTINI 22 use 32.8 kg·yr of GERDA phase 2 data to derive a limit of $g_{\nu\chi} < 1.8–4.4 \times 10^{-5}$ on the neutrino-Majoron coupling. The range reflects the author's evaluation of the spread of nuclear matrix elements. NODE=S029MT;LINKAGE=K

[5] AL-KHARUSI 21 utilize the complete dataset of the EXO-200 experiment, corresponding to an exposure of 234 kg yr, to place a limit on the one Majoron mode of the neutrinoless double beta decay of ^{136}Xe. Several limits are reported, the one given here corresponds to a spectral index of 1, resulting in a limit of $g_{\nu\chi} < 0.4–0.9 \times 10^{-5}$ on the Majoron-neutrino coupling constant. The range reflects the spread of the nuclear matrix elements. NODE=S029MT;LINKAGE=J

[6] ARNOLD 19 uses the NEMO-3 tracking calorimeter to determine limits for the Majoron emitting double beta decay, with spectral index n = 3. The limit corresponds to the range of the g_{ee} coupling of 0.013–0.035; dependimg on the nuclear matrix elements used. NODE=S029MT;LINKAGE=I

[7] ARNOLD 18 use the NEMO-3 tracking detector. The limit corresponds to $\langle g_{ee} \rangle < 3.2–8.0 \times 10^{-5}$; the range corresponds to different nuclear matrix element calculations. NODE=S029MT;LINKAGE=H

[8] AGOSTINI 15A analyze a 20.3 kg yr of data set of the GERDA calorimeter to determine $g_{\nu\chi} <$ 3.4–8.7 $\times 10^{-5}$ on the Majoron-neutrino coupling constant. The range reflects the spread of the nuclear matrix elements. NODE=S029MT;LINKAGE=E

[9] ARNOLD 15 use the NEMO-3 tracking calorimeter with 3.43 kg yr exposure to determine the limit on Majoron emission. The limit corresponds to $g_{\nu\chi} <$ 1.6–3.0 $\times 10^{-4}$. The spread reflects different nuclear matrix elements. Supersedes ARNOLD 06. NODE=S029MT;LINKAGE=F

[10] ALBERT 14A utilize 100 kg yr of exposure of the EXO-200 tracking calorimeter to place a limit on the $g_{\nu\chi} <$ 0.8–1.7 $\times 10^{-5}$ on the Majoron-neutrino coupling constant. The range reflects the spread of the nuclear matrix elements. NODE=S029MT;LINKAGE=D

[11] GANDO 12 use the KamLAND-Zen detector to obtain the limit on the $0\nu\chi$ decay with Majoron emission. It implies that the coupling constant $g_{\nu\chi} <$ 0.8–1.6 $\times 10^{-5}$ depending on the nuclear matrix elements used. NODE=S029MT;LINKAGE=GA

[12] ARNOLD 11 use the NEMO-3 detector to obtain the reported limit on Majoron emission. It implies that the coupling constant $g_{\nu\chi} <$ 0.6–1.6 $\times 10^{-4}$ depending on the nuclear matrix element used. Supercedes ARNABOLDI 03. NODE=S029MT;LINKAGE=AD

[13] ARGYRIADES 10 use the NEMO-3 tracking detector and ^{96}Zr to derive the reported limit. No limit for the Majoron electron coupling is given. NODE=S029MT;LINKAGE=RG

[14] ARGYRIADES 09 use ^{150}Nd data taken with the NEMO-3 tracking detector. The reported limit corresponds to $\langle g_{\nu\chi}\rangle <$ 1.7–3.0 $\times 10^{-4}$ using a range of nuclear matrix elements that include the effect of nuclear deformation. NODE=S029MT;LINKAGE=AG

[15] ARNOLD 06 use ^{100}Mo data taken with the NEMO-3 tracking detector. The reported limit corresponds to $\langle g_{\nu\chi}\rangle < (0.4–1.8) \times 10^{-4}$ using a range of matrix element calculations. Superseded by ARNOLD 15. NODE=S029MT;LINKAGE=AM

[16] NEMO-3 tracking calorimeter is used in ARNOLD 06 . Reported half-life limit for ^{82}Se corresponds to $\langle g_{\nu\chi}\rangle < (0.66–1.9)\times 10^{-4}$ using a range of matrix element calculations. Supersedes ARNOLD 04. NODE=S029MT;LINKAGE=AS

[17] ARNOLD 04 use the NEMO-3 tracking detector. The limit corresponds to $\langle g_{\nu\chi}\rangle <$ (0.5–0.9)10^{-4} using the matrix elements of SIMKOVIC 99, STOICA 01 and CIVITARESE 03. Superseded by ARNOLD 06. NODE=S029MT;LINKAGE=A1

[18] ARNOLD 04 use the NEMO-3 tracking detector. The limit corresponds to $\langle g_{\nu\chi}\rangle <$ (0.7–1.6)10^{-4} using the matrix elements of SIMKOVIC 99, STOICA 01 and CIVITARESE 03. NODE=S029MT;LINKAGE=A2

[19] Supersedes ALESSANDRELLO 00. Array of TeO_2 crystals in high resolution cryogenic calorimeter. Some enriched in ^{130}Te. Derive $\langle g_{\nu\chi}\rangle <$ 17–33 $\times 10^{-5}$ depending on matrix element. NODE=S029MT;LINKAGE=RO

[20] Supersedes ALESSANDRELLO 00. Cryogenic calorimeter search. NODE=S029MT;LINKAGE=RP

[21] Limit for the $0\nu\chi$ decay with Majoron emission of ^{116}Cd using enriched $CdWO_4$ scintillators. $\langle g_{\nu\chi}\rangle <$ 4.6–8.1 $\times 10^{-5}$ depending on the matrix element. Supersedes DANEVICH 00. NODE=S029MT;LINKAGE=VI

[22] Limit for the $0\nu2\chi$ decay of ^{116}Cd. Supersedes DANEVICH 00. NODE=S029MT;LINKAGE=VJ

[23] BERNABEI 02D obtain limit for $0\nu\chi$ decay with Majoron emission of ^{136}Xe using liquid Xe scintillation detector. They derive $\langle g_{\nu\chi}\rangle <$ 2.0–3.0 $\times 10^{-5}$ with several nuclear matrix elements. NODE=S029MT;LINKAGE=D5

[24] Replaces TANAKA 93. FUSHIMI 02 derive half-life limit for the $0\nu\chi$ decay by means of tracking calorimeter ELEGANT V. Considering various matrix element calculations, a range of limits for the Majoron-neutrino coupling is given: $\langle g_{\nu\chi}\rangle <$(6.3–360) $\times 10^{-5}$. NODE=S029MT;LINKAGE=FM

[25] ASHITKOV 01 result for $0\nu\chi$ of ^{100}Mo is less stringent than ARNOLD 00. NODE=S029MT;LINKAGE=SH

[26] DANEVICH 01 obtain limit for the $0\nu\chi$ decay with Majoron emission of ^{160}Gd using Gd_2SiO_5:Ce crystal scintillators. NODE=S029MT;LINKAGE=TH

[27] DANEVICH 01 obtain limit for the $0\nu2\chi$ decay with 2 Majoron emission of ^{160}Gd. NODE=S029MT;LINKAGE=TI

[28] ARNOLD 00 reports limit for the $0\nu\chi$ decay with Majoron emission derived from tracking calorimeter NEMO 2. Using ^{82}Se source: $\langle g_{\nu\chi}\rangle < 1.6 \times 10^{-4}$. Matrix element from GUENTHER 96. NODE=S029MT;LINKAGE=K1

[29] Using ^{96}Zr source: $\langle g_{\nu\chi}\rangle < 2.6 \times 10^{-4}$. Matrix element from ARNOLD 99. NODE=S029MT;LINKAGE=K2

[30] ARNOLD 00 reports limit for the $0\nu2\chi$ decay with two Majoron emission derived from tracking calorimeter NEMO 2. NODE=S029MT;LINKAGE=K5

[31] ARNOLD 98 determine the limit for $0\nu_\chi$ decay with Majoron emission of ^{82}Se using the NEMO-2 tracking detector. They derive $\langle g_{\nu_\chi}\rangle <$ 2.3–4.3 $\times 10^{-4}$ with several nuclear matrix elements. NODE=S029MT;LINKAGE=RN

[32] LUESCHER 98 report a limit for the 0ν decay with Majoron emission of ^{136}Xe using Xe TPC. This result is more stringent than BARABASH 89. Using the matrix elements of ENGEL 88, they obtain a limit on $\langle g_{\nu\chi}\rangle$ of 2.0×10^{-4}. NODE=S029MT;LINKAGE=LT

[33] See Table 1 in GUENTHER 96 for limits on the Majoron coupling in different models. NODE=S029MT;LINKAGE=C

Invisible A^0 (Axion) MASS LIMITS from Astrophysics and Cosmology

NODE=S029IAA

$v_1 = v_2$ is usually assumed (v_i = vacuum expectation values). For a review of these limits, see RAFFELT 91 and TURNER 90. In the comment lines below, D and K refer to DFSZ and KSVZ axion types, discussed in the above minireview.

NODE=S029IAA

NODE=S029IAA

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
none 0.55–1.5 $\times 10^{-13}$, 2–5 $\times 10^{-13}$	90	[1] ASWATHI	25	ASTR	BH superradiance
$> 2.2 \times 10^{-21}$	95	[2] ZIMMER...	25	ASTR	Ultralight dark matter
< 0.16	95	[3] BIANCHINI	24	COSM	Hot dark matter
		[4] CHENG	23	ASTR	BH superradiance
$> 3.2 \times 10^{-19}$	95	[5] DELLA-MON...	23	ASTR	Ultralight DM soliton halo core
<141	90	[6] DERBIN	23	CNTR	K, solar axions
< 0.24	95	[7] NOTARI	23	COSM	K, Hot dark matter
		[8] ROGERS	23	COSM	Ultra-light axion DM
none 10^{-24}–5×10^{-23}	95	[9] SMARRA	23	EPTA	Ultralight DM mass limit
		[10] XIA	23	ASTR	Fuzzy DM
		[11] LAGUE	22	COSM	Ultralight axion DM
none 0.15–1.5 $\times 10^{-12}$	95	[12] YUAN	22A	ASTR	BH superradiance
$> 1.4 \times 10^{-21}$	95	[13] BANIK	21	ASTR	Fuzzy DM
$< 1.9 \times 10^{4}$		[14] BAUMHOLZ...	21	COSM	warm dark matter
		[15] CROON	21	ASTR	SN 1987A, axion-muon coupling
		[16] FUJIKURA	21	ASTR	Microlensing
		[17] MARTINCAM...	21	ASTR	SN 1987A, Λ decay
none 1.3–2.7 $\times 10^{-13}$		[18] NG	21	ASTR	BH superradiance
$> 2 \times 10^{-20}$	95	[19] ROGERS	21	COSM	Lyman-α
none 0.8–6.5 $\times 10^{-13}$	95	[20] TSUKADA	21	ASTR	BH superradiance
$> 2 \times 10^{-17}$		[21] IRSIC	20	COSM	Isocurvature fluctuations
		[22] PODDAR	20	ASTR	Compact binary systems
$> 2.1 \times 10^{-21}$		[23] SCHUTZ	20	COSM	Fuzzy DM
none 6.4–8.0 $\times 10^{-13}$	95	[24] SUN	20	ASTR	BH superradiance
none 2.9–4.6 $\times 10^{-21}$		[25] DAVOUDIASL	19	ASTR	BH superradiance
none 10^{-21}–6×10^{-20}		[26] MARSH	19	ASTR	Fuzzy DM
none 1.1–4 $\times 10^{-13}$	95	[27] PALOMBA	19	ASTR	BH superradiance
< 0.06		[28] CHANG	18	ASTR	K, SN 1987A
		[29] PORAYKO	18	PPTA	Fuzzy DM
< 0.67	95	[30] ARCHIDIACO...	13A	COSM	K, hot dark matter
none 0.7–3 $\times 10^{5}$		[31] CADAMURO	11	COSM	D abundance
<105	90	[32] DERBIN	11A	CNTR	D, solar axion
		[33] ANDRIAMON...	10	CAST	K, solar axions
< 0.72	95	[34] HANNESTAD	10	COSM	K, hot dark matter
		[35] ANDRIAMON...	09	CAST	K, solar axions
<191	90	[36] DERBIN	09A	CNTR	K, solar axions
<334	95	[37] KEKEZ	09	HPGE	K, solar axions
< 1.02	95	[38] HANNESTAD	08	COSM	K, hot dark matter
< 1.2	95	[39] HANNESTAD	07	COSM	K, hot dark matter
< 0.42	95	[40] MELCHIORRI	07A	COSM	K, hot dark matter
< 1.05	95	[41] HANNESTAD	05A	COSM	K, hot dark matter
3 to 20		[42] MOROI	98	COSM	K, hot dark matter
< 0.007		[43] BORISOV	97	ASTR	D, neutron star
< 4		[44] KACHELRIESS	97	ASTR	D, neutron star cooling
$<(0.5–6) \times 10^{-3}$		[45] KEIL	97	ASTR	SN 1987A
< 0.018		[46] RAFFELT	95	ASTR	D, red giant
< 0.010		[47] ALTHERR	94	ASTR	D, red giants, white dwarfs
		[48] CHANG	93	ASTR	K, SN 1987A
< 0.01		WANG	92	ASTR	D, white dwarf
< 0.03		WANG	92C	ASTR	D, C-O burning
none 3–8		[49] BERSHADY	91	ASTR	D, K, intergalactic light
< 10		[50] KIM	91C	COSM	D, K, mass density of the universe, supersymmetry
		[51] RAFFELT	91B	ASTR	D,K, SN 1987A
$< 1 \times 10^{-3}$		[52] RESSELL	91	ASTR	K, intergalactic light
none 10^{-3}–3		BURROWS	90	ASTR	D,K, SN 1987A

OCCUR=2

	[53] ENGEL	90	ASTR	D,K, SN 1987A	
< 0.02	[54] RAFFELT	90D	ASTR	D, red giant	
$< 1 \times 10^{-3}$	[55] BURROWS	89	ASTR	D,K, SN 1987A	
$<(1.4\text{–}10) \times 10^{-3}$	[56] ERICSON	89	ASTR	D,K, SN 1987A	
$< 3.6 \times 10^{-4}$	[57] MAYLE	89	ASTR	D,K, SN 1987A	
< 12	CHANDA	88	ASTR	D, Sun	
$< 1 \times 10^{-3}$	RAFFELT	88	ASTR	D,K, SN 1987A	
	[58] RAFFELT	88B	ASTR	red giant	
< 0.07	FRIEMAN	87	ASTR	D, red giant	
< 0.7	[59] RAFFELT	87	ASTR	K, red giant	
$< 2\text{–}5$	TURNER	87	COSM	K, thermal production	
< 0.01	[60] DEARBORN	86	ASTR	D, red giant	
< 0.06	RAFFELT	86	ASTR	D, red giant	
< 0.7	[61] RAFFELT	86	ASTR	K, red giant	OCCUR=2
< 0.03	RAFFELT	86B	ASTR	D, white dwarf	
< 1	[62] KAPLAN	85	ASTR	K, red giant	
$< 0.003\text{–}0.02$	IWAMOTO	84	ASTR	D, K, neutron star	
$> 1 \times 10^{-5}$	ABBOTT	83	COSM	D,K, mass density of the universe	
$> 1 \times 10^{-5}$	DINE	83	COSM	D,K, mass density of the universe	
< 0.04	ELLIS	83B	ASTR	D, red giant	
$> 1 \times 10^{-5}$	PRESKILL	83	COSM	D,K, mass density of the universe	
< 0.1	BARROSO	82	ASTR	D, red giant	
< 1	[63] FUKUGITA	82	ASTR	D, stellar cooling	
< 0.07	FUKUGITA	82B	ASTR	D, red giant	

[1] ASWATHI 25 use LIGO-VIRGO-KAGRA data from the black hole binary merger events GW231123 and GW190517 to search for evidence of the superradiant build-up of a cloud of bosons, which could act to spin down the black holes. They rule out two windows of axion masses, and present limits in terms of the inverse energy scale for an attractive quartic scalar interaction in Fig. 2, e.g. the axion decay constant. The quoted limits are taken from Fig. 2 for the conservative spin-down timescale of 100,000 years. NODE=S029IAA;LINKAGE=FB

[2] ZIMMERMANN 25 place a lower bound on the mass an ultralight boson assumed to be all of the dark matter, by ensuring it is possible to have a dynamically self-consistent dark matter halo density profile for the observed Leo II dwarf spheroidal galaxy. NODE=S029IAA;LINKAGE=EB

[3] BIANCHINI 24 report a new limit on the axion mass, testing for the existence of a thermally produced hot dark matter population using current cosmic microwave background and baryon acoustic oscillation data. This analysis presents a stronger limit than previous bounds, e.g. NOTARI 23. NODE=S029IAA;LINKAGE=DB

[4] CHENG 23 employ an improved approximation of the boson cloud eigenfrequency to calculate the superradiance rate. They find that sensitivity depends on initial spin distribution and the merger timescale, and identify two preferred ranges for boson mass centered at 1.78×10^{-12} and 7.94×10^{-13} eV. NODE=S029IAA;LINKAGE=XA

[5] DELLA-MONICA 23 consider the solitonic core implied by ultralight scalar dark matter in the centre of the Milky Way and the effect its presence would have on the precisely tracked orbits of the stars orbiting our galaxy's central supermassive black hole, Sagittarius A*. NODE=S029IAA;LINKAGE=BB

[6] DERBIN 23 employ a thulium garnet crystal bolometer to search for the 8.4 keV solar axion line emitted from the M1 nuclear transition of thulium-169, ^{169}Tm. Mass bound applies to KSVZ axions, value for DFSZ is 244 eV. NODE=S029IAA;LINKAGE=CB

[7] NOTARI 23 improved the evaluation of axion production from pion scatterings by using pion-pion scattering data and incorporating the momentum dependence of the Boltzmann equation. The limit is based on the Planck 2018, BAO, and Pantheon SN Ia data. NODE=S029IAA;LINKAGE=UA

[8] ROGERS 23 use the CMB and BOSS galaxy-clustering data to set limits on the abundance of ultralight axion DM. They obtained $\Omega_{A^0} < 0.002$ for $m_{A^0} = 10^{-30}$–10^{-28} eV and set upper limits ranging from 0.002 to 0.07 for $m_{A^0} = 10^{-32}$–10^{-25} eV. See their Fig. 22 for mass-dependent limits. NODE=S029IAA;LINKAGE=YA

[9] SMARRA 23 is the European Pulsar Timing Array's constraint on the contribution of ultralight DM to the DM density in our local galactic neighbourhood. Ultralight DM cannot saturate the known DM density of 0.3 GeV/cc for masses inside this mass interval of 10^{-24}–5×10^{-23} eV. NODE=S029IAA;LINKAGE=ZA

[10] XIA 23 is analogous to PORAYKO 18 and use the Fermi-LAT pulsar timing array. They set a bound on the local density as $\rho_{A^0} \lesssim 8$ GeV/cm^3 for $m_{A^0} \lesssim 10^{-23}$ eV at 95% CL, with weaker constraints up to 10^{-22} eV. See their Fig. 1 for the mass-dependent limits. NODE=S029IAA;LINKAGE=WA

[11] LAGUE 22 used the BOSS galaxy-clustering data to set limits on the abundance of ultralight axion dark matter. When combined with the CMB data, they obtained $\Omega_{A^0} h^2 < 0.004$ for $m_{A^0} = 10^{-31}$–10^{-26} eV. See their Figs. 1 and 15 for mass-dependent limits. NODE=S029IAA;LINKAGE=SA

[12] YUAN 22A use the data of Advanced LIGO and Advanced Virgo's first three observing runs to search for stochastic GW background produced by scalar bosonic clouds formed by the BH superradiant instability. They set the limit, taking into account all the unstable modes. NODE=S029IAA;LINKAGE=TA

[13] BANIK 21 use the subhalo mass function inferred from the analyses of the GD-1 and Pal 5 stellar streams. The limit is strengthened to 2.2×10^{-21} eV when adding dwarf satellite counts. NODE=S029IAA;LINKAGE=QA

[14] BAUMHOLZER 21 study the freeze-in production of axion dark matter through couplings to photons, and set the limit using Lyman-α forest data and the observed number of Milky Way subhalos. NODE=S029IAA;LINKAGE=MA

[15] CROON 21 study the supernova cooling effect of the axion-muon coupling, taking account of semi-Compton scattering and muon-proton bremsstrahlung, as well as the loop-induced axion-photon coupling, and exclude the range of $g_{A\mu\mu} \simeq 7\times10^{-3}$–$2\times10^{-10}$ for $m_{A^0} < 0.5$ GeV. See their Fig. 8 for mass-dependent limits. NODE=S029IAA;LINKAGE=NA

[16] FUJIKURA 21 use the EROS-2 survey and the Subaru HSC observation to set limits on spherically symmetric axion clumps, taking account of the finite lens and source size effects. $f_{A^0} \gtrsim 10^{12}$ GeV can be constrained depending on the fraction of the axion dark matter collapsed into clumps, and the clump densities. See their Figs. 7–10 for the limits. NODE=S029IAA;LINKAGE=RA

[17] MARTINCAMALICH 21 considered axion emission from a supernova core through the Λ hyperon decay, and set the limit on B($\Lambda \rightarrow n A^0$) $\lesssim 8 \times 10^{-9}$, or equivalently, $f_{A^0}/C_{sd} \gtrsim 2.6 \times 10^9$ GeV in terms of the flavor-violating axion coupling to the down and strange quarks. NODE=S029IAA;LINKAGE=LA

[18] NG 21 use the binary black holes reported by LIGO and Virgo to determine the black hole spin distribution at formation and the scalar boson mass simultaneously, neglecting the boson self-interaction. NODE=S029IAA;LINKAGE=OA

[19] ROGERS 21 set the limit by using a framework involving Bayesian emulator optimization to accurately forward-model the Lyman-α flux power spectrum, and comparing this with small-scale data to constrain the predicted suppression of cosmic structure growth. NODE=S029IAA;LINKAGE=KA

[20] TSUKADA 21 look for a stochastic GW background produced by extragalactic BH-hidden photon cloud systems through the superradiant instability. They assume a uniform spin distribution at birth of isolated BHs from 0 to 1. NODE=S029IAA;LINKAGE=PA

[21] IRSIC 20 used the Lyman-α forest constraint on small-scale isocurvature perturbation to derive limits on the axion mass and decay constant, assuming that the axion makes up all dark matter in the post-inflationary scenario. See their Fig. 1 for other astrophysical limits as well as the limits on the case of the temperature-dependent axion mass. NODE=S029IAA;LINKAGE=DA

[22] PODDAR 20 used the observed decay in orbital period of four compact binary systems to derive a limit on the emission of axions with $m_{A^0} < 1 \times 10^{-19}$ eV, assuming they couple to nucleons and the strong *CP* phase vanishes at the potential minimum. They exclude $f_{A^0} \lesssim 10^{11}$ GeV for such axions. NODE=S029IAA;LINKAGE=EA

[23] SCHUTZ 20 set a limit on fuzzy dark matter based on the existing limits for warm dark matter derived from the inferred subhalo mass function. NODE=S029IAA;LINKAGE=FA

[24] SUN 20 look for quasimonochromatic gravitational waves emitted from boson clouds around the Cygnus X-1 black hole. The quoted limit assume the black hole age of 5×10^6 years. A mass range of 9.6–15.5×10^{-13} eV is disfavored when repeated induction of bosenova for string axions with decay constant $f_{A^0} \simeq 10^{15}$ GeV prevents the superradiance from being saturated. NODE=S029IAA;LINKAGE=BA

[25] DAVOUDIASL 19 used the observed data of M87* by the Event Horizon Telescope to set the limit. A mass range of 0.85–4.6×10^{-21} eV is disfavored for a spin-1 boson. NODE=S029IAA;LINKAGE=JA

[26] MARSH 19 considered heating of star clusters due to the stochastic oscillations of the core and granular quasiparticles in the outer halo. The limit was derived by requiring the survival of the old star cluster in Eridanus II, where the lower end is set by the validity of diffusion approximation. The effect of tidal stripping is also discussed for lower masses. NODE=S029IAA;LINKAGE=GA

[27] PALOMBA 19 used the LIGO O2 dataset to derive limits on nearly monochromatic gravitational waves emitted by boson clouds formed around a stellar-mass black hole. They exclude boson masses in a range of 1.1×10^{-13} and 4×10^{-13} eV for high initial black hole spin, and 1.2×10^{-13} and 1.8×10^{-13} eV for moderate spin. See their Figs. 2 and 3 for limits based on various values of black hole initial spin, boson cloud age, and distance. NODE=S029IAA;LINKAGE=Z

[28] CHANG 18 update axion bremsstrahlung emission rates in nucleon-nucleon collisions, shifting the excluded mass range to higher values. They rule out the hadronic axion with mass up to a few hundred eV, closing the hadronic axion window. See their Fig. 11 for results based on several different choices of the temperature and density profile of the proto-neutron star. NODE=S029IAA;LINKAGE=Y

[29] PORAYKO 18 look for time-dependent oscillations in the gravitational potential generated by ultralight scalar dark matter, and set a bound on its local density as $\rho_{A^0} \lesssim 6$ GeV/cm^3 for $m_{A^0} \lesssim 10^{-23}$ eV at 95% CL. See their Fig. 4 for the limits. NODE=S029IAA;LINKAGE=VA

[30] ARCHIDIACONO 13A is analogous to HANNESTAD 05A. The limit is based on the CMB temperature power spectrum of the Planck data, the CMB polarization from the WMAP 9-yr data, the matter power spectrum from SDSS-DR7, and the local Hubble parameter measurement by the Carnegie Hubble program. NODE=S029IAA;LINKAGE=V

[31] CADAMURO 11 use the deuterium abundance to show that the m_{A^0} range 0.7 eV – 300 keV is excluded for axions, complementing HANNESTAD 10. NODE=S029IAA;LINKAGE=CA

[32] DERBIN 11A look for solar axions produced by Compton and bremsstrahlung processes, in the resonant excitation of ^{169}Tm, constraining the axion-electron $\times$ axion nucleon couplings. NODE=S029IAA;LINKAGE=DR

[33] ANDRIAMONJE 10 search for solar axions produced from ^{7}Li (478 keV) and D(p,γ)^{3}He (5.5 MeV) nuclear transitions. They show limits on the axion-photon coupling for two reference values of the axion-nucleon coupling for $m_A < 100$ eV. NODE=S029IAA;LINKAGE=ND

[34] This is an update of HANNESTAD 08 including 7 years of WMAP data. NODE=S029IAA;LINKAGE=NN

[35] ANDRIAMONJE 09 look for solar axions produced from the thermally excited 14.4 keV level of ^{57}Fe. They show limits on the axion-nucleon $\times$ axion-photon coupling assuming $m_A < 0.03$ eV. NODE=S029IAA;LINKAGE=AD

[36] DERBIN 09A look for Primakoff-produced solar axions in the resonant excitation of ^{169}Tm, constraining the axion-photon $\times$ axion-nucleon couplings. NODE=S029IAA;LINKAGE=DE

[37] KEKEZ 09 look at axio-electric effect of solar axions in HPGe detectors. The one-loop axion-electron coupling for hadronic axions is used. NODE=S029IAA;LINKAGE=KE

[38] This is an update of HANNESTAD 07 including 5 years of WMAP data. NODE=S029IAA;LINKAGE=AN

[39] This is an update of HANNESTAD 05A with new cosmological data, notably WMAP (3 years) and baryon acoustic oscillations (BAO). Lyman-α data are left out, in contrast to HANNESTAD 05A and MELCHIORRI 07A, because it is argued that systematic errors are large. It uses Bayesian statistics and marginalizes over a possible neutrino hot dark matter component. NODE=S029IAA;LINKAGE=HN

[40] MELCHIORRI 07A is analogous to HANNESTAD 05A, with updated cosmological data, notably WMAP (3 years). Uses Bayesian statistics and marginalizes over a possible neutrino hot dark matter component. Leaving out Lyman-α data, a conservative limit is 1.4 eV. NODE=S029IAA;LINKAGE=ME

[41] HANNESTAD 05A puts an upper limit on the mass of hadronic axion because in this mass range it would have been thermalized and contribute to the hot dark matter component of the universe. The limit is based on the CMB anisotropy from WMAP, SDSS large scale structure, Lyman α, and the prior Hubble parameter from HST Key Project. A χ^2 statistic is used. Neutrinos are assumed not to contribute to hot dark matter. NODE=S029IAA;LINKAGE=HA

[42] MOROI 98 points out that a KSVZ axion of this mass range (see CHANG 93) can be a viable hot dark matter of Universe, as long as the model-dependent $g_{A\gamma}$ is accidentally small enough as originally emphasized by KAPLAN 85; see Fig. 1. NODE=S029IAA;LINKAGE=T

[43] BORISOV 97 bound is on the axion-electron coupling $g_{ae} < 1\times10^{-13}$ from the photo-production of axions off of magnetic fields in the outer layers of neutron stars. NODE=S029IAA;LINKAGE=P

[44] KACHELRIESS 97 bound is on the axion-electron coupling $g_{ae} < 1\times10^{-10}$ from the production of axions in strongly magnetized neutron stars. The authors also quote a stronger limit, $g_{ae} < 9\times10^{-13}$ which is strongly dependent on the strength of the magnetic field in white dwarfs. NODE=S029IAA;LINKAGE=Q

[45] KEIL 97 uses new measurements of the axial-vector coupling strength of nucleons, as well as a reanalysis of many-body effects and pion-emission processes in the core of the neutron star, to update limits on the invisible-axion mass. NODE=S029IAA;LINKAGE=R

[46] RAFFELT 95 reexamined the constraints on axion emission from red giants due to the axion-electron coupling. They improve on DEARBORN 86 by taking into proper account degeneracy effects in the bremsstrahlung rate. The limit comes from requiring the red giant core mass at helium ignition not to exceed its standard value by more than 5% (0.025 solar masses). NODE=S029IAA;LINKAGE=F

[47] ALTHERR 94 bound is on the axion-electron coupling $g_{ae} < 1.5\times10^{-13}$, from energy loss via axion emission. NODE=S029IAA;LINKAGE=K

[48] CHANG 93 updates ENGEL 90 bound with the Kaplan-Manohar ambiguity in z=m_u/m_d (see the Note on the Quark Masses in the Quark Particle Listings). It leaves the window f_A=3×10^5–3×10^6 GeV open. The constraint from Big-Bang Nucleosynthesis is satisfied in this window as well. NODE=S029IAA;LINKAGE=U

[49] BERSHADY 91 searched for a line at wave length from 3100–8300 Å expected from 2γ decays of relic thermal axions in intergalactic light of three rich clusters of galaxies. NODE=S029IAA;LINKAGE=AB

[50] KIM 91C argues that the bound from the mass density of the universe will change drastically for the supersymmetric models due to the entropy production of saxion (scalar component in the axionic chiral multiplet) decay. Note that it is an *upperbound* rather than a lowerbound. NODE=S029IAA;LINKAGE=O

[51] RAFFELT 91B argue that previous SN 1987A bounds must be relaxed due to corrections to nucleon bremsstrahlung processes. NODE=S029IAA;LINKAGE=N

[52] RESSELL 91 uses absence of any intracluster line emission to set limit. NODE=S029IAA;LINKAGE=M

[53] ENGEL 90 rule out $10^{-10} \lesssim g_{AN} \lesssim 10^{-3}$, which for a hadronic axion with EMC motivated axion-nucleon couplings corresponds to $2.5\times10^{-3}\,\text{eV} \lesssim m_{A^0} \lesssim 2.5\times10^4$ eV. The constraint is loose in the middle of the range, i.e. for $g_{AN} \sim 10^{-6}$. NODE=S029IAA;LINKAGE=L

[54] RAFFELT 90D is a re-analysis of DEARBORN 86. NODE=S029IAA;LINKAGE=J

[55] The region $m_{A^0} \gtrsim 2$ eV is also allowed. NODE=S029IAA;LINKAGE=AA

[56] ERICSON 89 considered various nuclear corrections to axion emission in a supernova core, and found a reduction of the previous limit (MAYLE 88) by a large factor. NODE=S029IAA;LINKAGE=I

[57] MAYLE 89 limit based on naive quark model couplings of axion to nucleons. Limit based on couplings motivated by EMC measurements is 2–4 times weaker. The limit from axion-electron coupling is weak: see HATSUDA 88B. NODE=S029IAA;LINKAGE=A

[58] RAFFELT 88B derives a limit for the energy generation rate by exotic processes in helium-burning stars $\epsilon < 100$ erg g^{-1} s^{-1}, which gives a firmer basis for the axion limits based on red giant cooling. NODE=S029IAA;LINKAGE=H

[59] RAFFELT 87 also gives a limit $g_{A\gamma} < 1\times10^{-10}$ GeV^{-1}. NODE=S029IAA;LINKAGE=B

[60] DEARBORN 86 also gives a limit $g_{A\gamma} < 1.4\times10^{-11}$ GeV^{-1}. NODE=S029IAA;LINKAGE=C

[61] RAFFELT 86 gives a limit $g_{A\gamma} < 1.1\times10^{-10}$ GeV^{-1} from red giants and $< 2.4\times10^{-9}$ GeV^{-1} from the sun. NODE=S029IAA;LINKAGE=G

[62] KAPLAN 85 says $m_{A^0} < 23$ eV is allowed for a special choice of model parameters. NODE=S029IAA;LINKAGE=D

[63] FUKUGITA 82 gives a limit $g_{A\gamma} < 2.3\times10^{-10}$ GeV^{-1}. NODE=S029IAA;LINKAGE=E

Search for Relic Invisible Axions

NODE=S029AXI

NODE=S029AXI

Limits are for the dimensionless quantity $[G_{A\gamma\gamma}/m_{A^0}]^2\rho_A$ where $G_{A\gamma\gamma}$ denotes the axion two-photon coupling, $L_{\rm int} = -\frac{G_{A\gamma\gamma}}{4}\phi_A F_{\mu\nu}\widetilde{F}^{\mu\nu} = G_{A\gamma\gamma}\phi_A \mathbf{E}\cdot\mathbf{B}$, and ρ_A is the axion energy density near the earth, unless otherwise stated. Notice that for QCD axions $G_{A\gamma\gamma}/m_{A^0}$ does not depend on m_{A^0}. For the reference values $m_{A^0} = 1\ \mu$eV, $G_{A\gamma\gamma} = 3.9\times10^{-16}$ GeV^{-1} (that would apply to KSVZ axions at that mass), and $\rho_A = 300$ MeV/cm^3 one finds $[G_{A\gamma\gamma}/m_{A^0}]^2\rho_A = 3.5\times10^{-43}$.

NODE=S029AXI

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<6.5 \times 10^{-41}$	95	[1] AHYOUNE	25	RADS	$m_{A^0} = 36.5676$–$36.5699\ \mu$eV
$<9.5 \times 10^{-43}$	90	[2] BAE	25	DMAG	$m_{A^0} = 20.95$–$21.37\ \mu$eV
$<4.4 \times 10^{-42}$	90	[3] BAI	25	HYST	$m_{A^0} = 17.28$–$19.46\ \mu$eV
$<1.8 \times 10^{-41}$	95	[4] BRAGGIO	25	QUAX	$m_{A^0} = 30.477$–$30.479\ \mu$eV
$<2.3 \times 10^{-44}$	90	[5] CAROSI	25	ADMX	$m_{A^0} = 4.5$–$5.44\ \mu$eV
$<2.9 \times 10^{-44}$	90	[6] GOODMAN	25	ADMX	$m_{A^0} = 3.27$–$3.34\ \mu$eV
$<1.8 \times 10^{-36}$	90	[7] HOSHINO	25	BRED	$m_{A^0} = 44$–$52\ \mu$eV
$<3 \times 10^{-4}$	95	[8] PORAYKO	25	EPTA	$m_{A^0} = 3\times10^{-24}$–$6\times10^{-21}$ eV
$<1.6 \times 10^{-37}$	95	[9] SANTOS-GAR...	25	MDMX	$m_{A^0} = 76.56$–76.82, 79.31–$79.53\ \mu$eV
$<8.5 \times 10^{-43}$	90	[10] SARDO-INF...	25	QUAX	$m_{A^0} = 41.991$–$42.234\ \mu$eV
$<1.0 \times 10^{-44}$	90	[11] AHN	24	CAPP	$m_{A^0} = 4.24$–$4.91\ \mu$eV
$<7.3 \times 10^{-41}$	95	[12] BAE	24	CAPP	$m_{A^0} = 21.38$–$21.79\ \mu$eV
$<1.0 \times 10^{-3}$	95	[13] DAVYDOV	24	ASTR	$m_{A^0} < 1\times10^{-20}$ eV
$<1.7 \times 10^{-26}$	95	[14] HEINZE	24	LIDA	$m_{A^0} = 1.97$–2.01 neV
$<3.5 \times 10^{-43}$	90	[15] KIM	24	CAPP	$m_{A^0} = 21.86$–$22\ \mu$eV
$<3.3 \times 10^{-25}$	95	[16] PANDEY	24	ADBC	$m_{A^0} = 40.9$–43.3, 49.3–50.6, 54.4–56.7 neV
$<4.6 \times 10^{-39}$	95	[17] QUISKAMP	24	ORGN	$m_{A^0} = 107.42$–$111.93\ \mu$eV
$<2 \times 10^{-41}$	90	[18] RETTAROLI	24	QUAX	$m_{A^0} = 36.52$–$36.55\ \mu$eV
$<1.3 \times 10^{-3}$	95	[19] ADACHI	23D	CMB	$m_{A^0} = 0.096$–2.2×10^{-20} eV
$<7.5 \times 10^{-43}$	90	[20] DI-VORA	23	QUAX	$m_{A^0} = 42.8178$–$42.8190\ \mu$eV
$<2.3 \times 10^{-42}$	90	[21] JEWELL	23	HYST	$m_{A^0} = 18.44$–$18.71\ \mu$eV
$<2.0 \times 10^{-42}$	90	[22] JEWELL	23	HYST	$m_{A^0} = 16.96$–17.12, 17.14–$17.28\ \mu$eV
$<2.5 \times 10^{-42}$	90	[23] KIM	23	CAPP	$m_{A^0} = 9.39$–$9.51\ \mu$eV
$<3.0 \times 10^{-4}$	95	[24] OSHIMA	23	DANC	$m_{A^0} = 4.1\times10^{-16}$–$2.0\times10^{-12}$ eV
$<2.56 \times 10^{-24}$	95	[25] THOMSON	23	UPLD	$m_{A^0} = 1.12$–$1.20\ \mu$eV
$<6.09 \times 10^{-43}$	90	[26] YANG	23	CAPP	$m_{A^0} = 19.883$–$19.926\ \mu$eV
$<6.6 \times 10^{-44}$	90	[27] YI	23	CAPP	$m_{A^0} = 4.51$–$4.59\ \mu$eV
$<2.6 \times 10^{-44}$	90	[28] YI	23A	CAPP	$m_{A^0} = 4.51$–$4.59\ \mu$eV
$<4.7 \times 10^{-5}$	95	[29] ADE	22	CMB	$m_{A^0} = 0.16$–4.8×10^{-20} eV
$<1.0 \times 10^{-41}$	90	[30] ALESINI	22	QUAX	$m_{A^0} = 42.8210$–$42.8223\ \mu$eV
$<7 \times 10^{-33}$	95	[31] BATTYE	22	ASTR	$m_{A^0} = 4.2$–$60\ \mu$eV
$<5.8 \times 10^{-41}$	95	[32] CHANG	22	TASE	$m_{A^0} = 19.4687$–$19.8436\ \mu$eV
$<3.2 \times 10^{-6}$	95	[33] FERGUSON	22	CMB	$m_{A^0} = 0.047$–4.7×10^{-20} eV
$<8.4 \times 10^{-43}$	90	[34] LEE	22	CAPP	$m_{A^0} = 19.764$–$19.890\ \mu$eV
$<4.9 \times 10^{-39}$	95	[35] QUISKAMP	22	ORGN	$m_{A^0} = 63.2$–$67.1\ \mu$eV
$<3.6 \times 10^{-43}$	90	[36] YOON	22	CAPP	$m_{A^0} = 19.764$–$19.890\ \mu$eV
$<1.03 \times 10^{-35}$	95	[37] ZHOU	22	ASTR	$m_{A^0} = 3.18$–$4.35\ \mu$eV
$<2.8 \times 10^{-4}$	95	[38] ADE	21	CMB	$m_{A^0} = 0.16$–4.8×10^{-20} eV
$<1.1 \times 10^{-41}$	90	[39] ALESINI	21	QUAX	$m_{A^0} = 43\ \mu$eV
$<1 \times 10^{-44}$	90	[40] BARTRAM	21A	ADMX	$m_{A^0} = 3.3$–$4.2\ \mu$eV

OCCUR=2

$<1.6 \times 10^{-29}$	95	[41] DEVLIN	21	TRAP	$m_{A^0} = 2.7906$–2.7914 neV	
$<1.4 \times 10^{-23}$	95	[42] GRAMOLIN	21	SHFT	$m_{A^0} = 0.012$–12 neV	
$<7 \times 10^{-43}$	90	[43] KWON	21	CAPP	$m_{A^0} = 10.7126$–10.7186 μeV	
$<4.6 \times 10^{-40}$	95	[44] MELCON	21	RADE	$m_{A^0} = 34.6738$–34.6771 μeV	
$<3.5 \times 10^{-28}$	95	[45] SALEMI	21	ABRA	$m_{A^0} = 0.41$–8.27 neV	
$<3 \times 10^{-3}$	95	[46] THOMSON	21		$m_{A^0} = 7.44$–19.38 neV	
$<1 \times 10^{-2}$	95	[46] THOMSON	21		$m_{A^0} = 74.4$–74.5 μeV	OCCUR=2
		[47] YUAN	21	ASTR	$m_{A^0} = 10^{-20}$–10^{-17} eV	
$<1.9 \times 10^{-44}$	90	[48] BRAINE	20	ADMX	$m_{A^0} = 2.81$–3.31 μeV	
$<2 \times 10^{-35}$	90	[49] CRISOSTO	20	SLIC	$m_{A^0} = 180.07$–180.15 neV	
$<4 \times 10^{-37}$	95	[50] DARLING	20A	ASTR	$m_{A^0} = 4.2$–165.6 μeV	
$<3.2 \times 10^{-36}$	95	[51] FOSTER	20	ASTR	$m_{A^0} = 5$–7, 10–11μeV	
$<5.7 \times 10^{-41}$	90	[52] JEONG	20	CAPP	$m_{A^0} = 13.0$–13.9 μeV	
		[53] KENNEDY	20		$m_{S^0} = 10^{-19}$–10^{-17} eV	
$<4.8 \times 10^{-42}$	90	[54] LEE	20A	CAPP	$m_{A^0} = 6.62$–6.82 μeV	
$<2.6 \times 10^{-39}$	95	[55] ALESINI	19	QUAX	$m_{A^0} = 37.5$ μeV	
$<6 \times 10^{-5}$		[56] FUJITA	19	ASTR	$m_{A^0} < 10^{-21}$ eV	
$<2 \times 10^{-27}$	95	[57] OUELLET	19A	ABRA	$m_{A^0} = 0.31$–8.3 neV	
$<7.3 \times 10^{-40}$	90	[58] BOUTAN	18	ADMX	$m_{A^0} = 17.38$–17.57 μeV	
$<1.8 \times 10^{-39}$	90	[58] BOUTAN	18	ADMX	$m_{A^0} = 21.03$–23.98 μeV	OCCUR=2
$<3.4 \times 10^{-39}$	90	[58] BOUTAN	18	ADMX	$m_{A^0} = 29.67$–29.79 μeV	OCCUR=3
$<1.4 \times 10^{-44}$	90	[59] DU	18	ADMX	$m_{A^0} = 2.66$–2.81 μeV	
$<2.87 \times 10^{-42}$	90	[60] ZHONG	18	HYST	$m_{A^0} = 23.15$–24 μeV	
		[61] BRANCA	17	AURG	$m_{S^0} = 3.5$–3.9 peV	
$<3 \times 10^{-42}$	90	[62] BRUBAKER	17	HYST	$m_{A^0} = 23.55$–24.0 μeV	
$<1.0 \times 10^{-29}$	95	[63] CHOI	17	CAPP	$m_{A^0} = 24.7$–29.1 μeV	
$<5.9 \times 10^{-36}$	90	[64] MCALLISTER	17	ORGN	at $m_{A^0} = 110$ μeV	
$<8.6 \times 10^{-42}$	90	[65] HOSKINS	16	ADMX	$m_{A^0} = 3.36$–3.52 or 3.55–3.69 μeV	
		[66] BECK	13		$m_{A^0} = 0.11$ meV	
$<3.5 \times 10^{-43}$		[67] HOSKINS	11	ADMX	$m_{A^0} = 3.3$–3.69×10^{-6} eV	
$<2.9 \times 10^{-43}$	90	[68] ASZTALOS	10	ADMX	$m_{A^0} = 3.34$–3.53×10^{-6} eV	
$<1.9 \times 10^{-43}$	97.7	[69] DUFFY	06	ADMX	$m_{A^0} = 1.98$–2.17×10^{-6} eV	
$<5.5 \times 10^{-43}$	90	[70] ASZTALOS	04	ADMX	$m_{A^0} = 1.9$–3.3×10^{-6} eV	
		[71] KIM	98	THEO		
$<2 \times 10^{-41}$		[72] HAGMANN	90	CNTR	$m_{A^0} = (5.4$–$5.9)10^{-6}$ eV	
$<6.3 \times 10^{-42}$	95	[73] WUENSCH	89	CNTR	$m_{A^0} = (4.5$–$10.2)10^{-6}$ eV	
$<5.4 \times 10^{-41}$	95	[73] WUENSCH	89	CNTR	$m_{A^0} = (11.3$–$16.3)10^{-6}$ eV	OCCUR=2

[1] AHYOUNE 25 report results from the RADES collaboration, where a custom resonant cavity was used with an 11.7 T dipole magnet. See their Fig. 9 for mass-dependent limits. NODE=S029AXI;LINKAGE=SB

[2] BAE 25 present first results from the IBS Dark Matter Axion Group (DMAG), using the TM020 mode of a cylindrical resonant cavity haloscope. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=UB

[3] BAI 25 present results from Phase II of the HAYSTAC resonant cavity haloscope search for axion dark matter. See their Fig. 3 for mass-dependent limits together with previous results. NODE=S029AXI;LINKAGE=VB

[4] BRAGGIO 25 presents limits from a cavity haloscope search for axion dark matter. This experiment employed a single-photon counter to circumvent the Standard Quantum Limit and enhance the search speed. See their Fig. 5 for mass-dependent limits. NODE=S029AXI;LINKAGE=WB

[5] CAROSI 25 reports the latest results from the ADMX collaboration, extending the exclusion of relic QCD axions between 1.1 and 1.3 GHz down to the DFSZ model line using a near-quantum-limited amplifier. Quoted limit is for the strongest point in the exclusion limit just below 5.4 μeV. NODE=S029AXI;LINKAGE=AC

[6] GOODMAN 25 present a limit on QCD axion dark matter from an ADMX resonant cavity haloscope with a sensitivity reaching the DFSZ model line. See their Fig. 4 for the mass-dependent limit. NODE=S029AXI;LINKAGE=XB

[7] HOSHINO 25 present a first limit on axion dark matter from the GigaBREAD experiment. They used a coaxial dish antenna haloscope design placed inside a 3.9 T solenoidal magnet. See their Fig. 3 for mass-dependent limits. NODE=S029AXI;LINKAGE=YB

[8] PORAYKO 25 use the European Pulsar Timing Array dataset to place constraints on ultralight axion-like particles making up the dark matter halo of the galaxy. They look for the effect of interactions between the local dark matter ALP field and the radio photons emitted by the pulsars, which would induce an oscillating rotation of the plane of linear polarisation. See their Fig. 7 for mass-dependent limits. NODE=S029AXI;LINKAGE=ZB

[9] SANTOS-GARCIA 25 present results for a prototype setup of the MADMAX dielectric haloscope searching for axion dark matter to photon conversion in a 1.6 T dipole magnet. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=TB

[10] SARDO-INFIRRI 25 report a result from the QUAX haloscope around 10.2 GHz, using a quantum-limited detection chain to achieve sensitivity to axions down to close to the KSVZ model. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=BC

[11] AHN 24 is from the CAPP-MAX experiment with sensitivity to DFSZ axions. See Fig. 22 for mass-dependent limits. NODE=S029AXI;LINKAGE=HB

[12] BAE 24 search for dark matter axions using a microwave cavity with a tunable TM020 mode, scanning around 5 GHz. See their Fig. 6 for mass-dependent limits. NODE=S029AXI;LINKAGE=NB

[13] DAVYDOV 24 constrain ultralight axion-like particle dark matter via the oscillating birefringence effect induced by the local ALP field. Their constraint is based on polarimetric measurements of the HL Tauri protoplanetary disk. Their constraint is $g_{a\gamma} < 2.111 \times 10^{-12}$ GeV$^{-1}(m_a/10^{-22})$ eV. NODE=S029AXI;LINKAGE=OB

[14] HEINZE 24 search for ALP dark matter using the LIDA experiment - a laser interferometric haloscope that can detect the axion-induced polarisation rotation of light. Quoted limit assumes a dark matter density of 0.4 GeV/cm^3. See their Fig. 2 for mass-dependent limits. NODE=S029AXI;LINKAGE=MB

[15] KIM 24 report results from the CAPP-12T experiment searching for dark matter axions around 22 μeV down to the KSVZ level. See their Fig. 5 for mass-dependent limits. NODE=S029AXI;LINKAGE=IB

[16] PANDEY 24 report first search from the ADBC haloscope - an optical bow-tie laser cavity searching for the oscillating birefringence effect due to axion dark matter coupled to the photon. See their Fig. 3 for mass-dependent limits. NODE=S029AXI;LINKAGE=PB

[17] QUISKAMP 24 present results from Phase 1b of the ORGAN experiment, a high-frequency resonant axion haloscope in the 15–50 GHz range. See their Fig. 5 for mass-dependent limits. NODE=S029AXI;LINKAGE=JB

[18] RETTAROLI 24 report results from the QUAX resonant cavity haloscope at 8.8 GHz. This extends their previous search around this mass range reported in ALESINI 19. See their Fig. 7 for mass-dependent limits. NODE=S029AXI;LINKAGE=KB

[19] ADACHI 23D is analogous to ADE 21. They used POLARBEAR data, and take account of a stochastic local axion field amplitude with the time-averaged local axion density $\rho_A = 0.3$ GeV/cm^3. Limits are set at $G_{A\gamma\gamma} < 2.4 \times 10^{-11}$ GeV^{-1} ($m_{A^0}/10^{-21}$ eV), which is 2.2 times larger than the deterministic case. See Fig. 5 for mass-dependent limits. NODE=S029AXI;LINKAGE=YA

[20] DI-VORA 23 searches for axions in a narrow mass window using an 8T haloscope and a travelling wave parametric amplifier to achieve noise close to the quantum limit. This is an improvement on their previous scan at the same mass, ALESINI 21. See Fig. 7 for mass-dependent limits and a comparison. NODE=S029AXI;LINKAGE=GB

[21] JEWELL 23 is an update of BRUBAKER 17. See their Fig. 11 for the mass-dependent limits. NODE=S029AXI;LINKAGE=WA

[22] JEWELL 23 correct an underestimation of intermediate frequency noise in BACKES 21. See their Fig. 11 for the mass-dependent limits. NODE=S029AXI;LINKAGE=XA

[23] KIM 23 is an update of KWON 21 on the CAPP-PACE experiment. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=TA

[24] OSHIMA 23 report first limits from the DANCE experiment. This experiment is based on a novel bow-tie cavity design that searches for the oscillating rotation of polarised laser light driven by the DM axion-photon mixing at low frequencies. See their Fig. 6 for mass-dependent limits. NODE=S029AXI;LINKAGE=EB

[25] THOMSON 23 used an AC microwave cavity to search for dark matter axions. The axion signal is resonantly enhanced when the axion mass matches the difference between a cavity which is pumped with power and another resonant mode close in frequency that is used to read out the signal. See their Fig. 7 for the mass-dependent limits. NODE=S029AXI;LINKAGE=CB

[26] YANG 23 extends the first phase of CAPP 18T to KSVZ axions between 4.8077 and 4.8181 GHz. They used an 18T high-temperature superconducting magnet haloscope. See their Fig. 5 for mass-dependent limits. Quoted value is for their limit derived with a Bayesian method. NODE=S029AXI;LINKAGE=DB

[27] YI 23 is analogous to LEE 20A, using the CAPP-12TB haloscope. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=UA

[28] YI 23A used the same data as YI 23, but instead of the standard halo model, they searched for axion dark matter in the Sagittarius tidal stream with a velocity $v = 300$ km/sec and a velocity dispersion $\delta v = 20$ km/sec. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=VA

[29] ADE 22 is an update of ADE 21 based on the expanded data of the 2012–2015 observing seasons. See their Fig. 3 for mass-dependent limits over the extended mass range 1×10^{-23}–6×10^{-19} eV. NODE=S029AXI;LINKAGE=MA

[30] ALESINI 22 is an update of ALESINI 21, using the TM030 mode of the cylindrical dielectric cavity. See their Fig. 8 for mass-dependent limits. NODE=S029AXI;LINKAGE=SA

[31] BATTYE 22 is analogous to DARLING 20A, and use plasma ray tracing technique to analyze the propagation of radio photons converted from axion dark matter in the magnetosphere of PSR J1745-2900. The quoted limit assumes $\rho_A = 6.5 \times 10^4$ GeV/cm^3 in the vicinity of the magnetar. See their Fig. 1 for mass-dependent limits. NODE=S029AXI;LINKAGE=OA

[32] CHANG 22 used a microwave cavity detector to search for dark matter axions. See Fig. 3 for the mass-dependent limits. NODE=S029AXI;LINKAGE=RA

[33] FERGUSON 22 is analogous to ADE 21. They use the data of the SPT-3G's 2019 observing season. See their Fig. 5 for mass-dependent limits over the extended mass range 0.047–9.5×10^{-20} eV. NODE=S029AXI;LINKAGE=NA

[34] LEE 22 is analogous to LEE 20A. They used an 18T high-temperature superconducting magnet haloscope. See their Fig. 5 for mass-dependent limits. NODE=S029AXI;LINKAGE=LA

[35] QUISKAMP 22 is a 15.28 to 16.23 GHz microwave cavity haloscope with 11.5 T B-field. See Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=ZA

[36] YOON 22 analyzed the data from LEE 22 and changed from a frequentist to a Bayesian method to set limits. See their Fig. 27 for mass-dependent limits. NODE=S029AXI;LINKAGE=QA

[37] ZHOU 22 is analogous to DARLING 20A, and they use the data from the MeerKAT radio telescope's observation of the neutron star J0806.4-4123, which is 250 pc from Earth. See their Fig.3 for mass-dependent limits. NODE=S029AXI;LINKAGE=PA

[38] ADE 21 looks for a time-variable global rotation of the CMB polarization induced by the harmonic oscillations of local axion-like dark matter and uses data from the 2012 observing season of the Keck Array, part of the BICEP program. The limits get 25% weaker for $m_{A^0} = 4.8 \times 10^{-20}$–$5.7 \times 10^{-19}$ eV. See their Eq. (80) and Fig. 6 for mass-dependent limits. NODE=S029AXI;LINKAGE=HA

[39] ALESINI 21 is an update of ALESINI 19. See their Figs. 5 and 6 for the mass-dependent limits. NODE=S029AXI;LINKAGE=FA

[40] BARTRAM 21A is analogous to DU 18. See their Fig.4 for mass-dependent limits. NODE=S029AXI;LINKAGE=JA

[41] DEVLIN 21 use the superconducting resonant detection circuit of a cryogenic Penning trap with a single antiproton. See their Fig. 3 for mass-dependent limits. NODE=S029AXI;LINKAGE=AA

[42] GRAMOLIN 21 use two detection channels, each consisting of two stacked toroids to look for the axion-induced oscillating magnetic field. The quoted limit applies at m_{A^0} = 0.02 neV. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=GA

[43] KWON 21 is analogous to LEE 20A. They also obtain weaker limits in the range of m_{A^0} = 10.16–11.37 μeV. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=IA

[44] MELCON 21 use a radio frequency cavity consisting of 5 sub-cavities coupled by inductive irises installed inside the CAST dipole magnet to look for higher axion masses. See their Fig. 9 for mass-dependent limits. NODE=S029AXI;LINKAGE=KA

[45] SALEMI 21 is an update of OUELLET 19A. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=EA

[46] THOMSON 21 use a resonant cavity supporting two spatially overlapping microwave modes, which is sensitive to the axion mass corresponding to the sum or difference of the two resonant frequencies. The original limit was retracted due to a sign error. See their Fig. 2 in the erratum for the corrected limits. NODE=S029AXI;LINKAGE=DA

[47] YUAN 21 use polarimetric observations of Sgr A* taken by the Event Horizon Telescope to search for periodic oscillation of the polarization induced by axion dark matter, assuming a solitonic core near the Galactic center. They obtained limits in the range of $G_{A\gamma\gamma} = 8 \times 10^{-13}$–$3 \times 10^{-11}$ GeV^{-1}. NODE=S029AXI;LINKAGE=CA

[48] BRAINE 20 is analogous to DU 18. See Fig. 4 for their mass-dependent limits. NODE=S029AXI;LINKAGE=U

[49] CRISOSTO 20 used a resonant LC circuit to look for lighter axion dark matter. They obtained a similar, slightly weaker limit for m_{A^0} = 174.98–175.19 and 177.34–177.38 neV. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=T

[50] DARLING 20A use VLA data to look for radio-frequency radiation converted from axion dark matter in the magnetosphere of the Galactic Center magnetar PSR J1745-2900. They extended the results of DARLING 20, which used only data with the highest angular resolution, by adding sub-optimal data. They use $\rho_A = 6.5\times10^4$ GeV/cm^3 in the vicinity of the magnetar. See their Fig. 2 for mass-dependent limits. NODE=S029AXI;LINKAGE=BA

[51] FOSTER 20 look for radio-frequency radiation converted from axion dark matter in the magnetic field around neutron stars. They use the observed data of isolated local neutron stars and in the Galactic center. The quoted limit applies to $m_{A^0} \simeq 7$ μeV. See their Fig. 2 for mass-dependent limits. NODE=S029AXI;LINKAGE=Y

[52] JEONG 20 is analogous to LEE 20A, and they use a double-cell cavity to look for axions with mass > 10 μeV. See their Fig. 5 for mass-dependent limits. NODE=S029AXI;LINKAGE=X

[53] KENNEDY 20 is analogous to BRANCA 17, and they compare the frequency ratios of the Si cavity measured by a Sr optical lattice clock and by a H maser. Assuming the local density of moduli dark matter, $\rho_S = 0.3$ GeV/cm^3, they obtain a limit $G_{S\gamma\gamma} < 5.8 \times 10^{-24}$ GeV^{-1} at $m_{S^0} = 2 \times 10^{-19}$ eV. See their Fig. 2 for mass-dependent limits as well as limits on the modulus coupling to electrons. NODE=S029AXI;LINKAGE=W

[54] LEE 20A used a microwave cavity detector at the IBS/CAPP to search for dark matter axions. See Fig. 3 for the mass-dependent limits. NODE=S029AXI;LINKAGE=V

[55] ALESINI 19 used a superconducting resonant cavity made of NbTi to increase the quality factor. The limit applies to a mass range of 0.2 neV around $m_{A^0} = 37.5$ μeV. NODE=S029AXI;LINKAGE=Q

[56] FUJITA 19 look for photon birefringence under the oscillating axion background using the polarimetric imaging observation of a protoplanetary disk, AB Aur. See their Fig. 2 for a more conservative limit taking account of possible systematic effects. NODE=S029AXI;LINKAGE=P

[57] OUELLET 19A look for the axion-induced oscillating magnetic field generated by a toroidal magnetic field. The quoted limit applies at $m_{A^0} = 8$ neV. See their Fig. 3 for the mass-dependent limits. NODE=S029AXI;LINKAGE=O

[58] BOUTAN 18 use a small high frequency cavity installed above the main ADMX cavity to look for heavier axion dark matter. See their Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=M

[59] DU 18 is analogous to DUFFY 06. They upgraded a dilution refrigerator to reduce the system noise. The quoted limit is around $m_{A^0} = 2.69$ μeV for the boosted Maxwellian axion line shape. See Fig. 4 for their mass-dependent limits. NODE=S029AXI;LINKAGE=K

[60] ZHONG 18 is analogous to BRUBAKER 17. The quoted limit applies at $m_{A^0} = 23.76$ μeV. See Fig. 4 for their mass-dependent limits. NODE=S029AXI;LINKAGE=L

[61] BRANCA 17 look for modulations of the fine-structure constant and the electron mass due to moduli dark matter by using the cryogenic resonant-mass AURIGA detector. The limit on the assumed dilatonic coupling implies $G_{S\gamma\gamma} < 1.5 \times 10^{-24}$ GeV^{-1} for the scalar to two-photon coupling. See Fig. 5 for the mass-dependent limits. NODE=S029AXI;LINKAGE=H

[62] BRUBAKER 17 used a microwave cavity detector at the Yale Wright Laboratory to search for dark matter axions. See Fig. 3 for the mass-dependent limits. NODE=S029AXI;LINKAGE=F

[63] CHOI 17 used a microwave cavity detector with toroidal geometry. See Fig. 4 for their mass-dependent limits. NODE=S029AXI;LINKAGE=I

[64] MCALLISTER 17 used a high-frequency microwave cavity haloscope at 26.6 GHz in a 7 T magnetic field. See Fig. 4 for mass-dependent limits. NODE=S029AXI;LINKAGE=AB

[65] HOSKINS 16 is analogous to DUFFY 06. See Fig. 12 for mass-dependent limits in terms of the local dark matter density. NODE=S029AXI;LINKAGE=G

[66] BECK 13 argues that dark-matter axions passing through Earth may generate a small observable signal in resonant S/N/S Josephson junctions. A measurement by HOFFMANN 04 [Physical Review **B70** 180503 (2004)] is interpreted in terms of subdominant dark matter axions with $m_{A^0} = 0.11$ meV. NODE=S029AXI;LINKAGE=E

[67] HOSKINS 11 is analogous to DUFFY 06. See Fig. 4 for the mass-dependent limit in terms of the local density. NODE=S029AXI;LINKAGE=HO

[68] ASZTALOS 10 used the upgraded detector of ASZTALOS 04 to search for halo axions. See their Fig. 5 for the m_{A^0} dependence of the limit. NODE=S029AXI;LINKAGE=SZ

[69] DUFFY 06 used the upgraded detector of ASZTALOS 04, while assuming a smaller velocity dispersion than the isothermal model as in Eq. (8) of their paper. See Fig. 10 of their paper on the axion mass dependence of the limit. NODE=S029AXI;LINKAGE=DU

[70] ASZTALOS 04 looked for a conversion of halo axions to microwave photons in magnetic field. At 90% CL, the KSVZ axion cannot have a local halo density more than 0.45 GeV/cm^3 in the quoted mass range. See Fig. 7 of their paper on the axion mass dependence of the limit. NODE=S029AXI;LINKAGE=AS

[71] KIM 98 calculated the axion-to-photon couplings for various axion models and compared them to the HAGMANN 90 bounds. This analysis demonstrates a strong model dependence of $G_{A\gamma\gamma}$ and hence the bound from relic axion search. NODE=S029AXI;LINKAGE=D

[72] HAGMANN 90 experiment is based on the proposal of SIKIVIE 83. NODE=S029AXI;LINKAGE=B

[73] WUENSCH 89 looks for condensed axions near the earth that could be converted to photons in the presence of an intense electromagnetic field via the Primakoff effect, following the proposal of SIKIVIE 83. The theoretical prediction with $[G_{A\gamma\gamma}/m_{A^0}]^2 = 2 \times 10^{-14}$ MeV^{-4} (the three generation DFSZ model) and $\rho_A = 300$ MeV/cm^3 that makes up galactic halos gives $(G_{A\gamma\gamma}/m_{A^0})^2\, \rho_A = 4 \times 10^{-44}$. Note that our definition of $G_{A\gamma\gamma}$ is $(1/4\pi)$ smaller than that of WUENSCH 89. NODE=S029AXI;LINKAGE=A

Invisible A^0 (Axion) Limits from Photon Coupling

NODE=S029IAG

Limits are for the modulus of the axion-two-photon coupling $G_{A\gamma\gamma}$ defined by $L = -G_{A\gamma\gamma}\phi_A \mathbf{E}\cdot\mathbf{B}$. For scalars S^0 the limit is on the coupling constant in $L = G_{S\gamma\gamma}\phi_S(\mathbf{E}^2 - \mathbf{B}^2)$. The relation between $G_{A\gamma\gamma}$ and m_{A^0} is not used unless stated otherwise, i.e., many of these bounds apply to low-mass axion-like particles (ALPs), not to QCD axions. NODE=S029IAG

NODE=S029IAG

VALUE (GeV^{-1})	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<1 \times 10^{-4}$	90	[1] ABRAHAM	25	FASR	$m_{A^0} < 74$ MeV
$<1 \times 10^{-10}$	80	[2] ADAMS	25C	ASTR	$m_{A^0} = 2 \times 10^{-7}$–$4 \times 10^{-7}$ eV
$<9 \times 10^{-11}$	95	[3] ALTENMULL...	25	CAST	$m_{A^0} \lesssim 0.02$ eV
$<6 \times 10^{-13}$	95	[4] CANDON	25	ASTR	$m_{A^0} = 10$–700 keV
$<6.5 \times 10^{-13}$	95	[5] CHEN	25	ASTR	$m_{A^0} = 0.2$–10 keV
$<4.33 \times 10^{-11}$	95	[6] CHEN	25A	ASTR	$m_{A^0} < 10^{-6}$ eV
$<3.6 \times 10^{-11}$	95	[7] CHEN	25B	ASTR	$m_{A^0} = 4.4 \times 10^{-10}$ – 1.3×10^{-8} eV
$<1 \times 10^{-18}$	95	[8] FONG	25	DM	$m_{A^0} = 1.78$–18.0 keV
$<2 \times 10^{-12}$	95	[9] GOLDSTEIN	25	ASTR	$m_{A^0} = 2 \times 10^{-13}$–$3 \times 10^{-12}$ eV
$<8 \times 10^{-5}$	95	[10] HAYRAPETY...	25Z	CMS	$m_{A^0} = 5$–100 GeV
$<1.3 \times 10^{-11}$	95	[11] JANISH	25	DM	$m_{A^0} = 0.8$–2.5 eV
$<3 \times 10^{-14}$	95	[12] KAR	25	DM	$m_{A^0} = 8$–20 eV
$<4 \times 10^{-7}$	95	[13] KIRITA	25	SAPH	$m_{A^0} = 3 \times 10^{-3}$–$0.5$ eV
$<1.1 \times 10^{-12}$	95	[14] LI	25D	ASTR	$m_{A^0} = 4 \times 10^{-10}$–$1 \times 10^{-8}$ eV
$<1 \times 10^{-5}$	90	[15] MIRZAKHANI	25	MINR	$m_{A^0} < 10^7$ eV

$<6 \times 10^{-13}$	95	[16] NING	25	ASTR	$m_{A^0} < 10^{-9}$ eV	
$<6.24 \times 10^{-6}$	95	[17] PARK	25	NEON	$m_{A^0} < 7$ MeV	
$<7.3 \times 10^{-12}$	95	[18] RUZ	25	ASTR	$m_{A^0} < 4 \times 10^{-7}$ eV	
$<2 \times 10^{-13}$	95	[19] TODARELLO	25	DM	$m_{A^0} = 14.4$–22.2 eV	
$(6.5 {}^{+1.1}_{-1.3}) \times 10^{-11}$		[20] TROITSKY	25	ASTR	$m_{A^0} \lesssim 10$ keV	
$<2 \times 10^{-11}$	95	[21] YIN	25	DM	$m_{A^0} = 1.8$–2.7 eV	
$<5.6 \times 10^{-10}$	90	[22] ZENG	25	PNDX	$m_{A^0} \lesssim$ keV	
$<2.2 \times 10^{-4}$	95	[23] ABLIKIM	24AD	BES3	$m_{A^0} = 0.18$–2.85 GeV	
$<5.8 \times 10^{-11}$	95	[24] ALTENMULL...	24	CAST	$m_{A^0} < 0.02$ eV	
$<7 \times 10^{-12}$	95	[25] DEV	24	ASTR	$m_{A^0} = 0.01$–100 MeV	
$<5 \times 10^{-11}$		[26] DIAMOND	24	ASTR	$m_{A^0} = 1$–300 MeV	
$<1.38 \times 10^{-10}$	95	[27] FORDHAM	24	ASTR	$m_{A^0} <$ keV	
$<2 \times 10^{-11}$	95	[28] GAO	24	ASTR	$m_{A^0} = 10^{-9}$–10^{-7} eV	
$<2 \times 10^{-11}$	95	[29] GAO	24A	ASTR	$m_{A^0} = 10^{-10}$–2×10^{-7} eV	
$<4 \times 10^{-9}$	95	[30] GUO	24	DM	$m_{A^0} = 4.15$–6.06 or 8.3–12.2 μeV	
$<1.5 \times 10^{-11}$	95	[31] LI	24A	ASTR	$m_{A^0} = 5 \times 10^{-10}$–$1 \times 10^{-7}$ eV	
$<7.5 \times 10^{-11}$	95	[32] LI	24B	ASTR	$m_{A^0} = 2 \times 10^{-8}$–$2 \times 10^{-6}$ eV	
$<4 \times 10^{-12}$	99	[33] LI	24D	ASTR	$m_{A^0} = 10^{-9}$–10^{-8} eV	
$<3 \times 10^{-12}$	95	[34] MANZARI	24	ASTR	$m_{A^0} < 0.01$ eV	
$<3 \times 10^{-11}$	95	[35] PANT	24	ASTR	$m_{A^0} = 0.3$–1 neV	
$<8 \times 10^{-4}$	95	[36] PYBUS	24	GLUX	$m_{A^0} = 200$–450 MeV	
$<3 \times 10^{-11}$	95	[37] RAVENSBURG	24	ASTR	$m_{A^0} < 0.5$ MeV	
$<3 \times 10^{-13}$	95	[38] TODARELLO	24	DM	$m_{A^0} = 2.7$–5.3 eV	
$<1.1 \times 10^{-12}$		[39] WANG	24A	DM	$m_{A^0} = 2.8$–12.4 eV	
$<5.5 \times 10^{-11}$	95	[40] BATTYE	23	DM	$m_{A^0} = 3.9$–4.7 μeV	
$<2 \times 10^{-13}$	95	[41] BEAUFORT	23	ASTR	$m_{A^0} = 3$–38 keV	
$<2 \times 10^{-12}$	99	[42] BERNAL	23	COSM	$m_{A^0} = 8$–25 eV	
$<4 \times 10^{-14}$	99	[43] CAPOZZI	23	COSM	$m_{A^0} = 30$–800 eV	
$<1.3 \times 10^{-7}$	95	[44] CAPOZZI	23A	DUMP	$m_{A^0} = 10^{3}$–2×10^{8} eV	
$<5 \times 10^{-12}$	95	[45] DAVIES	23	ASTR	$m_{A^0} = 5$–200 neV	
$<1.7 \times 10^{-10}$		[46] DIAMOND	23	ASTR	$m_{A^0} = 2$–56 MeV	
$<6 \times 10^{-29}$	95	[47] FILZINGER	23		Dilaton-like dark matter	OCCUR=2
$<4.5 \times 10^{-12}$	95	[48] HOOF	23	ASTR	$m_{A^0} = 4 \times 10^{-10}$ eV	
$<3 \times 10^{-12}$	95	[49] HOOF	23	ASTR	$m_{A^0} = 60$ MeV	OCCUR=2
$<2.7 \times 10^{-11}$	99.7	[50] JACOBSEN	23	ASTR	$m_{A^0} < 3 \times 10^{-7}$ eV	
$<2 \times 10^{-11}$	99	[51] LI	23H	ASTR	$m_{A^0} = 1$–100 neV	
$<3.0 \times 10^{-12}$	95	[52] NOORDHUIS	23	ASTR	$m_{A^0} = 10^{-9}$–10^{-5} eV	
$<5 \times 10^{-11}$	95	[53] PANT	23	ASTR	$m_{A^0} = 0.1$–1000 neV	
$<5 \times 10^{-26}$	95	[54] SHERRILL	23	DM	Dilaton-like dark matter	
$<8 \times 10^{-9}$	95	[55] SULAI	23	DM	$m_{A^0} = 0.25$–2×10^{-14} eV	
$<7.9 \times 10^{-12}$		[56] YAO	23	ASTR	$m_{A^0} \lesssim 10^{-13}$ eV	
$<3.8 \times 10^{-22}$	95	[57] ZHANG	23A		Dilaton-like dark matter	
$<5 \times 10^{-10}$	90	[58] APRILE	22B	XENT	Solar axions	
$<1.45 \times 10^{-9}$	95	[59] ARNQUIST	22	MAJD	$m_{A^0} < 100$ eV	
$<7 \times 10^{-11}$	95	[60] ARZA	22	DM	$m_{A^0} = 0.2$–7×10^{-17} eV	
3–6×10^{-11}	95	[61] BERNAL	22	COSM	$m_{A^0} = 8$–20 eV	
$<3.76 \times 10^{-11}$	95	[62] CALORE	22	ASTR	$m_{A^0} < 10^{-11}$ eV	
$<2 \times 10^{-10}$		[63] CAPUTO	22	ASTR	$m_{A^0} = 1$–500 MeV	
$<3 \times 10^{-14}$	95	[64] CASTILLO	22	ASTR	$m_{A^0} = 3 \times 10^{-23}$ eV	
$<6 \times 10^{-12}$	90	[65] DEROCCO	22	ASTR	$m_{A^0} = 5$–30 keV	
$<5.4 \times 10^{-12}$	95	[66] DESSERT	22A	ASTR	$m_{A^0} \lesssim 3 \times 10^{-7}$ eV	
$<2.1 \times 10^{-11}$	95	[67] ECKNER	22	ASTR	$m_{A^0} < 2 \times 10^{-7}$ eV	
$<1 \times 10^{-11}$	95	[68] FOSTER	22	ASTR	$m_{A^0} = 16.5$–32.5 μeV	
$<1.14 \times 10^{-5}$	95	[69] KIRITA	22	SAPH	$m_{A^0} = 0.5$–500 meV	

<2	$\times 10^{-16}$		70 LANGHOFF	22	COSM	$m_{A^0} = 0.1–3 \times 10^4$ keV	
<6	$\times 10^{-12}$	95	71 LI	22	ASTR	$m_{A^0} = 0.2–20$ neV	
<1.3	$\times 10^{-11}$	95	72 LI	22C	ASTR	$m_{A^0} = 8–200$ neV	
<1	$\times 10^{-5}$		73 LUCENTE	22	ASTR	$m_{A^0} \lesssim 0.4$ MeV	
<9.2	$\times 10^{-11}$	95	74 BASU	21	ASTR	$m_{A^0} = 3.6 \times 10^{-21}$ eV	
<1.8	$\times 10^{-10}$	95	75 BI	21	ASTR	$m_{A^0} = 2–6 \times 10^{-7}$ eV	
<1.6	$\times 10^{-10}$	95	76 DOLAN	21A	ASTR	$m_{A^0} = 1–570$ keV	
<5	$\times 10^{-11}$	95	77 GUO	21	ASTR	$m_{A^0} = 8–23$ neV	
<1.2	$\times 10^{-4}$	95	78 HOMMA	21	SAPH	$m_{A^0} = 0.4–600$ meV	
<1.2	$\times 10^{-11}$	95	79 LI	21B	ASTR	$m_{A^0} = 0.5–500$ neV	
			80 LLOYD	21	ASTR	Magnetars	
<1	$\times 10^{-13}$	95	81 REGIS	21	DM	$m_{A^0} = 2.7–5.3$ eV	
<1.8	$\times 10^{-11}$	95	82 XIAO	21	ASTR	$m_{A^0} < 3.5 \times 10^{-11}$eV	
<7	$\times 10^{-4}$	95	83 ABUDINEN	20	BEL2	$m_{A^0} = 0.2–1$ GeV	
<2	$\times 10^{-4}$	90	84 BANERJEE	20A	NA64	$m_{A^0} < 55$ MeV	
<1.0	$\times 10^{-11}$	95	85 BUEHLER	20	ASTR	$m_{A^0} < 3$ neV	
<5	$\times 10^{-10}$		86 CALORE	20	ASTR	$m_{A^0} \lesssim 10^{-11}$ eV	
			87 CARENZA	20	ASTR	Globular clusters	
$2–4 \times 10^{-10}$		95	88 DENT	20A	ASTR	Solar axions	
			89 DEPTA	20	COSM	Axion-like particles	
<3.6	$\times 10^{-12}$	95	90 DESSERT	20A	ASTR	$m_{A^0} < 5 \times 10^{-11}$ eV	
			91 ESTEBAN	20	ANIT	Axion-like particles	
$4–6 \times 10^{-10}$		90	92 GAO	20	ASTR	Solar axions	
<2.8	$\times 10^{-11}$	95	93 KOROCHKIN	20	ASTR	$m_{A^0} = 25$ eV	
none $6.0 \times 10^{-9}–1.3 \times 10^{-5}$			94 LUCENTE	20A	ASTR	$m_{A^0} < 270$ MeV	
<2.6	$\times 10^{-11}$	95	95 MEYER	20	FLAT	$m_{A^0} < 3 \times 10^{-10}$ eV	
<8.4	$\times 10^{-8}$	99	96 YAMAMOTO	20	COSM	$m_{A^0} < 4 \times 10^{-6}$ eV	
<1	$\times 10^{-3}$	95	97 ALONI	19	PRMX	$m_{A^0} = 0.16$ GeV	
<1.4	$\times 10^{-14}$	95	98 CAPUTO	19	ASTR	$m_{A^0} = 5 \times 10^{-24}$ eV	
<9.6	$\times 10^{-14}$	95	99 FEDDERKE	19	CMB	$m_{A^0} = 10^{-22}$ eV	
<7	$\times 10^{-13}$	95	100 IVANOV	19	ASTR	$m_{A^0} = 5 \times 10^{-23}$ eV	
<4	$\times 10^{-11}$	95	101 LIANG	19	ASTR	$m_{A^0} = 1.2 \times 10^{-7}$ eV	
			102 FORTIN	18	ASTR	Axion-like particles	
<3	$\times 10^{-12}$		103 JAECKEL	18	ASTR	$m_{A^0} = 30–100$ MeV	
<5.0	$\times 10^{-3}$	90	104 YAMAJI	18	LSW	$m_{A^0} = 46–1020$ eV	
<1	$\times 10^{-11}$	99.9	105 ZHANG	18	ASTR	$m_{A^0} = 0.6–4$ neV	
			106 ADE	17	CMB	Axion-like particles	
<6.6	$\times 10^{-11}$	95	107 ANASTASSO...	17	CAST	$m_{A^0} < 0.02$ eV	
			108 DOLAN	17	RVUE	Axion-like particles	
<2.51	$\times 10^{-4}$	95	109 INADA	17	LSW	$m_{A^0} < 0.1$ eV	
>1.5	$\times 10^{-11}$	95	110 KOHRI	17	ASTR	$m_{A^0} = 0.7–50$ neV	
<2.6	$\times 10^{-12}$	95	111 MARSH	17	ASTR	$m_{A^0} \leq 10^{-13}$ eV	
<6	$\times 10^{-13}$		112 TIWARI	17	COSM	$m_{A^0} \leq 10^{-15}$ eV	
<5	$\times 10^{-12}$	95	113 AJELLO	16	ASTR	$m_{A^0} = 0.5–5$ neV	
<1.2	$\times 10^{-7}$	95	114 DELLA-VALLE	16	LASR	$m_{A^0} = 1.3$ meV	
<7.2	$\times 10^{-8}$	95	115 DELLA-VALLE	16	LASR	$m_{A^0} < 0.5$ meV	OCCUR=2
<8	$\times 10^{-4}$		116 JAECKEL	16	ALPS	$m_{A^0} = 0.1–100$ GeV	
<6	$\times 10^{-21}$		117 LEEFER	16		$m_{S^0} < 10^{-18}$ eV	
			118 ANASTASSO...	15	CAST	Chameleons	
<1.47	$\times 10^{-10}$	95	119 ARIK	15	CAST	$m_{A^0} = 0.39–0.42$ eV	
<3.5	$\times 10^{-8}$	95	120 BALLOU	15	LSW	$m_{A^0} < 2 \times 10^{-4}$ eV	
			121 BRAX	15	ASTR	$m_{S^0} < 4 \times 10^{-12}$ eV	
<5.42	$\times 10^{-4}$	95	122 HASEBE	15	LASR	$m_{A^0} = 0.15$ eV	
			123 MILLEA	15	COSM	Axion-like particles	
			124 VANTILBURG	15		Dilaton-like dark matter	
<4.1	$\times 10^{-10}$	99.7	125 VINYOLES	15	ASTR	$m_{A^0} = 0.6–185$ eV	
<3.3	$\times 10^{-10}$	95	126 ARIK	14	CAST	$m_{A^0} = 0.64–1.17$ eV	
<6.6	$\times 10^{-11}$	95	127 AYALA	14	ASTR	Globular clusters	
<1.4	$\times 10^{-7}$	95	128 DELLA-VALLE	14	LASR	$m_{A^0} = 1$ meV	

			[129] EJLLI	14	COSM	$m_{A^0} = 2.66$–$48.8\ \mu$eV	
< 8	$\times 10^{-8}$	95	[130] PUGNAT	14	LSW	$m_{A^0} < 0.3$ meV	
< 1	$\times 10^{-11}$		[131] REESMAN	14	ASTR	$m_{A^0} < 1 \times 10^{-10}$ eV	
< 2.1	$\times 10^{-11}$	95	[132] ABRAMOWSKI	13A	IACT	$m_{A^0} = 15$–60 neV	OCCUR=3
< 2.15	$\times 10^{-9}$	95	[133] ARMENGAUD	13	EDEL	$m_{A^0} < 200$ eV	
< 4.5	$\times 10^{-8}$	95	[134] BETZ	13	LSW	$m_{A^0} = 7.2 \times 10^{-6}$ eV	
< 8	$\times 10^{-11}$		[135] FRIEDLAND	13	ASTR	Red giants	
> 2	$\times 10^{-11}$		[136] MEYER	13	ASTR	$m_{A^0} < 1 \times 10^{-7}$ eV	
< 8.3	$\times 10^{-12}$	95	[137] WOUTERS	13	ASTR	$m_{A^0} < 7 \times 10^{-12}$ eV	
			[138] CADAMURO	12	COSM	Axion-like particles	
< 2.5	$\times 10^{-13}$	95	[139] PAYEZ	12	ASTR	$m_{A^0} < 4.2 \times 10^{-14}$ eV	
< 2.3	$\times 10^{-10}$	95	[140] ARIK	11	CAST	$m_{A^0} = 0.39$–0.64 eV	
< 6.5	$\times 10^{-8}$	95	[141] EHRET	10	ALPS	$m_{A^0} < 0.7$ meV	
< 2.4	$\times 10^{-9}$	95	[142] AHMED	09A	CDMS	$m_{A^0} < 100$ eV	
< 1.2–2.8×10^{-10}		95	[143] ARIK	09	CAST	$m_{A^0} = 0.02$–0.39 eV	
			[144] CHOU	09		Chameleons	
< 7	$\times 10^{-10}$		[145] GONDOLO	09	ASTR	$m_{A^0} <$ few keV	
< 1.3	$\times 10^{-6}$	95	[146] AFANASEV	08		$m_{S^0} < 1$ meV	
< 3.5	$\times 10^{-7}$	99.7	[147] CHOU	08		$m_{A^0} < 0.5$ meV	
< 1.1	$\times 10^{-6}$	99.7	[148] FOUCHE	08		$m_{A^0} < 1$ meV	
< 5.6–13.4×10^{-10}		95	[149] INOUE	08		$m_{A^0} = 0.84$–1.00 eV	
< 5	$\times 10^{-7}$		[150] ZAVATTINI	08		$m_{A^0} < 1$ meV	
< 8.8	$\times 10^{-11}$	95	[151] ANDRIAMON...	07	CAST	$m_{A^0} < 0.02$ eV	
< 1.25	$\times 10^{-6}$	95	[152] ROBILLIARD	07		$m_{A^0} < 1$ meV	
2–5×10^{-6}			[153] ZAVATTINI	06		$m_{A^0} = 1$–1.5 meV	
< 1.1	$\times 10^{-9}$	95	[154] INOUE	02		$m_{A^0} = 0.05$–0.27 eV	
< 2.78	$\times 10^{-9}$	95	[155] MORALES	02B		$m_{A^0} < 1$ keV	
< 1.7	$\times 10^{-9}$	90	[156] BERNABEI	01B		$m_{A^0} < 100$ eV	
< 1.5	$\times 10^{-4}$	90	[157] ASTIER	00B	NOMD	$m_{A^0} < 40$ eV	
			[158] MASSO	00	THEO	induced γ coupling	
< 2.7	$\times 10^{-9}$	95	[159] AVIGNONE	98	SLAX	$m_{A^0} < 1$ keV	
< 6.0	$\times 10^{-10}$	95	[160] MORIYAMA	98		$m_{A^0} < 0.03$ eV	
< 3.6	$\times 10^{-7}$	95	[161] CAMERON	93		$m_{A^0} < 10^{-3}$ eV, optical rotation	
< 6.7	$\times 10^{-7}$	95	[162] CAMERON	93		$m_{A^0} < 10^{-3}$ eV, photon regeneration	OCCUR=2
< 3.6	$\times 10^{-9}$	99.7	[163] LAZARUS	92		$m_{A^0} < 0.03$ eV	
< 7.7	$\times 10^{-9}$	99.7	[163] LAZARUS	92		$m_{A^0} = 0.03$–0.11 eV	OCCUR=2
< 7.7	$\times 10^{-7}$	99	[164] RUOSO	92		$m_{A^0} < 10^{-3}$ eV	
< 2.5	$\times 10^{-6}$		[165] SEMERTZIDIS	90		$m_{A^0} < 7 \times 10^{-4}$ eV	

[1] ABRAHAM 25 search for axions as a long-lived particle decaying into photons in the FASER detector at the LHC. They constrain models where the axion dominantly couples to W bosons. The quoted limit is from their Fig. 11, which shows the bound interpreted in terms of a coupling to photons, taking the value at a mass of 70 MeV where the constraint is strongest. Bounds on the axion-gluon coupling extend up to axion masses of up to 800 MeV. NODE=S029IAG;LINKAGE=DE

[2] ADAMS 25C present a search for ALP-photon mixing imprinted on the gamma-ray spectrum of the flaring NGC 1275 radio galaxy at the centre of the Perseus cluster observed by the VERITAS observatory. They adopt the CLs method for reporting exclusion limits as shown in their Fig. 3. No point in the tested parameter space is excluded at or above 95% confidence. The quoted limit is reached at $m_{A^0} = 3.03 \times 10^{-7}$ eV. NODE=S029IAG;LINKAGE=UE

[3] ALTENMULLER 25 primarily reports a new limit from the CAST helioscope on the product of the axion-photon and axion-electron coupling, but they also exploit the same analysis to set a new limit on the axion-photon coupling alone, although this is weaker than their previous limit in ALTENMULLER 24. NODE=S029IAG;LINKAGE=VE

[4] CANDON 25 place bounds on heavy photon-coupled axion-like particles produced in the interiors of the stars in the starburst galaxy M82 and then decaying to two photons. This process would generate an X-ray flux peaking around 100 keV, which they search for using data from the NuSTAR space telescope. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=EE

[5] CHEN 25 use data from X-ray satellites Chandra and eROSITA to search for the decays of axion-like particles produced by the Alpha Centauri binary system. Specifically, they consider the argument also used by BEAUFORT 23 in the case of the Sun, in which axions emitted with low speed from the star can build up in a gravitationally trapped 'basin' over the star's life. See their Fig. 3 for mass-dependent limits. The quoted value applies to the case where the axion-electron coupling is taken to be negligible. NODE=S029IAG;LINKAGE=FE

[6] CHEN 25A constrain low-mass axion-like particles by searching for the imprints of axion-photon oscillations on the gamma-ray spectra of two active galactic nuclei measured by the Fermi and MAGIC gamma-ray telescopes. See their Fig. 11 for mass-dependent limits. NODE=S029IAG;LINKAGE=GE

[7] CHEN 25B constrain low-mass axion-like particles by searching for the imprints of axion-photon oscillations on the gamma-ray spectra of several blazars observed by the Fermi gamma-ray telescope. See Figs. 2, 3 and 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=HE

[8] FONG 25 use early-release data from the eROSITA X-ray telescope's Final Equatorial Depth Survey to search for axion-like particle dark matter decaying to two photons in the Milky Way's dark matter halo. See their Fig. 7 for mass-dependent limits. NODE=S029IAG;LINKAGE=XE

[9] GOLDSTEIN 25 place bounds on low mass axions mixing with photons over cosmological distances as they traverse large-scale structure, which would lead to an observable patchy screening effect in CMB anisotropy maps. See their Fig. 3 for mass-dependent limits. This bound is analogous to that placed on dark photons by MCCARTHY 24. NODE=S029IAG;LINKAGE=IE

[10] HAYRAPETYAN 25Z places a bound on heavy axion-like particles coupled to photons via measurements of light-by-light scattering in ultraperipheral PbPb collisions at the CMS experiment. The bound is based on a search for diphoton events due to $\gamma\gamma \to a \to \gamma\gamma$ on top of the light-by-light scattering continuum. See Fig. 9 for mass-dependent limits on the axion-photon coupling. NODE=S029IAG;LINKAGE=JE

[11] JANISH 25 use blank-sky observations of the James Webb Space Telescope to search for dark matter axions present in the galactic halo. eV-mass axions decaying into two photons would present an emission line in the infrared band. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=KE

[12] KAR 25 use infrared to ultraviolet observations of the giant elliptical galaxy M87 to search for evidence of eV-scale axions decaying to two photons, assuming they make up the dark matter halo of the galaxy. See their Fig. 2, 3 and 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=ME

[13] KIRITA 25 presents a new result from the SAPPHIRES collaboration, namely a search for the production of axion-like particles in a quasi-parallel stimulated resonant photon-photon collider. See their Fig. 11 for mass-dependent limits. NODE=S029IAG;LINKAGE=NE

[14] LI 25D search for evidence of axion-photon mixing imprinted on the gamma-ray spectrum of the flat-spectrum radio quasar Ton-599 detected by Fermi-LAT. See their Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=YE

[15] MIRZAKHANI 25 search for axion-like particles coupled to photons using the MINER reactor neutrino experiment. Their search assumes axions would be produced via Primakoff emission from the reactor photon flux, which can then decay to two photons or convert to a photon through the inverse Primakoff effect in the detector. See Fig. 10 for mass-dependent limits. NODE=S029IAG;LINKAGE=OE

[16] NING 25 sets bounds on low-mass axion-like particle Primakoff emission by stars in the M87 and M82 starburst galaxies. They use data from the NuSTAR space telescope to search for evidence of the emitted axions converting into hard X-ray photons in the surrounding galactic magnetic fields. See Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=PE

[17] PARK 25 present a search for axion-like particles from the NEON reactor neutrino experiment. Axions would be produced by the large MeV photon flux from the reactor and subsequently scatter or decay to a photon pair in the detector. The quoted limit is at m_{A^0} = 3 MeV. See their Fig. 3 for mass-dependent limits. NODE=S029IAG;LINKAGE=LE

[18] RUZ 25 use data from the NuSTAR X-ray telescope to search for solar axions converting into photons as they traverse the Sun's atmospheric magnetic field. For larger m_{A^0}, the limit becomes weaker due to loss of coherence in the conversion. See their Fig. 1 for mass-dependent limits. NODE=S029IAG;LINKAGE=WE

[19] TODARELLO 25 use observations of dwarf spheroidal galaxies and galaxy clusters made by the Hubble Space Telescope to constrain axions decaying to two photons at UV wavelengths, assuming axions make up the dark matter halos of those astrophysical objects. See their Fig. 3 for mass-dependent limits. NODE=S029IAG;LINKAGE=QE

[20] TROITSKY 25 searches for evidence of any anomalous cooling due to axion emission from red giants and helium-burning stars in seven globular clusters observed by the Gaia survey. A 3.3σ hint for anomalous cooling is found, which could be explained by a non-zero axion-photon coupling. NODE=S029IAG;LINKAGE=TE

[21] YIN 25 use the WINERED spectrograph on the Magellan Clay Telescope to search for evidence of dark matter axions decaying into photons in the halos of the Leo V and Tucana II dwarf spheroidal galaxies. See their Fig. 1 for mass-dependent limits and the dependence on the assumed dark matter halo models. NODE=S029IAG;LINKAGE=RE

[22] ZENG 25 place a bound on axions emitted by the Sun due to a nonzero axion-photon coupling using electronic recoil data collected by the PandaX detector. Electron recoil events are generated via the axion-photon coupling by the inverse Primakoff effect. The limit is independent of the axion mass up to around the core temperature of the Sun. NODE=S029IAG;LINKAGE=SE

[23] ABLIKIM 24AD constrain the axion-photon coupling through radiative J/ψ decays in the BESIII detector at the Beijing electron-positron collider. See their Fig. 5 for mass-dependent limits. NODE=S029IAG;LINKAGE=LD

[24] ALTENMULLER 24 report an extended search for solar axions using the CAST experiment. The experiment employed a new xenon-based microMEGAS detector - a pathfinder NODE=S029IAG;LINKAGE=ZD

for the future International Axion Observatory (IAXO). This limit improves upon ANASTASSOPOULOS 17. See Fig. 4 for mass-dependent limits.

[25] DEV 24 use Fermi gamma-ray observations of the neutron star merger GW170817 to constrain the production and subsequent decay of high-mass axion-like particles. Constraint extends diagonally in mass-coupling space, reaching 7×10^{-12} GeV^{-1} at 100 MeV. See Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=MD

[26] DIAMOND 24 use multi-messenger observations of the neutron star merger GW170817 to constrain the production and radiative decay of axions in the event. Limits shown in their Fig. 3 extend diagonally in mass-coupling space. NODE=S029IAG;LINKAGE=ND

[27] FORDHAM 24 use asteroseismology observations of a solar-like star, KIC 6933899, to constrain axion emission from its interior via the photon coupling. Bound applies to all axion masses up to around the core temperature of the star $\sim$ keV. NODE=S029IAG;LINKAGE=OD

[28] GAO 24 constrain ALP-photon oscillations via their imprint on the gamma-ray spectrum of the blazar Mrk 421, as observed by MAGIC and Fermi-LAT. See their Fig. 5 for mass-dependent limits. NODE=S029IAG;LINKAGE=PD

[29] GAO 24A constrain ALP-photon oscillations using the high-energy gamma-ray spectrum observed by LHAASO of the brightest gamma-ray burst so far detected, GRB 221009A. See their Fig. 5 for mass-dependent limits. The strength of the limit depends on the magnetic field of the host galaxy. NODE=S029IAG;LINKAGE=QD

[30] GUO 24 search for axion dark matter decaying or converting into photons in the Coma Berenices dwarf galaxy using the radio telescope FAST. The quoted limit is for the case of axions decaying, including stimulated emission. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=RD

[31] LI 24A constrain the imprint of ALP-photon oscillations on the TeV gamma-ray spectrum of the BL Lac blazar 1ES 1215+303 using VERITAS and Fermi-LAT data. See their Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=TD

[32] LI 24B constrain the imprint of ALP-photon oscillations on the very-high-energy gamma-ray spectrum of various galactic sources detected by the LHAASO air-shower array. Best limits are obtained from the Crab Nebula after combining several observations from different gamma-ray observatories in addition to LHAASO. See their Fig. 5 for mass-dependent limits. NODE=S029IAG;LINKAGE=UD

[33] LI 24D search for evidence of axion-photon oscillations imprinted on the gamma-ray spectrum of the nearby BL Lac blazar Markarian 421. They set upper limits using data from Fermi-LAT and HAWC. The quoted limit applies for $m_{A^0} \simeq 3 \times 10^{-9}$ eV. See their Fig. 3 for mass-dependent limits. NODE=S029IAG;LINKAGE=AE

[34] MANZARI 24 search for evidence of axions produced in SN1987A converting into gamma-rays that would have been detectable by the Solar Maximum Mission. This analysis improves upon previous studies of axion-photon conversion after SN1987A (e.g. HOOF 23) by including the magnetic field of the progenitor star. Quoted limit applies for masses below 0.1 neV and rises towards larger masses. See their Fig. 1 for mass-dependent limits. NODE=S029IAG;LINKAGE=BE

[35] PANT 24 searches for the imprint of axion-photon oscillations in the very-high-energy gamma-ray spectrum of the quasar QSO B1420+326 observed by the MAGIC telescope. Three small disconnected regions of mass-coupling parameter space below 1 neV are ruled out. See Fig. 4 for the limits. NODE=S029IAG;LINKAGE=DD

[36] PYBUS 24 report results from the GlueX detector, which has searched for the two-photon decay of heavy axions produced through the nuclear Primakoff effect due to a beam of photons incident on a Carbon target. See their Fig. 8 for mass-dependent limits. NODE=S029IAG;LINKAGE=VD

[37] RAVENSBURG 24 search for heavy axions decaying to two photons using the recent nearby type-II supernova SN 2023ixf. Constraint extends diagonally downwards in mass-coupling space, see their Fig. 2 for full limits. Quoted limit is the most constraining point for the most conservative choices for supernova parameters. NODE=S029IAG;LINKAGE=WD

[38] TODARELLO 24 search for axions decaying to two photons in the halos of Milky Way dwarf galaxies observed in the MUSE-Faint survey. This study improves upon an earlier one presented in REGIS 21. See their Fig. 5 for compiled mass-dependent limits. NODE=S029IAG;LINKAGE=XD

[39] WANG 24A search for axions decaying into two photons assuming that they make up the dark matter halos of galaxies. They use data from the Dark Energy Spectroscopic Instrument, searching for the axion decay line in optical wavelengths with their Bright Galaxy and Luminous Red Galaxy samples. See their Fig. 8 for mass-dependent limits on the axion to photon decay rate. Their constraint is quoted as a 5σ detection limit. NODE=S029IAG;LINKAGE=CE

[40] BATTYE 23 look for dark-matter axions falling into pulsar magnetospheres and converting into narrow radio lines. Unlike the earlier FOSTER 22 they search for evidence of conversion in the time-domain signal of a single pulsar, using 1 hour of MeerKAT data on the pulsar PSR J2144-3933. The quoted limit applies to an assumed magnetic field of 2×10^{12} G and a dark matter density of 0.45 GeV/cm^3. NODE=S029IAG;LINKAGE=ID

[41] BEAUFORT 23 extends DEROCCO 22 who searched for the X-ray decay of axions that build up in the gravitational well of the Sun over its lifetime, the 'solar basin'. They use data from NuSTAR and SphinX telescopes and extends the previous study by accounting for the axion production via photon coalescence. NODE=S029IAG;LINKAGE=HD

[42] BERNAL 23 use gamma-ray data from 739 blazars observed by FermiLAT and 38 blazars by Cherenkov observatories. They estimate optical depth, subtract the astrophysical component, and attribute the residual to axion two-photon decay. The quoted limit is for $m_{A^0} \simeq 25$ eV. See their Fig. 3 for the mass-dependent limits. NODE=S029IAG;LINKAGE=TC

[43] CAPOZZI 23 use Planck CMB and Lyman-α observations to set limits on early energy injection by decaying dark matter axions that would affect CMB anisotropies and the reionisation history of the Universe. The quoted limit applies to $m_{A^0} = 100$ eV and the NODE=S029IAG;LINKAGE=AD

reionization model of Fauchere-Giguere. See Fig. 4 for mass-dependent constraints from different reionization models.

[44] CAPOZZI 23A search for axions produced in electromagnetic showers in proton beam dumps and fixed target experiments. In this case, they reinterpret MiniBoone data. Quoted limit applies at 100 MeV but the limit does not extend to arbitrarily large couplings. See Fig. 7 for mass-dependent limits. NODE=S029IAG;LINKAGE=GD

[45] DAVIES 23 is analogous to AJELLO 16, and use the Fermi-LAT data from three quasars (3C454.3, CTA 102, and 3C279), considering the blazer jets as the regions where the axion-photon oscillations occur. See Fig. 8 for the mass-dependent limits. NODE=S029IAG;LINKAGE=SC

[46] DIAMOND 23 demonstrate that a window of decaying 10-MeV-mass ALP parameter space previously thought to be excluded by the lack of gamma-ray emission from the SN 1987A explosion is actually unconstrained because of the formation of a fireball that would prevent decay photons from escaping. They nevertheless re-exclude this window by considering the non-detection of the sub-MeV emission by the Pioneer Venus Orbiter. The quoted limit is at $m_{A^0} = 56$ MeV. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=BD

[47] FILZINGER 23 searched for oscillations in the fine structure constant induced by dilaton-like dark matter by measuring the frequency ratio between the E3 and E2 transitions of $^{171}\mathrm{Yb}^+$. They assume the local dark matter density $\rho_S = 0.4$ GeV/cm^3. The quoted limit is set at $m_{S^0} \simeq 4 \times 10^{-23}$ eV. See their Fig. 4 for the limits over $m_{S^0} = 1 \times 10^{-24}$–$1 \times 10^{-17}$ eV. NODE=S029IAG;LINKAGE=QC

[48] HOOF 23 consider axions emitted from SN1987A converting to gamma rays in Galactic magnetic fields, using temporal information of the Solar Maximum Mission data. They set a limit $G_{A\gamma\gamma} \lesssim 5 \times 10^{-12}$ for masses $m_{A^0} \lesssim 2 \times 10^{-10}$ eV. See left panel in Fig. 3 for mass-dependent limits. NODE=S029IAG;LINKAGE=UC

[49] HOOF 23 look for gamma rays resulting from the decay of axions produced from SN1987A, using the Solar Maximum Mission data. See right panel in Fig. 3 for mass-dependent limits. NODE=S029IAG;LINKAGE=VC

[50] JACOBSEN 23 search for the imprints of axion-photon mixing on the TeV spectra of several blazars using data from the HAWC air shower detector. NODE=S029IAG;LINKAGE=FD

[51] LI 23H look for gamma-ray spectral irregularities induced by axion-photon oscillations from AGN VER J0521+211, using the Fermi-LAT and VERITAS data. See their Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=XC

[52] NOORDHUIS 23 places strong constraints on the axion-photon coupling over a broad mass window using the fact that the polar cap regions of pulsars can generate a population of axions, which would then convert into an observable outgoing radio flux in the presence of the neutron star's B-field. They search for this signal in 27 pulsars and set mass-dependent limits shown in their Fig. 2. NODE=S029IAG;LINKAGE=ED

[53] PANT 23 study the effect of axion-photon oscillations on the gamma-ray spectrum from the extragalactic neutrino source, TXS 0506+056. The quoted limit is at $m_{A^0} \simeq 2.7 \times 10^{-7}$ eV. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=WC

[54] SHERRILL 23 search for scalar dilaton-like dark matter via oscillations in the fundamental constants. Their most competitive constraint is on the scalar photon coupling (Fig. 6, upper panel) that affects the fine-structure constant, which they extract using an optical-to-optical clock comparison between $^{171}\mathrm{Yb}^+$ and $^{87}\mathrm{Sr}$. Quoted limit applies at the smallest mass in their search window for this case of 10^{-20} eV. NODE=S029IAG;LINKAGE=JD

[55] SULAI 23 looked for ultralight axion dark matter using the "Earth as a transducer" concept over the 0.5 to 5 Hz frequency range. They situate several magnetometers at magnetically quiet places and search for spatially-correlated magnetic field patterns induced by axion dark matter interacting in the effective cavity formed between the Earth's surface and the ionosphere. See their Fig. 12 for mass-dependent limits in context. This limit extends to higher-frequencies than their previous limit using archival geomagnetic field data collected by the SuperMAG collaboration, see ARZA 22 NODE=S029IAG;LINKAGE=CD

[56] YAO 23 study an optical circular polarization in blazers induced by the axion-photon mixing. The quoted limit assumes the transverse magnetic field at the jet's emission site, with $B_T = 1$ G, and this limit inversely scales with B_T. See their Fig. 3 for the limits' dependence on B_T and electron density. NODE=S029IAG;LINKAGE=YC

[57] ZHANG 23A searched for oscillations in the fine structure constant induced by dilaton-like dark matter by measuring the frequencies of a hyperfine-structure transition in $^{87}\mathrm{Rb}$ and an electronic transition in $^{164}\mathrm{Dy}$, and by comparing them with that of a quartz oscillator. They assume the local dark matter density $\rho_S \simeq 0.4$ GeV/cm^3. The quoted limit is set at $m_{S^0} \simeq 1 \times 10^{-17}$ eV. See their Fig. 3 for the limits over $m_{S^0} = 1 \times 10^{-17}$–$8.3 \times 10^{-13}$ eV. NODE=S029IAG;LINKAGE=RC

[58] APRILE 22B is an update of APRILE 20 based on a similar solar axion modeling to DENT 20A and GAO 20. They exclude the XENON1T excess found in APRILE 20. The quoted limit holds for small g_{Aee}. See Fig. 6 for correlation between $G_{A\gamma\gamma}$ and g_{Aee}. NODE=S029IAG;LINKAGE=NC

[59] ARNQUIST 22 is analogous to AVIGNONE 98, and supersedes ANASTASSOPOULOS 17 for $m_{A^0} \gtrsim 1.2$ eV. NODE=S029IAG;LINKAGE=MC

[60] ARZA 22 search for low-mass axions as dark matter using the Earth as a transducer for axion-photon conversion. The concept works because the region between the Earth and the ionosphere forms an insulating cavity that parametrically enhances the axion signal by the radius of the Earth. The result is an oscillating and spatially correlated magnetic field induced via the interaction between axion dark matter and the geomagnetic field, which they searched for using archival magnetometer field data over 20 years compiled NODE=S029IAG;LINKAGE=KD

by the SuperMAG collaboration. Quoted limit applies for masses 3–4 $\times 10^{-17}$ eV, see Fig. 1 for mass-dependent limits.

[61] BERNAL 22 explored the possibility that the excess in the cosmic optical background measured by New Horizonss Long Range Reconnaisance Imager was due to axion dark matter decaying into monoenergetic photons. See their Fig. 2 for the axion-photon coupling to explain the excess. NODE=S029IAG;LINKAGE=LC

[62] CALORE 22 update CALORE 20 by evaluating axion fluxes from progenitors of various masses and performing a template-based analysis using 12 years of Fermi-LAT data in the energy range from 50 MeV to 500 GeV. See their Fig. 10 for mass-dependent limits. NODE=S029IAG;LINKAGE=EC

[63] CAPUTO 22 study the effect of energy deposition by radiative decay of axions produced via the Primakoff process and photon coalescence in the supernova core, and set the limits by the radiative energy deposition $< 10^{50}$ erg and progenitor radius $= 5 \times 10^{13}$ cm. The quoted limit is at $m_{A^0} = 150$ MeV. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=DC

[64] CASTILLO 22 update CAPUTO 19 using the polarization measurements of the Crab Pulsar by the QUIJOTE MFI instrument and 20 Galactic pulsars from the PPTA project. See their Table 1 for the assumed local axion energy density ρ_A for each pulsar and their Fig. 7 for the mass-dependent limits in the range of 3×10^{-23} eV $\leq m_{A^0} \leq 10^{-19}$ eV. NODE=S029IAG;LINKAGE=FC

[65] DEROCCO 22 uses the NuSTAR data to search for monochromatic X-ray lines produced by the decay of solar axions trapped on bound orbits. The quoted limit applies to $m_{A^0} \simeq$ 9 keV. They also derive limits in the plane of g_{Aee} and $G_{A\gamma\gamma}$. See their Figs. 2 and 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=BC

[66] DESSERT 22A look for an axion-induced linear polarization using data from multiple magnetic white dwarf stars. See their Figs. 1 and 8 for the mass-dependent limits. NODE=S029IAG;LINKAGE=CC

[67] ECKNER 22 set limits by using sub-PeV diffuse gamma-ray data from HAWC and Tibet ASγ by assuming that gamma rays produced simultaneously with high-energy neutrinos from extragalactic sources suggested by IceCube are converted to axions in the magnetic field at the source and reconverted to gamma rays in the Galactic magnetic field. See their Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=KC

[68] FOSTER 22 is an update of FOSTER 20 in the list of limits on relic invisible axions. They search for axion-photon transitions generated by neutron stars in the Galactic center region. They use improved population models of the Galactic center neutron stars and a Navarro-Frenk-White (NFW) model of the galactic dark matter distribution. The quoted limit applies to $m_{A^0} \simeq$ 17–25 μeV. See their Fig. 1 for mass-dependent limits. NODE=S029IAG;LINKAGE=JC

[69] KIRITA 22 update HOMMA 21 by increasing the laser energy and developing a background discrimination method using the beam cross-section dependence of the background originated from optical elements. The quoted limits applies to $m_{A^0} = 0.18$ eV. See their Fig. 11 for mass-dependent limits. NODE=S029IAG;LINKAGE=IC

[70] LANGHOFF 22 set limits by considering the freeze-in production of axions coupled only to photons. The quoted limit applies to $m_{A^0} = 2$ MeV for the reheating temperature equal to 5 MeV. See their Fig. 1 for mass-dependent limits. NODE=S029IAG;LINKAGE=HC

[71] LI 22 is analogous to LI 21B, and use the spectra of the blazar FSRQ 4C+21.35 measured by MAGIC, VERITAS, and Fermi-LAT. The quoted limit applies to $m_{A^0} \simeq 8 \times 10^{-10}$ eV. See their Fig. 1 for mass-dependent limits. NODE=S029IAG;LINKAGE=YB

[72] LI 22C is analogous to LI 21B, and use the spectra of the blazars Mrk 421 and PG 1553+113 measured by MAGIC and Fermi-LAT. The quoted limit applies to $m_{A^0} \simeq$ 1×10^{-8} eV. See their Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=ZB

[73] LUCENTE 22 developed a method to correctly incorporate the effects of axions decaying into photons inside the core of horizontal-branch stars. They update CARENZA 20 by evaluating axion energy transfer in the range of axion mean free path where the diffusive energy transport and free streaming approximations are not applicable. See their Fig. 1 for the limits. NODE=S029IAG;LINKAGE=AC

[74] BASU 21 searched for birefringence induced by axion dark matter using multiple images of the polarized source in the strongly gravitationally lensed system CLASS B1152+199. They assume the axion makes up all dark matter, and used the axion density in the emitting region, $\rho_A = 20$ GeV/cm^3. Limits between 9.2×10^{-11}–7.7×10^{-8} GeV^{-1} are obtained for $m_{A^0} = 3.6 \times 10^{-21}$–$4.6 \times 10^{-18}$eV. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=RB

[75] BI 21 look for the gamma-ray spectral distortions induced by axion-photon oscillations in the presence of the Galactic magnetic field, using the measurements of sub-PeV gamma-rays from the Crab Nebula by the Tibet ASγ and HAWC experiments, together with MAGIC and HEGRA gamma-ray data. See their Fig. 3 for mass-dependent limits. NODE=S029IAG;LINKAGE=SB

[76] DOLAN 21A study the effect of axion production on the evolution of asymptotic giant branch stars, and use the white-dwarf initial-final mass relation to set the limits. See their Fig. 1 for mass-dependent limits. NODE=S029IAG;LINKAGE=WB

[77] GUO 21 is analogous to AJELLO 16, and use the Fermi-LAT and H.E.S.S. II measurements of PG 1553+113 and PKS 2155-304. See their Fig. 6 for mass-dependent limits. NODE=S029IAG;LINKAGE=VB

[78] HOMMA 21 look for the production of axion resonance states and their subsequent stimulated decays by combining linearly polarized creation laser pulses and circularly polarized inducing laser pulses. The quoted limit is at $m_{A^0} \simeq 0.178$ eV. See their Fig. 14 for mass-dependent limits. NODE=S029IAG;LINKAGE=XB

[79] LI 21B is analogous to AJELLO 16, and use the spectra of the blazar Mrk 421 measured by ARGO-YBJ and Fermi-LAT. They consider ALP-photon mixing in the magnetic fields NODE=S029IAG;LINKAGE=UB

of both the blazar jet and the Galaxy. The quoted limit applies to $m_{A^0} \simeq 1 \times 10^{-9}$ eV. See their Fig. 5 for mass-dependent limits.

[80] LLOYD 21 is analogous to FORTIN 18, and set limits on the product of the axion couplings to photons and nucleons as $g_{ANN}\, G_{A\gamma\gamma} \lesssim 4.6\times10^{-19}$ GeV^{-1} for $m_{A^0} \lesssim 10^{-5}$ eV by using the quiescent soft gamma-ray flux upper limits in five magnetars. We use $g_{ANN} = G_{AN}\, 2m_N$ to translate their limits. See their Table II and Fig. 3 for the limits. NODE=S029IAG;LINKAGE=TB

[81] REGIS 21 look for monochromatic photons from axion decay, using the MUSE spectroscopic data on the Leo T dwarf spheroidal galaxy. They assume that axions make up all of dark matter and use the integrated dark matter density along the line of sight determined by observations. NODE=S029IAG;LINKAGE=QB

[82] XIAO 21 use X-ray data from Betelgeuse to look for signals from axions produced in the stellar core that were converted to X-rays by the Galactic magnetic field. See their Fig. 1 for the mass-dependent limit. NODE=S029IAG;LINKAGE=IB

[83] ABUDINEN 20 look for the process $e^+ e^- \rightarrow \gamma A^0$ ($A^0 \rightarrow \gamma\gamma$) and set upper limits of around 10^{-3} over the mass range. The quoted limit is at $m_{A^0} = 0.3$ GeV. See their Fig. 5 for mass dependent limits. NODE=S029IAG;LINKAGE=HB

[84] BANERJEE 20A look for axions produced from high-energy bremsstrahlung photons through the Primakoff effect with the electric field of the target nuclei. They exclude $G_{A\gamma\gamma} = 2 \times 10^{-4}$–$5 \times 10^{-2}$ GeV^{-1} for $m_{A^0} < 55$ MeV. See their Fig. 5 for mass-dependent limits. NODE=S029IAG;LINKAGE=XA

[85] BUEHLER 20 look for the γ-ray transparency due to axion-photon oscillations using high-energy photon events from 79 sources in the Second Fermi-LAT Catalog of High-Energy Sources. The quoted limit is for the intergalactic magnetic field strength and coherence length of $B = 1$ nG and $s = 1$ Mpc. See their Figs. 4 and 5 for mass-dependent limits and for different magnetic-field parameters. NODE=S029IAG;LINKAGE=OB

[86] CALORE 20 use the isotropic diffuse γ-ray background measured by the Fermi-LAT to constrain the γ-ray flux converted in the Galactic magnetic field from axions produced from past core-collapse supernovae. They also derive a limit on a heavier axion with $m_{A^0} \gtrsim$ keV decaying into two photons of $G_{A\gamma\gamma} \lesssim 5 \times 10^{-11}$ GeV^{-1} for $m_{A^0} = 5$ keV. See their Figs. 5 and 7 for the limits as well as limits in the presence of axion-nucleon couplings. NODE=S029IAG;LINKAGE=NB

[87] CARENZA 20 extend the globular cluster bound of AYALA 14 to heavier masses ($m_{A^0} \leq$ a few 100 keV) by taking account of the coalescence process $\gamma + \gamma \rightarrow A^0$ as well as the decay of the ALP inside the stellar core. See their Fig.4 for mass-dependent limits. NODE=S029IAG;LINKAGE=AB

[88] DENT 20A is analogous to GAO 20. The quoted limit is from their arXiv:2006.15118v3 (v2 is their published version), using the relativistic Hartree-Fock form factor. The limit is up to two times weaker than the published one. See Fig. 4 in their arXiv version 3 for the correlation between $G_{A\gamma\gamma}$ and g_{Aee} corresponding to the excess reported in APRILE 20. NODE=S029IAG;LINKAGE=PB

[89] DEPTA 20 correct the underestimated D abundance in MILLEA 15, and derive robust cosmological bounds by allowing the reheating temperature, $N_{\rm eff}$, and neutrino chemical potential to vary. See their Fig. 6 for mass-dependent limits. NODE=S029IAG;LINKAGE=CB

[90] DESSERT 20A use the NuSTAR data of the Quintuplet and Westerlund 1 super star clusters to look for X-rays converted in the Galactic magnetic field from the axions produced in stellar cores. See their Fig. 3 for the mass-dependent limits. NODE=S029IAG;LINKAGE=MB

[91] ESTEBAN 20 show that the two anomalous ANITA events can be explained by the reflected radio pulses that are resonantly produced in the ionosphere via axion-photon conversion for $m_{A^0} \lesssim 1 \times 10^{-7}$ eV , if an axion clump passes the Earth about once a month. See their Fig.5 for the region consistent with this interpretation for different values of the axion density inside the clumps. NODE=S029IAG;LINKAGE=YA

[92] GAO 20 correct the limit of APRILE 20 by including inverse Primakoff scattering in the XENON1T detector. The quoted limit is from their arXiv:2006.14598v4 (v3 is their published version), taking account of the atomic form factor of Xe as pointed out in ABE 20J. The limit is weaker by a factor of 1.5–2 than the published one. See Fig. 3 in their arXiv version 4 for correlation between $G_{A\gamma\gamma}$ and g_{Aee} corresponding to the excess reported in APRILE 20. NODE=S029IAG;LINKAGE=LB

[93] KOROCHKIN 20 assume the axion makes up all dark matter, and look for a dip in the observed gamma-ray spectrum of the blazar 1ES 1218+304 by Fermi/LAT and VERITAS due to the extragalactic background light produced by the axion decay. Their analysis favors nonzero axion-induced absorption with $G_{A\gamma\gamma} = 3 \times 10^{-11}$–$2 \times 10^{-10}$ GeV^{-1} over a range of $m_{A^0} = 2$–18 eV. See their Fig. 1 for mass-dependent limits between $0.25 < m_{A^0} < 25$ eV. NODE=S029IAG;LINKAGE=EB

[94] LUCENTE 20A study the SN 1987A energy-loss argument on the axion-like particle production. In addition to the Primakoff process, they take account of photon coalescence as well as gravitational trapping that become relevant at $m_{A^0} > 100$ MeV. See their Fig. 12 for the mass-dependent limit. NODE=S029IAG;LINKAGE=JB

[95] MEYER 20 look for prompt γ-rays converted in the Galactic magnetic fields from axions produced via the Primakoff process in a sample of 20 extragalactic core-collapse supernovae. The limits assume a progenitor mass of 10 times the solar mass and certain models for the optical emission and the galactic magnetic field. See their Figs. 2 and 6 in the erratum for mass- and model-dependent limits. NODE=S029IAG;LINKAGE=DB

[96] YAMAMOTO 20 look for X-ray photons converted by the Earth's magnetic field from the axions produced by the two-body decay of dark matter, and set the limits by using the Suzaku data. The quoted limit is for the monochromatic X-ray line from the galactic dark matter with lifetime $\tau = 4.32 \times 10^{17}$ sec. They also derive limits on the continuum spectrum from the extragalactic component. See their Fig. 7 for the limits. NODE=S029IAG;LINKAGE=FB

[97] ALONI 19 used the data collected by the PRIMEX experiment to derive a limit based on a data-driven method. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=TA

[98] CAPUTO 19 look for an oscillating variation of the polarization angle of the pulsar J0437-4715, where they assume the local axion energy density $\rho_A = 0.3$ GeV/cm^3. See their Fig. 2 for mass-dependent limits for 5×10^{-24} eV $\leq m_{A^0} \leq 2 \times 10^{-19}$ eV. NODE=S029IAG;LINKAGE=WA

[99] FEDDERKE 19 look for a uniform reduction of the CMB polarization at large scales, which is induced by the oscillating axion background during CMB decoupling. The quoted limit is based on the assumption that axions make up all of the dark matter. See their Fig. 3 for mass-dependent limits for $m_{A^0} = 10^{-22}$–10^{-19} eV. NODE=S029IAG;LINKAGE=UA

[100] IVANOV 19 look for the axion-induced periodic changes in the polarization angle of parsec-scale jets in active galactic nuclei observed by the MOJAVE program, where they use the axion energy density $\rho_A = 20$ GeV/cm^3. See their Fig. 6 for mass-dependent limits for 5×10^{-23} eV $\leq m_{A^0} \leq 1.2 \times 10^{-21}$ eV. NODE=S029IAG;LINKAGE=VA

[101] LIANG 19 look for spectral irregularities in the spectrum of 10 bright H.E.S.S. sources in the Galactic plane, assuming photon-ALP mixing in the Galactic magnetic fields. See their Fig. 2 for mass-dependent limits with different Galactic magnetic field models. NODE=S029IAG;LINKAGE=RA

[102] FORTIN 18 studied the conversion of axion-like particles produced in the core of a magnetar to hard X-rays in the magnetosphere. See their Fig. 5 for mass-dependent limits with different values of the magnetar core temperature. NODE=S029IAG;LINKAGE=QA

[103] JAECKEL 18 study axions produced through the Primakoff process from SN 1987A, which subsequently decay into photon pairs. See their Fig. 1 for the mass-dependent limits in the range of $m_{A^0} = 0.01$–100 MeV. NODE=S029IAG;LINKAGE=ZC

[104] YAMAJI 18 search for axions with an x-ray LSW at Spring-8, using the Laue-case conversion in a silicon crystal. They also obtain $G_{A\gamma\gamma} < 4.2 \times 10^{-3}$ GeV^{-1} for $m_{A^0} <$ 10 eV. See their Fig. 5 for mass-dependent limits. NODE=S029IAG;LINKAGE=NA

[105] ZHANG 18 look for spectral irregularities in the spectrum of PKS 2155-304 measured by Fermi LAT, assuming photon-ALP mixing in the intercluster and Galactic magnetic fields. See their Figs. 2 and 3 for mass-dependent limits with different values of the intercluster magnetic field parameters. NODE=S029IAG;LINKAGE=OA

[106] ADE 17 look for cosmic birefringence from axion-like particles using CMB polarization data taken by the BICEP2 and Keck Array experiments. They set a limit $G_{A\gamma\gamma} H_I < 7.2 \times 10^{-2}$ at 95 %CL for $m_{A^0} < 10^{-28}$ eV, where H_I is the Hubble parameter during inflation. NODE=S029IAG;LINKAGE=LA

[107] ANASTASSOPOULOS 17 looked for solar axions by the CAST axion helioscope in the vacuum phase, and supersedes ANDRIAMONJE 07. NODE=S029IAG;LINKAGE=HA

[108] DOLAN 17 update existing limits on $G_{A\gamma\gamma}$ for axion-like particles. The limits from the proton beam dump experiments in their Fig. 2 contained an error, and the corrected version is shown in Fig. 1 of DOLAN 21. NODE=S029IAG;LINKAGE=MA

[109] INADA 17 search for axions with an x-ray LSW at Spring-8. See their Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=IA

[110] KOHRI 17 attributed to axion-photon oscillations the excess of cosmic infrared background observed by the CIBER experiment. See their Fig. 5 for the region preferred by their scenario. NODE=S029IAG;LINKAGE=JA

[111] MARSH 17 is similar to WOUTERS 13, using Chandra observations of M87. See their Fig. 6 for mass-dependent limits. NODE=S029IAG;LINKAGE=KA

[112] TIWARI 17 use observed limits of the cosmic distance-duality relation to constrain the photon-ALP mixing based on 3D simulations of the magnetic field configuration. The quoted value is for the averaged magnetic field of 1nG with a coherent length of 1 Mpc. See their Fig. 5 for mass-dependent limits. NODE=S029IAG;LINKAGE=EA

[113] AJELLO 16 look for irregularities in the energy spectrum of the NGC1275 measured by Fermi LAT, assuming photon-ALP mixing in the intra-cluster and Galactic magnetic fields. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=DA

[114] DELLA-VALLE 16 look for the birefringence induced by axion-like particles. See their Fig. 14 for mass-dependent limits. NODE=S029IAG;LINKAGE=BA

[115] DELLA-VALLE 16 look for the dichroism induced by axion-like particles. See their Fig. 14 for mass-dependent limits. NODE=S029IAG;LINKAGE=Z

[116] JAECKEL 16 use the LEP data of $Z \to 2\gamma$ and $Z \to 3\gamma$ to constrain the ALP production via $e^+ e^- \to Z \to A^0 \gamma$ ($A^0 \to \gamma\gamma$), assuming the ALP coupling with two hypercharge bosons. See their Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=Y

[117] LEEFER 16 derived limits by using radio-frequency spectroscopy of dysprosium and atomic clock measurements. See their Fig. 1 for mass-dependent limits as well as limits on Yukawa-type couplings of the scalar to the electron and nucleons. NODE=S029IAG;LINKAGE=GA

[118] ANASTASSOPOULOS 15 search for solar chameleons with CAST and derived limits on the chameleon coupling to photons and matter. See their Fig. 12 for the exclusion region. NODE=S029IAG;LINKAGE=P

[119] ARIK 15 is analogous to ARIK 09, and search for solar axions for m_{A^0} around 0.2 and 0.4 eV. See their Figs. 1 and 3 for the mass-dependent limits. NODE=S029IAG;LINKAGE=Q

120 Based on OSQAR photon regeneration experiment. See their Fig. 6 for mass-dependent limits on scalar and pseudoscalar bosons. NODE=S029IAG;LINKAGE=R

121 BRAX 15 derived limits on conformal and disformal couplings of a scalar to photons by searching for a chaotic absorption pattern in the X-ray and UV bands of the Hydra A galaxy cluster and a BL lac object, respectively. See their Fig. 8. NODE=S029IAG;LINKAGE=V

122 HASEBE 15 look for an axion via a four-wave mixing process at quasi-parallel colliding laser beams. They also derived limits on a scalar coupling to photons $G_{S\gamma\gamma} < 2.62 \times 10^{-4}$ GeV^{-1} at $m_{S^0} = 0.15$ eV. See their Figs. 11 and 12 for mass-dependent limits. NODE=S029IAG;LINKAGE=S

123 MILLEA 15 is similar to CADAMURO 12, including the Planck data and the latest inferences of primordial deuterium abundance. See their Fig. 3 for mass-dependent limits. NODE=S029IAG;LINKAGE=W

124 VANTILBURG 15 look for harmonic variations in the dyprosium transition frequency data, induced by coherent oscillations of the fine-structure constant due to dilaton-like dark matter, and set the limits, $G_{S\gamma\gamma} < 6 \times 10^{-27}$ GeV^{-1} at $m_{S^0} = 6 \times 10^{-23}$ eV. See their Fig. 4 for mass-dependent limits between $1 \times 10^{-24} < m_{S^0} < 1 \times 10^{-15}$ eV. NODE=S029IAG;LINKAGE=T

125 VINYOLES 15 performed a global fit analysis based on helioseismology and solar neutrino observations. See their Fig. 9. NODE=S029IAG;LINKAGE=U

126 ARIK 14 is similar to ARIK 11. See their Fig. 2 for mass-dependent limits. NODE=S029IAG;LINKAGE=I

127 AYALA 14 derived the limit from the helium-burning lifetime of horizontal-branch stars based on number counts in globular clusters. NODE=S029IAG;LINKAGE=J

128 DELLA-VALLE 14 use the new PVLAS apparatus to set a limit on vacuum magnetic birefringence induced by axion-like particles. See their Fig. 6 for the mass-dependent limits. NODE=S029IAG;LINKAGE=K

129 EJLLI 14 set limits on a product of primordial magnetic field and the axion mass using CMB distortion induced by resonant axion production from CMB photons. See their Fig. 1 for limits applying specifically to the DFSZ and KSVZ axion models. NODE=S029IAG;LINKAGE=M

130 PUGNAT 14 is analogous to EHRET 10. See their Fig. 5 for mass-dependent limits on scalar and pseudoscalar bosons. NODE=S029IAG;LINKAGE=L

131 REESMAN 14 derive limits by requiring effects of axion-photon interconversion on gamma-ray spectra from distant blazars to be no larger than errors in the best-fit optical depth based on a certain extragalactic background light model. See their Fig. 5 for mass-dependent limits. NODE=S029IAG;LINKAGE=O

132 ABRAMOWSKI 13A look for irregularities in the energy spectrum of the BL Lac object PKS 2155–304 measured by H.E.S.S. The limits depend on assumed magnetic field around the source. See their Fig. 7 for mass-dependent limits. NODE=S029IAG;LINKAGE=C

133 ARMENGAUD 13 is analogous to AVIGNONE 98. See Fig. 6 for the limit. NODE=S029IAG;LINKAGE=G

134 BETZ 13 performed a microwave-based light shining through the wall experiment. See their Fig. 13 for mass-dependent limits. NODE=S029IAG;LINKAGE=E

135 FRIEDLAND 13 derived the limit by considering blue-loop suppression of the evolution of red giants with 7–12 solar masses. NODE=S029IAG;LINKAGE=F

136 MEYER 13 attributed to axion-photon oscillations the observed excess of very high-energy γ-rays with respect to predictions based on extragalactic background light models. See their Fig.4 for mass-dependent lower limits for various magnetic field configurations. NODE=S029IAG;LINKAGE=H

137 WOUTERS 13 look for irregularities in the X-ray spectrum of the Hydra cluster observed by Chandra. See their Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=X

138 CADAMURO 12 derived cosmological limits on $G_{A\gamma\gamma}$ for axion-like particles. See their Fig. 1 for mass-dependent limits. NODE=S029IAG;LINKAGE=CA

139 PAYEZ 12 derive limits from polarization measurements of quasar light (see their Fig. 3). The limits depend on assumed magnetic field strength in galaxy clusters. The limits depend on assumed magnetic field and electron density in the local galaxy supercluster. NODE=S029IAG;LINKAGE=PA

140 ARIK 11 search for solar axions using ^{3}He buffer gas in CAST, continuing from the ^{4}He version of ARIK 09. See Fig. 2 for the exact mass-dependent limits. NODE=S029IAG;LINKAGE=AI

141 ALPS is a photon regeneration experiment. See their Fig. 4 for mass-dependent limits on scalar and pseudoscalar bosons. NODE=S029IAG;LINKAGE=EH

142 AHMED 09A is analogous to AVIGNONE 98. NODE=S029IAG;LINKAGE=AH

143 ARIK 09 is the ^{4}He filling version of the CAST axion helioscope in analogy to INOUE 02 and INOUE 08. See their Fig. 7 for mass-dependent limits. NODE=S029IAG;LINKAGE=AR

144 CHOU 09 use the GammeV apparatus in the afterglow mode to search for chameleons, (pseudo)scalar bosons with a mass depending on the environment. For pseudoscalars they exclude at 3σ the range 2.6×10^{-7} GeV^{-1} $< G_{A\gamma\gamma} <$ 4.2×10^{-6} GeV^{-1} for vacuum m_{A^0} roughly below 6 meV for density scaling index exceeding 0.8. NODE=S029IAG;LINKAGE=CH

145 GONDOLO 09 use the all-flavor measured solar neutrino flux to constrain solar interior temperature and thus energy losses. NODE=S029IAG;LINKAGE=GO

146 LIPSS photon regeneration experiment, assuming scalar particle S^0. See Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=AF

147 CHOU 08 perform a variable-baseline photon regeneration experiment. See their Fig. 3 for mass-dependent limits. Excludes the PVLAS result of ZAVATTINI 06. NODE=S029IAG;LINKAGE=HO

148 FOUCHE 08 is an update of ROBILLIARD 07. See their Fig. 12 for mass-dependent limits. NODE=S029IAG;LINKAGE=FO

149 INOUE 08 is an extension of INOUE 02 to larger axion masses, using the Tokyo axion helioscope. See their Fig. 4 for mass-dependent limits. NODE=S029IAG;LINKAGE=IO

150 ZAVATTINI 08 is an upgrade of ZAVATTINI 06, see their Fig. 8 for mass-dependent limits. They now exclude the parameter range where ZAVATTINI 06 had seen a positive signature. NODE=S029IAG;LINKAGE=ZV

[151] ANDRIAMONJE 07 looked for Primakoff conversion of solar axions in 9T superconducting magnet into X-rays. Supersedes ZIOUTAS 05. NODE=S029IAG;LINKAGE=AN

[152] ROBILLIARD 07 perform a photon regeneration experiment with a pulsed laser and pulsed magnetic field. See their Fig. 4 for mass-dependent limits. Excludes the PVLAS result of ZAVATTINI 06 with a CL exceeding 99.9%. NODE=S029IAG;LINKAGE=RO

[153] ZAVATTINI 06 propagate a laser beam in a magnetic field and observe dichroism and birefringence effects that could be attributed to an axion-like particle. This result is now excluded by ROBILLIARD 07, ZAVATTINI 08, and CHOU 08. NODE=S029IAG;LINKAGE=ZA

[154] INOUE 02 looked for Primakoff conversion of solar axions in 4T superconducting magnet into X ray. NODE=S029IAG;LINKAGE=IN

[155] MORALES 02B looked for the coherent conversion of solar axions to photons via the Primakoff effect in Germanium detector. NODE=S029IAG;LINKAGE=ML

[156] BERNABEI 01B looked for Primakoff coherent conversion of solar axions into photons via Bragg scattering in NaI crystal in DAMA dark matter detector. NODE=S029IAG;LINKAGE=BB

[157] ASTIER 00B looked for production of axions from the interaction of high-energy photons with the horn magnetic field and their subsequent re-conversion to photons via the interaction with the NOMAD dipole magnetic field. NODE=S029IAG;LINKAGE=GB

[158] MASSO 00 studied limits on axion-proton coupling using the induced axion-photon coupling through the proton loop and CAMERON 93 bound on the axion-photon coupling using optical rotation. They obtained the bound $g_p^2/4\pi < 1.7 \times 10^{-9}$ for the coupling $g_p \overline{p} \gamma_5 p \phi_A$. NODE=S029IAG;LINKAGE=MS

[159] AVIGNONE 98 result is based on the coherent conversion of solar axions to photons via the Primakoff effect in a single crystal germanium detector. NODE=S029IAG;LINKAGE=FT

[160] Based on the conversion of solar axions to X-rays in a strong laboratory magnetic field. NODE=S029IAG;LINKAGE=D

[161] Experiment based on proposal by MAIANI 86. NODE=S029IAG;LINKAGE=C1

[162] Experiment based on proposal by VANBIBBER 87. NODE=S029IAG;LINKAGE=C2

[163] LAZARUS 92 experiment is based on proposal found in VANBIBBER 89. NODE=S029IAG;LINKAGE=AA

[164] RUOSO 92 experiment is based on the proposal by VANBIBBER 87. NODE=S029IAG;LINKAGE=B

[165] SEMERTZIDIS 90 experiment is based on the proposal of MAIANI 86. The limit is obtained by taking the noise amplitude as the upper limit. Limits extend to $m_{A^0} = 4 \times 10^{-3}$ where $G_{A\gamma\gamma} < 1 \times 10^{-4}$ GeV^{-1}. NODE=S029IAG;LINKAGE=A

Limit on Invisible A^0 (Axion) Electron Coupling

NODE=S029AEC

The limit is for $g_{Aee}\ \phi_A\ \overline{e}(i\,\gamma_5)e$, or equivalently, the dipole-dipole potential $-\frac{g^2_{Aee}}{16\pi m^2_e}\ ((\boldsymbol{\sigma}_1 \cdot \boldsymbol{\sigma}_2) - 3(\boldsymbol{\sigma}_1 \cdot \boldsymbol{n})\ (\boldsymbol{\sigma}_2 \cdot \boldsymbol{n}))/r^3$ where $\boldsymbol{n}=\boldsymbol{r}/r$ and the sign of the potential was corrected based on DAIDO 17.

NODE=S029AEC

NODE=S029AEC

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE	CL%	DOCUMENT ID		TECN	COMMENT	
$<4 \times 10^{-10}$	90	[1] ALBAKRY	25	CDMS	$m_{A^0} = 1.2$–23.3 eV	
$<5 \times 10^{-13}$	90	[2] APRILE	25A	XENT	$m_{A^0} = 0.01$–0.4 keV	
$<2.7 \times 10^{-13}$	90	[3] LI	25	PNDX	$m_{A^0} = 0.03$–1 MeV	
$<4 \times 10^{-7}$	90	[4] MIRZAKHANI	25	MINR	$m_{A^0} < 2$ MeV	
$<2 \times 10^{-19}$	95	[5] MONTEFAL...	25	CMB	$m_{A^0} = 10^2$–10^6 eV	
$<4.95 \times 10^{-8}$	95	[6] PARK	25	NEON	$m_{A^0} < 1.6$ MeV	
$<5.2 \times 10^{-14}$	95	[7] TROITSKY	25	ASTR	$m_{A^0} \lesssim 10$ keV	
$<2.9 \times 10^{-12}$	90	[8] ZENG	25	PNDX	$m_{A^0} \lesssim$ keV	
$<4 \times 10^{-14}$	90	[9] ZENG	25	PNDX	$m_{A^0} = 1$–30 keV	OCCUR=2
$<3.3 \times 10^{-12}$	90	[10] AGOSTINI	24A	GRDA	$m_{A^0} = 65$–1021 keV	
$<1.5 \times 10^{-13}$	90	[11] ARNQUIST	24	MAJD	$m_{A^0} = 1$–100 keV	
$<2.35 \times 10^{-12}$	90	[12] AALBERS	23A	LZ	Solar axions	
$<1.3 \times 10^{-14}$	90	[13] AALBERS	23A	LZ	$m_{A^0} = 1$–17 keV	OCCUR=2
$<1.61 \times 10^{-11}$	90	[14] ADHIKARI	23	C100	Solar axions	
$<6 \times 10^{-13}$	90	[15] ADHIKARI	23A	C100	$m_{A^0} = 10$–1000 keV	
$<8 \times 10^{-14}$	90	[16] AGNES	23A	DS50	$m_{A^0} = 0.03$–20 keV	
		[17] APRILE	23B	XE1T	Neutron star merger	OCCUR=2
$<3 \times 10^{-9}$	95	[18] CAPOZZI	23A	DUMP	$m_{A^0} = 10^4$–2×10^7 eV	
$<6 \times 10^{-15}$		[19] WADEKAR	23	ASTR	$m_{A^0} = 100$ keV	
$<4 \times 10^{-12}$	90	[20] APRILE	22	XE1T	$m_{A^0} = 0.01$–0.4 keV	
$<9 \times 10^{-15}$	90	[21] APRILE	22B	XENT	$m_{A^0} = 1$–39, 44–140 keV	
$<2 \times 10^{-12}$	90	[22] APRILE	22B	XENT	Solar axions	OCCUR=2
		[23] DESSERT	22	ASTR	Magnetic white dwarf	
$<2.6 \times 10^{-6}$	95	[24] IKEDA	22		$m_{A^0} = 33.117$–33.130 μeV	
$<2.5 \times 10^{-18}$		[25] LANGHOFF	22	COSM	$m_{A^0} = 20$–3×10^4 keV	
		[26] WANG	22C		$m_{A^0} \leq 0.47$ meV	

		27 XIAO	22	ASTR	Betelgeuse	OCCUR=2
		28 CALORE	21	ASTR	Core-collapse SNe	
$<2 \times 10^{-9}$		29 LUCENTE	21	ASTR	SN 1987A	
$<5.1 \times 10^{-12}$	90	30 AGOSTINI	20	HPGE	m_{A^0} = 0.06–1 MeV	
$<1 \times 10^{-9}$	90	31 AMARAL	20	SCDM	m_{A^0} = 1.2–50 eV	
$<2 \times 10^{-14}$	90	32 APRILE	20	XE1T	m_{A^0} = 1 keV	
2.6–3.7 $\times 10^{-12}$	90	33 APRILE	20	XE1T	Solar axions	OCCUR=2
$<6 \times 10^{-13}$	90	34 ARALIS	20	SCDM	m_{A^0} = 0.04–500 keV	
$<1.3 \times 10^{-13}$	95	35 CAPOZZI	20	ASTR	Tip of the Red Giant Branch	
$<1.7 \times 10^{-11}$	95	36 CRESCINI	20	QUAX	m_{A^0} = 42.4–43.1 μeV	
$<1.8 \times 10^{-9}$		37 GHOSH	20A	COSM	$m_{A^0} \lesssim$ 0.5 MeV	
$<1.48 \times 10^{-13}$	95	38 STRANIERO	20	ASTR	Tip of the Red Giant Branch	
$<2.48 \times 10^{-11}$	90	39 WANG	20A	CDEX	Solar axions	
$<4 \times 10^{-13}$	90	40 WANG	20A	CDEX	m_{A^0} = 1.5 keV	OCCUR=2
$<1.7 \times 10^{-11}$	90	41 ADHIKARI	19B	C100	Solar axions	
$<2.3 \times 10^{-14}$	90	42 APRILE	19D	XE1T	m_{A^0} = 0.186–1 keV	
		43 DESSERT	19	ASTR	Magnetic white dwarf	
$<2.6 \times 10^{-10}$	95	44 TERRANO	19		Torsion pendulum	
$<1.5 \times 10^{-13}$	90	45 ABE	18F	XMAS	m_{A^0} = 40–120 keV	
$<1.1 \times 10^{-11}$	90	46 ARMENGAUD	18	EDE3	Solar axions	
$<4 \times 10^{-13}$	90	47 ARMENGAUD	18	EDE3	m_{A^0} = 0.8–500 keV	OCCUR=2
$<4.9 \times 10^{-10}$	95	48 CRESCINI	18	QUAX	m_{A^0} = 58 μeV	
		49 FICEK	18	THEO	m_{A^0} < 10 keV	
$<4.5 \times 10^{-13}$	90	50 ABGRALL	17	HPGE	m_{A^0} = 11.8 keV	
$<3.5 \times 10^{-12}$	90	51 AKERIB	17B	LUX	Solar axions	
$<4.2 \times 10^{-13}$	90	52 AKERIB	17B	LUX	m_{A^0} = 1–16 keV	OCCUR=2
$<2.3 \times 10^{-13}$	90	53 APRILE	17B	X100	m_{A^0} = 6 keV	
$<4 \times 10^{-4}$	90	54 FICEK	17	THEO	m_{A^0} < 1 keV	
$<4.35 \times 10^{-12}$	90	55 FU	17A	PNDX	Solar axions	
$<4.3 \times 10^{-14}$	90	56 FU	17A	PNDX	m_{A^0} = 2 keV	OCCUR=2
$<5 \times 10^{-13}$	90	57 LIU	17A	CDEX	m_{A^0} = 13 keV	
$<2.5 \times 10^{-11}$	90	58 LIU	17A	CDEX	Solar axions	OCCUR=2
<0.15	95	59 LUO	17		m_{A^0} = 300 eV	
$<3.3 \times 10^{-13}$	68	60 BATTICH	16	ASTR	White dwarf cooling	
$<7 \times 10^{-13}$		61 CORSICO	16	ASTR	White dwarf cooling	
$<1.39 \times 10^{-11}$	90	62 YOON	16	KIMS	Solar axions	
$<7.4 \times 10^{-9}$	95	63 TERRANO	15		m_{A^0} < 30 μeV	
$<8 \times 10^{-13}$	90	64 ABE	14F	XMAS	m_{A^0} = 60 keV	
$<7.7 \times 10^{-12}$	90	65 APRILE	14B	X100	Solar axions	
		66 APRILE	14B	X100	m_{A^0} = 5–7 keV	OCCUR=2
$<$ 0.96–8.2 $\times 10^{-8}$	90	67 DERBIN	14	CNTR	m_{A^0} = 0.1–1 MeV	
$<2.8 \times 10^{-13}$	99	68 MILLER-BER...	14	ASTR	White dwarf cooling	
$<5.4 \times 10^{-11}$	90	69 ABE	13D	XMAS	Solar axions	
$<1.07 \times 10^{-12}$	90	70 ARMENGAUD	13	EDEL	m_{A^0} = 12.5 keV	
$<2.59 \times 10^{-11}$	90	71 ARMENGAUD	13	EDEL	Solar axions	OCCUR=2
		72 BARTH	13	CAST	Solar axions	
$<$ 1.4–9.7 $\times 10^{-7}$	90	73 DERBIN	13	CNTR	m_{A^0} = 0.1–1 MeV	
$<1.5 \times 10^{-8}$	68	74 HECKEL	13		$m_{A^0} \leq$ 0.1 μeV	
$<4.3 \times 10^{-13}$	95	75 VIAUX	13A	ASTR	Low-mass red giants	
$<7 \times 10^{-13}$	95	76 CORSICO	12	ASTR	White dwarf cooling	
$<2.2 \times 10^{-10}$	90	77 DERBIN	12	CNTR	Solar axions	
$<$ 0.02–1 $\times 10^{-10}$	90	78 AALSETH	11	CNTR	m_{A^0} = 0.3–8 keV	
$<1.4 \times 10^{-12}$	90	79 AHMED	09A	CDMS	m_{A^0} = 2.5 keV	
$<4 \times 10^{-9}$		80 DAVOUDIASL	09	ASTR	Earth cooling	
$<2.7 \times 10^{-8}$	66	81 NI	94		Induced magnetism	
		81 CHUI	93		Induced magnetism	
$<3.6 \times 10^{-7}$	66	82 PAN	92		Torsion pendulum	
$<2.9 \times 10^{-8}$	95	81 BOBRAKOV	91		Induced magnetism	
$<1.9 \times 10^{-6}$	66	83 WINELAND	91	NMR		
$<7 \times 10^{-7}$	66	82 RITTER	90		Torsion pendulum	
$<6.6 \times 10^{-8}$	95	81 VOROBYOV	88		Induced magnetism	

[1] ALBAKRY 25 report a search with the SuperCDMS detector for axion-like particle dark matter absorption on silicon. See their Fig. 4 for mass-dependent limits. NODE=S029AEC;LINKAGE=WB

[2] APRILE 25A presents results from a search with XENONnT for axion-like particle dark matter absorption on electrons in liquid xenon. See their Fig. 5 for mass-dependent limits. NODE=S029AEC;LINKAGE=XB

[3] LI 25 search for MeV-mass axion-like particles coupled to electrons making up the dark matter halo of the galaxy that could be absorbed by liquid xenon in the PandaX detector. The local density ρ_A = 0.3 GeV/cm^3 is assumed. The quoted limit is at m_{A^0} = 150 keV. See their Fig. 3 for mass-dependent limits. NODE=S029AEC;LINKAGE=ZB

[4] MIRZAKHANI 25 search for axion-like particles coupled to electrons using the MINER reactor neutrino experiment. Their search assumes the axions would be produced via Compton scattering of the reactor photon flux, which then either decay to an electron-positron pair or undergo inverse Compton scattering in the detector. See Fig. 10 for mass-dependent limits. NODE=S029AEC;LINKAGE=AC

[5] MONTEFALCONE 25 place bounds on axion-like particle dark matter coupled to electrons using Planck CMB data. They search for the effects of anomalous energy injection on CMB anisotropies due to electron-loop induced ALP decays to two photons. See their Fig. 6 for mass-dependent limits. NODE=S029AEC;LINKAGE=BC

[6] PARK 25 present a search for axion-like particles from the NEON reactor neutrino experiment. Axions would be produced through the Compton scattering of electrons with the large MeV photon flux from the reactor and then subsequently scatter or decay to an electron-positron pair in the detector. The quoted limit is at m_{A^0} = 1.02 MeV. See their Fig. 3 for mass-dependent limits. NODE=S029AEC;LINKAGE=YB

[7] TROITSKY 25 sets a bound on axions coupled to electrons through their cooling effect on red giants and helium-burning stars in seven globular clusters observed by the Gaia survey. The bound is independent of the axion mass up to approximately values close to the stellar core temperatures. NODE=S029AEC;LINKAGE=CC

[8] ZENG 25 place a bound on axions emitted by the Sun due to a nonzero axion-electron coupling using electronic recoil data collected by the PandaX detector. The limit is independent of the axion mass up to around the core temperature of the Sun. NODE=S029AEC;LINKAGE=DC

[9] ZENG 25 place a bound on keV-scale axion-like particles making up the halo of the galaxy by searching for electron recoil events in the PandaX detector. See Fig. 3(e) for mass-dependent limits. NODE=S029AEC;LINKAGE=EC

[10] AGOSTINI 24A report a search for axion-like particle dark matter absorption and dark Compton scattering on germanium, generating electron events in the GERDA experiment. The quoted limit is at m_{A^0} = 150 keV. See their Fig. 7 for mass-dependent limits. NODE=S029AEC;LINKAGE=VB

[11] ARNQUIST 24 use the MAJORANA DEMONSTRATOR to search for high-mass axion-like particle dark matter absorption by Germanium. See Fig. 5 for mass-dependent limits. NODE=S029AEC;LINKAGE=UB

[12] AALBERS 23A look for solar axions from the ABC processes. See their Fig. 6 for the limits. NODE=S029AEC;LINKAGE=QB

[13] AALBERS 23A look for absorption of axion dark matter. The quoted limit is for m_{A^0} $\simeq$ 1.4 keV. The local density ρ_A = 0.3 GeV/cm^3 is assumed. See their Fig. 7 for mass-dependent limits. NODE=S029AEC;LINKAGE=RB

[14] ADHIKARI 23 is an update of ADHIKARI 19B. NODE=S029AEC;LINKAGE=NB

[15] ADHIKARI 23A look for absorption and Compton-like processes of axion dark matter. The quoted limit is for m_{A^0} $\simeq$ 37 keV. See their Fig. 4 for mass-dependent limits. NODE=S029AEC;LINKAGE=PB

[16] AGNES 23A look for absorption of axion dark matter. The quoted limit is for m_{A^0} $\simeq$ 0.25 keV. The local density ρ_A = 0.3 GeV/cm^3 is assumed. See their Fig. 2 for mass-dependent limits. NODE=S029AEC;LINKAGE=MB

[17] APRILE 23B look for an absorption signal of axions within $\pm$500 seconds of the GW signals, including the neutron star merger GW170817. They set a 90% CL upper limit on the product of coincident fluence and cross section of axions to be less than 10^{-29} cm^2/cm^2 in the recoil energy range of 5.5–210 keV$_{ee}$. NODE=S029AEC;LINKAGE=SB

[18] CAPOZZI 23A search for axions produced in electromagnetic showers in proton beam dumps and fixed target experiments. In this case, they reinterpret MiniBoone data. Quoted limit applies at 1 MeV. See Fig. 8 for mass-dependent limits. NODE=S029AEC;LINKAGE=TB

[19] WADEKAR 23 use the Leo T dwarf galaxy's interstellar medium to derive limits, requiring the heating rate from axion dark matter absorption into hydrogen atoms and two-photon decay to be less than the astrophysical cooling rate. See Fig. 2 for limits over m_{A^0} = 1–100 keV, which loosen for lighter masses. NODE=S029AEC;LINKAGE=OB

[20] APRILE 22 extend APRILE 19D to lower masses by removing the background of ionization signals correlated with high-energy events. The quoted limit applies to m_{A^0} = 0.1 keV. See their Fig. 15 for mass-dependent limits. NODE=S029AEC;LINKAGE=DB

[21] APRILE 22B is an update of APRILE 20, and set the limit, $g_{Aee} \lesssim 9 \times 10^{-15}$–$3 \times 10^{-13}$. The quoted limit applies to m_{A^0} = 2 keV. They exclude the XENON1T excess found in APRILE 20. See their Fig. 6 for mass-dependent limits. NODE=S029AEC;LINKAGE=JB

[22] APRILE 22B is an update of APRILE 20. They exclude the XENON1T excess found in APRILE 20. The quoted limit holds for small $G_{A\gamma\gamma}$. See their Fig. 6 for correlation between g_{Aee} and $G_{A\gamma\gamma}$. NODE=S029AEC;LINKAGE=LB

[23] DESSERT 22 is an update of DESSERT 19. They used the Chandra observation of the magnetic white dwarf RE J0317-853 to look for converted X-rays in the magnetosphere from axions produced in the core through electron bremsstrahlung. They obtained the NODE=S029AEC;LINKAGE=FB

limit, $g_{Aee} \cdot G_{A\gamma\gamma} < 1.3 \times 10^{-25}$ GeV^{-1} at 95% CL for $m_{A^0} \lesssim 10^{-5}$ eV. See their Fig. 1 for mass-dependent limits.

[24] IKEDA 22 look for magnons excited by dark matter axions, using data taken with a hybrid quantum system consisting of a superconducting qubit and a spherical ferrimagnetic crystal. The quoted limit assumes the local dark matter density $\rho_A = 0.45$ GeV/cm^3 and the velocity $v = 220$ km/sec. See their Fig. 4 for the limits. NODE=S029AEC;LINKAGE=EB

[25] LANGHOFF 22 set limits by considering the freeze-in production of axions coupled to electrons without anomalous coupling to photons. The quoted limit applies to $m_{A^0} = 15$ MeV for the reheating temperature equal to 5 MeV. See their Fig. 2 for mass-dependent limits. NODE=S029AEC;LINKAGE=IB

[26] WANG 22C use the spin-amplifier based on hyperpolarized ^{129}Xe to set limits on the product of the axion couplings to electrons and nucleons as $g_{Aee}\, g_{Ann} < 4 \times 10^2$ (95 % CL) at $m_{A^0} = 0.1$ meV. Here g_{Ann} is the dimensionless axion-neutron coupling. See their Fig. 4 for the mass-dependent limits. NODE=S029AEC;LINKAGE=BB

[27] XIAO 22 extend XIAO 21 in the list of photon coupling limits by including the production of axions from Compton and bremsstrahlung processes, and set limits on the product of the axion couplings to electrons and photons as $G_{A\gamma\gamma}\, g_{Aee} < 0.4\text{–}2.8 \times 10^{-24}$ GeV^{-1} (95 % CL) for $m_{A^0} < 3.5 \times 10^{-11}$eV. See their Fig. 5 for the limits. They are comparable to those of DESSERT 19 and more restrictive than the CAST bounds of BARTH 13. NODE=S029AEC;LINKAGE=KB

[28] CALORE 21 consider the production of axions from Galactic and extragalactic SNe via nucleon-nucleon bremsstrahlung and their subsequent decay into electron-positron pairs, and exclude the range of $g_{Aee} \simeq 10^{-19}\text{–}10^{-11}$ at $g_{App} = 10^{-9}$ for $m_{A^0} = 3\text{–}30$ MeV. See their Fig. 7 for the limits. NODE=S029AEC;LINKAGE=YA

[29] LUCENTE 21 study the axion production in a supernova via electron-proton bremsstrahlung and electron-positron fusion, and exclude the range of $g_{Aee} \simeq 2 \times 10^{-9}\text{–}5.5 \times 10^{-7}$ for masses less than 1 MeV. See their Fig. 12 for the mass-dependent limits extending up to 150 MeV. This limit was corrected in the erratum. NODE=S029AEC;LINKAGE=ZA

[30] AGOSTINI 20 is analogous to AHMED 09A. The quoted limit applies to $m_{A^0} = 150$ keV. Their limits in their Fig. 3 were later found to be incorrect due to an error of their Eqs. (1) and (2). See Fig. 3 in AGOSTINI 22A for the corrected limits. NODE=S029AEC;LINKAGE=MA

[31] AMARAL 20 use a second-generation SuperCDMS high-voltage eV-resolution detector to set limits on dark-matter axion absorption. The quoted limit is for $m_{A^0} \simeq 17$ eV. The local density $\rho_A = 0.3$ GeV/cm^3 is assumed. See their Fig. 3 for mass-dependent limits. NODE=S029AEC;LINKAGE=RA

[32] APRILE 20 is an update of APRILE 17B where they look for an absorption signal of axion dark matter. They obtained the limit, $g_{Aee} \lesssim 2 \times 10^{-14}\text{–}1 \times 10^{-12}$ at 90%CL for $m_{A^0} = 1\text{–}200$ keV. They also found an excess over known backgrounds, which favors the mass $m_{A^0} = 2.3 \pm 0.2$ keV with a 3 σ significance. See their Fig. 10 for mass-dependent limits. NODE=S029AEC;LINKAGE=UA

[33] APRILE 20 look for solar axions from the ABC interactions, the Primakoff conversion, and the 14.4 keV M1 transition of ^{57}Fe, and set limits on g_{Aee}, $G_{A\gamma\gamma}$, g_{ANN}, and their products. An excess is observed at low energies between 2 and 3 keV. See their Fig.8 for correlation between the couplings. The quoted limit applies to the case of vanishing $G_{A\gamma\gamma}$ and g_{ANN}. NODE=S029AEC;LINKAGE=VA

[34] ARALIS 20 is analogous to AHMED 09A. The quoted limit applies to $m_{A^0} = 0.3$ keV. The limits at masses above 3 keV in their Fig. 9 was later found to be incorrect due to an error in their analysis. See Fig. 2 in erratum for the corrected limits. NODE=S029AEC;LINKAGE=NA

[35] CAPOZZI 20 obtains a limit on the axion-electron coupling from the brightness of the tip of the red-giant branch in ω Centauri. A similar limit of $< 1.6 \times 10^{-13}$ is obtained in NGC 4258. NODE=S029AEC;LINKAGE=SA

[36] CRESCINI 20 is an update of CRESCINI 18. They assume a local axion dark matter density, $\rho_A = 0.3$ GeV/cm^3. See their Fig.4 for the limits. NODE=S029AEC;LINKAGE=OA

[37] GHOSH 20A study thermal production of axion via coupling to leptons in the early universe and estimate its contribution to ΔN_{eff}. The quoted limit is for $\Delta N_{\text{eff}} < 0.5$. See their Fig. 7 for their mass-dependent limits. NODE=S029AEC;LINKAGE=WA

[38] STRANIERO 20 is analogous to CAPOZZI 20, with 22 galactic globular clusters used to derive the limit. NODE=S029AEC;LINKAGE=XA

[39] WANG 20A is an update of LIU 17A. See their Fig. 9. NODE=S029AEC;LINKAGE=PA

[40] WANG 20A is an update of LIU 17A. They assume a local axion dark matter density, $\rho_A = 0.3$ GeV/cm^3. See their Fig. 10 for limits between $0.185 < m_{A^0} < 10$ keV. NODE=S029AEC;LINKAGE=QA

[41] ADHIKARI 19B is analogous to LIU 17A. NODE=S029AEC;LINKAGE=IA

[42] APRILE 19D is analogous to APRILE 17B, but they use only ionization signals. The quoted limit applies to $m_{A^0} = 0.7$ keV. See their Fig. 5(e) for mass-dependent limits. NODE=S029AEC;LINKAGE=LA

[43] DESSERT 19 used the Suzaku observations of a magnetic white dwarf (RE J0317-853) to look for X-ray signatures converted from axions in the surrounding magnetic fields. They obtained the limit, $g_{Aee} \cdot G_{A\gamma\gamma} < 1.6 \times 10^{-24}$ GeV^{-1} at 95%CL for $m_{A^0} \lesssim 10^{-5}$ eV. See their Fig. 2 for mass-dependent limits. NODE=S029AEC;LINKAGE=JA

[44] TERRANO 19 look for the axion-induced oscillating magnetic field acting on the electron spin, using data taken with a rotating torsion pendulum containing polarized electrons. NODE=S029AEC;LINKAGE=KA

The quoted limit applies to $m_{A^0} = 10^{-23}$–10^{-18} eV and assumes a local axion dark matter density, $\rho_A = 0.45$ GeV/cm^3. See their Fig. 5 for mass-dependent limits.

[45] ABE 18F is an update of ABE 14F. The quoted limit applies to $m_{A^0} = 60$ keV. See their Fig. 5 for mass-dependent limits. NODE=S029AEC;LINKAGE=GA

[46] ARMENGAUD 18 is analogous to LIU 17A. NODE=S029AEC;LINKAGE=BA

[47] ARMENGAUD 18 is analogous to AHMED 09A. See the left panel of Fig. 5 for mass-dependent limits. NODE=S029AEC;LINKAGE=FA

[48] CRESCINI 18 look for collective excitations of the electron spins caused by dark matter axions. The quoted limit assumes the local dark matter density, $\rho_A = 0.45$ GeV/cm^3. NODE=S029AEC;LINKAGE=AA

[49] FICEK 18 use the measurements of the hyperfine structure of antiprotonic helium to constrain a dipole-dipole potential between electron and antiproton. See their Fig. 3 for limits on various spin- and velocity-dependent potentials. NODE=S029AEC;LINKAGE=CA

[50] ABGRALL 17 is analogous to AHMED 09A using the MAJORANA DEMONSTRATOR. See their Fig. 2 for limits between 6 keV $< m_{A^0} <$ 97 keV. NODE=S029AEC;LINKAGE=W

[51] AKERIB 17B is analogous to LIU 17A. NODE=S029AEC;LINKAGE=X

[52] AKERIB 17B is analogous to AHMED 09A. See their Fig. 7 for mass-dependent limits. NODE=S029AEC;LINKAGE=Y

[53] APRILE 17B is analogous to AHMED 09A. They found a bug in their code and needed to correct the limits in Fig. 7 of APRILE 14B. See their Fig. 1 for the corrected limits between 1 keV $< m_{A^0} <$ 40 keV. NODE=S029AEC;LINKAGE=S

[54] FICEK 17 look for spin-dependent interactions between electrons by comparing precision spectroscopic measurements in ^{4}He with theoretical calculations. See their Fig. 1 for limits up to $m_{A^0} = 10$ keV. NODE=S029AEC;LINKAGE=N

[55] FU 17A is analogous to LIU 17A. See their Fig. 3 for mass-dependent limits. NODE=S029AEC;LINKAGE=P

[56] FU 17A is analogous to AHMED 09A. See their Fig. 4 for mass-dependent limits. NODE=S029AEC;LINKAGE=V

[57] LIU 17A is analogous to AHMED 09A. See their Fig. 9 for limits between 0.25 keV $< m_{A^0} <$ 20 keV. NODE=S029AEC;LINKAGE=T

[58] LIU 17A look for solar axions produced from Compton, bremsstrahlung, atomic-recombination and deexcitation channels, and set a limit for $m_{A^0} <$ 1 keV. NODE=S029AEC;LINKAGE=U

[59] LUO 17 use a recent measurement of the dipole-dipole interaction between two iron atoms at the nanometer scale and set a limit for $m_{A^0} <$ 1 keV. See their Fig. 3 for mass-dependent limits. NODE=S029AEC;LINKAGE=Z

[60] BATTICH 16 is analogous to CORSICO 16 and used the pulsating DB white dwarf PG 1351+489. NODE=S029AEC;LINKAGE=R

[61] CORSICO 16 studied the cooling rate of the pulsating DA white dwarf L19-2 based on an asteroseismic model. NODE=S029AEC;LINKAGE=Q

[62] YOON 16 look for solar axions with the axio-electric effect in CsI(Tl) crystals and set a limit for $m_{A^0} <$ 1 keV. NODE=S029AEC;LINKAGE=M

[63] TERRANO 15 used a torsion pendulum and rotating attractor with 20-pole electron-spin distributions. See their Fig. 4 for a mass-dependent limit up to $m_{A^0} = 500$ μeV. NODE=S029AEC;LINKAGE=O

[64] ABE 14F set limits on the axioelectric effect in the XMASS detector assuming the pseudoscalar constitutes all the local dark matter. See their Fig. 3 for limits between m_{A^0} = 40–120 keV. NODE=S029AEC;LINKAGE=L

[65] APRILE 14B look for solar axions using the XENON100 detector. NODE=S029AEC;LINKAGE=H

[66] APRILE 14B is analogous to AHMED 09A. Their Fig. 7 was later found to be incorrect due to a bug in their code. See Fig. 1 in APRILE 17B for the corrected limits. NODE=S029AEC;LINKAGE=I

[67] DERBIN 14 is an update of DERBIN 13 with a BGO scintillating bolometer. See their Fig. 3 for mass-dependent limits. NODE=S029AEC;LINKAGE=J

[68] MILLER-BERTOLAMI 14 studied the impact of axion emission on white dwarf cooling in a self-consistent way. NODE=S029AEC;LINKAGE=K

[69] ABE 13D is analogous to DERBIN 12, using the XMASS detector. NODE=S029AEC;LINKAGE=A

[70] ARMENGAUD 13 is similar to AALSETH 11. See their Fig. 10 for limits between 3 keV $< m_{A^0} <$ 100 keV. NODE=S029AEC;LINKAGE=D

[71] ARMENGAUD 13 is similar to DERBIN 12, and take account of axio-recombination and axio-deexcitation effects. See their Fig. 12 for mass-dependent limits. NODE=S029AEC;LINKAGE=E

[72] BARTH 13 search for solar axions produced by axion-electron coupling, and obtained the limit, $g_{Aee} \cdot G_{A\gamma\gamma} < 8.1 \times 10^{-23}$ GeV^{-1} at 95%CL. NODE=S029AEC;LINKAGE=B

[73] DERBIN 13 looked for 5.5 MeV solar axions produced in $pd \rightarrow {}^3\mathrm{He}\, A^0$ in a BGO detector through the axioelectric effect. See their Fig. 4 for mass-dependent limits. NODE=S029AEC;LINKAGE=C

[74] HECKEL 13 studied the influence of 2 or 4 stationary sources each containing 6.0×10^{24} polarized electrons, on a rotating torsion pendulum containing 9.8×10^{24} polarized electrons. See their Fig. 4 for mass-dependent limits. NODE=S029AEC;LINKAGE=G

[75] VIAUX 13A constrain axion emission using the observed brightness of the tip of the red-giant branch in the globular cluster M5. NODE=S029AEC;LINKAGE=F

[76] CORSICO 12 attributed the excessive cooling rate of the pulsating white dwarf R548 to emission of axions with $g_{Aee} \simeq 4.8 \times 10^{-13}$. NODE=S029AEC;LINKAGE=CO

[77] DERBIN 12 look for solar axions with the axio-electric effect in a Si(Li) detector. The solar production is based on Compton and bremsstrahlung processes. NODE=S029AEC;LINKAGE=DE

[78] AALSETH 11 is analogous to AHMED 09A. See their Fig. 4 for mass-dependent limits. NODE=S029AEC;LINKAGE=AL

[79] AHMED 09A assume keV-mass pseudoscalars are the local dark matter and constrain the axio-electric effect in the CDMS detector. See their Fig. 5 for mass-dependent limits. NODE=S029AEC;LINKAGE=AH

[80] DAVOUDIASL 09 use geophysical constraints on Earth cooling by axion emission. NODE=S029AEC;LINKAGE=DA

[81] These experiments measured induced magnetization of a bulk material by the spin-dependent potential generated from other bulk material with aligned electron spins, where the magnetic field is shielded with superconductor. The sign of the limit set by CHUI 93 is opposite to that of the axion-mediated dipole-dipole potential. NODE=S029AEC;LINKAGE=B4

[82] These experiments used a torsion pendulum to measure the potential between two bulk matter objects where the spins are polarized but without a net magnetic field in either of them. The limits reflect the corrected sign of the dipole-dipole potential. NODE=S029AEC;LINKAGE=D4

[83] WINELAND 91 looked for an effect of bulk matter with aligned electron spins on atomic hyperfine splitting using nuclear magnetic resonance. NODE=S029AEC;LINKAGE=A4

Invisible A^0 (Axion) Limits from Nucleon Coupling

NODE=S029IAN

Limits are for the axion mass in eV. NODE=S029IAN

NODE=S029IAN

• • • We do not use the following data for averages, fits, limits, etc. • • •

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT	
		[1] ALONSO-GON...	25	SK	Diffuse supernova axions	
		[2] ARIAS-ARAG...	25	BORX	Solar axions	
		[3] BASILICO	25	BORX	Solar axions	
		[4] GENG	25		Solar axions	
		[5] WALTER	25	CASP	Dark matter, NMR	
		[6] ZHANG	25A	NMR	Ultralight dark matter	
< 0.01	95	[7] LELLA	24	ASTR	SN1987A	
		[8] SU	24	NMR	polarized ^{129}Xe	
		[9] KARANTH	23		Deuteron EDM	
		[10] LEE	23		Axion dark matter	
< 0.016	95	[11] BUSCHMANN	22	ASTR	Neutron star cooling	
<320	90	[12] GAVRILYUK	22	CNTR	Solar axion	
		[13] SCHULTHESS	22		Neutron EDM	
		[14] AYBAS	21	CASP	Nucleon EDM	
		[15] BHUSAL	21		Solar axion	
		[16] JIANG	21	NMR	Axion dark matter	
		[17] ROUSSY	21		Molecular EDM	
		[18] ZHANG	21B	ASTR	Neutron star inspiral	
< 24	90	[19] ABDELHAME...	20	CNTR	Solar axion	
		[20] ABDELHAME...	20	CNTR	Solar axion	OCCUR=2
		[21] APRILE	20	XE1T	Solar axion	
		[22] KLIMCHITSK...	20		Casimir effect	
< 7.3	90	[23] WANG	20A	CDEX	Solar axion	
< 0.03		[24] LEINSON	19	ASTR	Neutron star cooling	
< 9.6 $\times 10^{-3}$	95	[25] LLOYD	19	ASTR	γ-rays from NS	
		[26] SMORRA	19		$\overline{p}$ g-factor	
		[27] WU	19	NMR	Axion dark matter	
< 65	95	[28] AKHMATOV	18	CNTR	Solar axion	
< 6.6	90	[29] ARMENGAUD	18	EDE3	Solar axion	
< 0.085	90	[30] BEZNOGOV	18	ASTR	Neutron star cooling	
< 12.7	95	[31] GAVRILYUK	18	CNTR	Solar axion	
< 0.01		[32] HAMAGUCHI	18	ASTR	Neutron star cooling	
		[33] ABEL	17		Neutron EDM	
< 93	90	[34] ABGRALL	17	HPGE	Solar axion	
< 4	90	[35] FU	17A	PNDX	Solar axion	
		[36] KLIMCHITSK...	17A		Casimir effect	
<177	90	[37] LIU	17A	CDEX	Solar axion	
< 0.079	95	[38] BERENJI	16	ASTR	γ-rays from NS	
<100	95	[39] GAVRILYUK	15	CNTR	Solar axion	OCCUR=2
		[40] KLIMCHITSK...	15		Casimir-less	
		[41] BEZERRA	14		Casimir effect	
		[42] BEZERRA	14A		Casimir effect	
		[43] BEZERRA	14B		Casimir effect	
		[44] BEZERRA	14C		Casimir effect	
		[45] BLUM	14	COSM	^{4}He abundance	
		[46] LEINSON	14	ASTR	Neutron star cooling	
<250	95	[47] ALESSANDRIA	13	CNTR	Solar axion	
<155	90	[48] ARMENGAUD	13	EDEL	Solar axion	
< 8.6 $\times 10^3$	90	[49] BELLI	12	CNTR	Solar axion	
< 1.4 $\times 10^4$	90	[50] BELLINI	12B	BORX	Solar axion	
<145	95	[51] DERBIN	11	CNTR	Solar axion	
		[52] BELLINI	08	CNTR	Solar axion	
		[53] ADELBERGER	07		Test of Newton's law	

[1] ALONSO-GONZALEZ 25 use Super-Kamiokade data to search for the diffuse flux of axion-like particles produced in galactic core-collapse supernovae via the interaction with protons in the detector, $A^0 p \to p\gamma$. They set bounds on axion-proton couplings between a minimum and maximum of 2×10^{-5}–2×10^{-4} up to axion masses of 70 MeV, see their Fig. 4. ALONSO-GONZALEZ 25A details an erratum for this publication. NODE=S029IAN;LINKAGE=TA

[2] ARIAS-ARAGON 25 use Borexino data to search for axion-induced pair production and inverse Compton scattering due to the flux of 5.5 MeV axions from proton-deuteron fusion in the Sun. They constrain the combination of axion-electron and axion-nucleon couplings for $m_{A^0} \lesssim 1$ MeV as shown in their Fig. 4. NODE=S029IAN;LINKAGE=UA

[3] BASILICO 25 use Borexino data to search for the flux of 5.5 MeV axions produced through proton-deuteron fusion in the Sun, which can lead to detectable signals in the detector through axion decay to two photons, Primakoff and Compton conversion to photons, and the liberation of electrons through the axio-electric effect. They set bounds on the product of the axion-electron and axion-nucleon couplings, and the product of the axion-photon and axion-nucleon couplings, for $m_{A^0} < 1$ MeV. NODE=S029IAN;LINKAGE=VA

[4] GENG 25 use a public electron recoil dataset from the XENONnT collaboration to search for events caused by the flux of 14.4 keV axions produced in M1 transitions of ^{57}Fe nuclei in the solar interior. They set limits on the product of the axion-photon and axion-nucleon couplings and the product of the axion-electron and axion-nucleon couplings for axion masses below 14.4 keV. NODE=S029IAN;LINKAGE=WA

[5] WALTER 25 report results from a demonstrator for the CASPEr-Gradient experiment, which in this case used proton nuclear magnetic resonance spectroscopy of methanol to search for axion-like particle dark matter coupled to protons. They are sensitive in a narrow window around an ALP mass of 5.576741 neV. See their Fig. 3 for mass-dependent limits. NODE=S029IAN;LINKAGE=XA

[6] ZHANG 25A set limits on dark matter axion-like particles coupled to nucleons in the 1×10^{-24}–5×10^{-21} eV mass range by reanalyzing data from a Helium-3/Xenon-129 comagnetometer experiment originally performed to test for Lorentz and CPT violations. See their Fig. 3 for mass-dependent limits. NODE=S029IAN;LINKAGE=YA

[7] LELLA 24 update constraints on the axion-proton coupling from supernova 1987A based on the SN cooling argument (including a treatment of the trapping regime) as well as the non-observation of any coincident axion-induced events in the Kamiokande II neutrino detector. They exclude QCD axion models above 0.01 eV, and axion-like particles in a window that extends up to 300 MeV. See their Fig. 3 for mass-dependent limits. NODE=S029IAN;LINKAGE=RA

[8] SU 24 search for an axion-mediated dipole-dipole force between two separated spin-polarized samples of ^{129}Xe gas. They set limits on the axion-neutron coupling for axion masses between 3.2 and 24.3 μeV. See their Fig. 4(b) for mass-dependent limits. NODE=S029IAN;LINKAGE=SA

[9] KARANTH 23 utilized an in-plane polarized deuteron beam in a storage ring to constrain the axion-induced oscillating EDM of the deuteron for $m_{A^0} = 0.496$–0.502 neV. Assuming axions account for all dark matter with $\rho_A \simeq 0.55$ GeV/cm^3, they derived constraints on axion couplings to the deuteron EDM operator, gluons, and the deuteron spin. For detailed limits, see their Figs. 19–21. NODE=S029IAN;LINKAGE=QA

[10] LEE 23 analyzed data from a K$-^3$He comagnetometer, accounting for stochastic effects, to limit the axion-neutron coupling $g_{Ann} < 2.4 \times 10^{-10}$ GeV^{-1} at 95% CL for m_{A^0} = 0.4–4 feV. They assumed axions form all dark matter with a density of 0.3 GeV/cm^3. See their Fig. 5 for the limits. NODE=S029IAN;LINKAGE=PA

[11] BUSCHMANN 22 studied the axion emission from five neutron stars with ages $\sim 10^5$–10^6 years, comparing the simulation with axions to age and luminosity measurements. The mass bound assumes the KSVZ axion model with $C_p = -0.47$ and $C_n = -0.02$. See their Fig. 3 for the limits on the DFSZ axion model. NODE=S029IAN;LINKAGE=MA

[12] GAVRILYUK 22 look for solar axions from the ABC interactions with the experimental setup similar to GAVRILYUK 15. The mass bound assumes the KSVZ axion model, $S = 0.5$, and $m_u/m_d = 0.56$. NODE=S029IAN;LINKAGE=LA

[13] SCHULTHESS 22 look for a time-oscillating neutron EDM caused by the coupling between axion dark matter and gluons, using a Ramsey-type apparatus for a cold neutron beam. See their Fig. 4 for limits in the range of $m_{A^0} = 10^{-19}$–4×10^{-12} eV. NODE=S029IAN;LINKAGE=OA

[14] AYBAS 21 limits the axion couplings to the nucleon EDM and the nucleons as $g_{AN\gamma} < 9.5 \times 10^{-4}$ GeV^{-2} and $g_{ANN}/2m_N < 0.28$ GeV^{-1} (95 % CL) for $m_{A^0} = 162$–166 neV, based on a measurement of ^{207}Pb solid-state NMR in a polarized ferroelecrtric crystal. Here m_N is the nucleon mass and g_{ANN} is the dimensionless axion-nucleon coupling. They assume that axions make up all the dark matter with $\rho_A \simeq 0.46$ GeV/cm^3. See their Fig. 3 for the limits. NODE=S029IAN;LINKAGE=HA

[15] BHUSAL 21 looked for 5.5 MeV solar axions produced by $pd \to {}^3\mathrm{He}\, A^0$ through the axion-induced dissociation of deuterons by using SNO data, and set a limit on the isovector axion-nucleon coupling, $|g^3_{aN}| < 2 \times 10^{-5}$ GeV^{-1}, which is equivalent to $|g_{Ann} - g_{App}| < 4 \times 10^{-5}$ in terms of the dimensionless axion-nucleon couplings. NODE=S029IAN;LINKAGE=IA

[16] JIANG 21 use the spin-amplifier based on hyperpolarized ^{129}Xe gas to set limits on the axion couplings to nucleons as $g_{ANN}/2m_N < 3.2 \times 10^{-9}$ GeV^{-1} (95 % CL) at $m_{A^0} = 52.94$ feV, and comparable limits in the mass range of 8.3–744 feV. Here m_N is the nucleon mass and g_{ANN} is the dimensionless axion-nucleon coupling. They assume NODE=S029IAN;LINKAGE=KA

that axions make up all the dark matter with $\rho_A \simeq 0.4$ GeV/cm^3. See their Fig. 4b for the limits.

[17] ROUSSY 21 look for a time-oscillating EDM of molecular ions HfF$^+$ induced by axion dark matter couplings to gluons. See their Fig. 3 for limits in the range of m_{A^0} = 10^{-22}–10^{-15} eV. NODE=S029IAN;LINKAGE=GA

[18] ZHANG 21B use the gravitational waves from the binary neutron star inspiral GW170817 to look for a type of axion whose mass is suppressed due to cancellation with additional contributions. They exclude $1.6 \times 10^{16} < f_A < 10^{18}$ GeV at 3 σ for $m_{A^0} \lesssim 10^{-13}$ eV. See their Fig. 1 for mass-dependent limits. NODE=S029IAN;LINKAGE=JA

[19] ABDELHAMEED 20 look for the resonant excitation of ^{169}Tm (8.41 keV) by solar axions produced via the Primakoff effect. The mass bound assumes the KSVZ axion model, $S = 0.5$, and $m_u/m_d = 0.56$. They set a limit on the product of axion couplings to photons and nucleons as $G_{A\gamma\gamma} \cdot g_{App} < 1.44 \times 10^{-14}$ GeV^{-1} (90 % CL). NODE=S029IAN;LINKAGE=BA

[20] ABDELHAMEED 20 look for the resonant excitation of ^{169}Tm (8.41 keV) by solar axions produced via the axion-electron coupling. They set a limit on the product of axion couplings to electrons and nucleons as $g_{Aee} \cdot g_{App} < 2.81 \times 10^{-16}$ (90 % CL). NODE=S029IAN;LINKAGE=CA

[21] APRILE 20 look for solar axions from the ABC interactions, the Primakoff conversion, and the 14.4 keV M1 transition of ^{57}Fe. An excess is observed at low energies between 2 and 3 keV. See their Fig.8 for correlation between the couplings. NODE=S029IAN;LINKAGE=FA

[22] KLIMCHITSKAYA 20 use the measurement of the Casimir force between a Au-coated microsphere and a SiC plate to constrain the force due to two-axion exchange for 17.8 $< m_{A^0} <$ 100 eV. See their Fig. 2 for mass-dependent limits. NODE=S029IAN;LINKAGE=DA

[23] WANG 20A is an update of LIU 17A. The limit assumes the DFSZ axion. See their Fig. 7 for the limit on product of axion couplings to electrons and nucleons. NODE=S029IAN;LINKAGE=EA

[24] LEINSON 19 is analogous to BEZNOGOV 18, but estimating the axion luminosity based on the Tolman's analytic solution to the Einstein equations of spherical fluids in hydrostatic equilibrium. The dimensionless axion-neutron coupling is constrained as $g_{Ann} < 1.0 \times 10^{-10}$. NODE=S029IAN;LINKAGE=Y

[25] LLOYD 19 is analogous to BERENJI 16. They highlight that the limit obtained with this technique strongly depends on the assumed NS core temperature. NODE=S029IAN;LINKAGE=AA

[26] SMORRA 19 look for spin-precession effects from ultra-light axion dark matter in the $\overline{p}$ spin-flip resonance data. Assuming $\rho_A = 0.4$ GeV/cm^3, they constrain the dimensionless axion-antiproton coupling as $g_{A\overline{p}\overline{p}} <$ 2–9 at 95% CL for $m_{A^0} = 2\times10^{-23}$–$4\times10^{-17}$ eV. See the right panel of their Fig. 3. NODE=S029IAN;LINKAGE=X

[27] WU 19 look for axion-induced time-oscillating features of the NMR spectrum of acetonitrile-2-^{13}C. Assuming $C_p = C_n$ and $\rho_A = 0.4$ GeV/cm^3, they constrain the dimensionless axion-nucleon coupling as $g_{ANN} < 6 \times 10^{-5}$ for m_{A^0} = 10^{-21}–1.3×10^{-17} eV. Note that the limits for $m_{A^0} < 10^{-21}$ eV in their Fig. 3(a) should be weaker than those for heavier masses. See ADELBERGER 19 and WU 19C on this issue. NODE=S029IAN;LINKAGE=W

[28] AKHMATOV 18 is an update of GAVRILYUK 15. NODE=S029IAN;LINKAGE=R

[29] ARMENGAUD 18 is analogous to ALESSANDRIA 13. The quoted limit assumes the DFSZ axion model. See their Fig. 4 for the limit on product of axion couplings to electrons and nucleons. NODE=S029IAN;LINKAGE=T

[30] BEZNOGOV 18 constrain the axion-neutron coupling by assuming that thermal evolution of the hot neutron star HESS J1731-347 is dominated by the lowest possible neutrino emission. The quoted limit assumes the KSVZ axion with the effective Peccei-Quinn charge of the neutron $C_n = -0.02$. The dimensionless axion-neutron couling is constrained as $g_{Ann} < 2.8 \times 10^{-10}$. NODE=S029IAN;LINKAGE=U

[31] GAVRILYUK 18 look for the resonant excitation of ^{83}Kr (9.4 keV) by solar axions produced via the Primakoff effect. The mass bound assumes $m_u/m_d = 0.56$ and $S = 0.5$. NODE=S029IAN;LINKAGE=S

[32] HAMAGUCHI 18 studied the axion emission from the neutron star in Cassiopeia A based on the minimal cooling scenario which explains the observed rapid cooling rate. The quoted limit corresponds to $f_A > 5 \times 10^8$ GeV obtained for the KSVZ axion with $C_p = -0.47$ and $C_n = -0.02$. NODE=S029IAN;LINKAGE=V

[33] ABEL 17 look for a time-oscillating neutron EDM and an axion-wind spin-precession effect respectively induced by axion dark matter couplings to gluons and nucleons. See their Fig. 4 for limits in the range of $m_{A^0} = 10^{-24}$–10^{-17} eV. NODE=S029IAN;LINKAGE=Q

[34] ABGRALL 17 limit assumes the hadronic axion model used in ALESSANDRIA 13. See their Fig. 4 for the limit on product of axion couplings to electrons and nucleons. NODE=S029IAN;LINKAGE=N

[35] FU 17A look for the 14.4 keV ^{57}Fe solar axions. The limit assumes the DFSZ axion model. See their Fig. 3 for mass-dependent limits on the axion-electron coupling. Notice that in this figure the DFSZ and KSVZ lines should be interchanged. NODE=S029IAN;LINKAGE=P

[36] KLIMCHITSKAYA 17A use the differential measurement of the Casimir force between a Ni-coated sphere and Au and Ni sectors of the structured disc to constrain the axion coupling to nucleons for 2.61 meV $< m_{A^0} <$ 0.9 eV. See their Figs. 1 and 2 for mass dependent limits. NODE=S029IAN;LINKAGE=O

[37] LIU 17 is analogous to ALESSANDRIA 13. The limit assumes the hadronic axion model. See their Fig. 6(b) for the limit on product of axion couplings to electrons and nucleons. NODE=S029IAN;LINKAGE=M

[38] BERENJI 16 used the Fermi LAT observations of neutron stars to look for photons from axion decay. They assume the effective Peccei-Quinn charge of the neutron $C_n = 0.1$ and a neutron-star core temperature of 20 MeV. NODE=S029IAN;LINKAGE=Z

[39] GAVRILYUK 15 look for solar axions emitted by the M1 transition of ^{83}Kr (9.4 keV). The mass bound assumes $m_u/m_d = 0.56$ and $S = 0.5$. NODE=S029IAN;LINKAGE=K

[40] KLIMCHITSKAYA 15 use the measurement of differential forces between a test mass and rotating source masses of Au and Si to constrain the force due to two-axion exchange for $1.7 \times 10^{-3} < m_{A^0} < 0.9$ eV. See their Figs. 1 and 2 for mass dependent limits. NODE=S029IAN;LINKAGE=L

[41] BEZERRA 14 use the measurement of the thermal Casimir-Polder force between a Bose-Einstein condensate of ^{87}Rb atoms and a SiO_2 plate to constrain the force mediated by exchange of two pseudoscalars for 0.1 meV $< m_{A^0} <$ 0.3 eV. See their Fig. 2 for the mass-dependent limit on pseudoscalar coupling to nucleons. NODE=S029IAN;LINKAGE=E

[42] BEZERRA 14A is analogous to BEZERRA 14. They use the measurement of the Casimir pressure between two Au-coated plates to constrain pseudoscalar coupling to nucleons for 1×10^{-3} eV $< m_{A^0} <$ 15 eV. See their Figs. 1 and 2 for the mass-dependent limit. NODE=S029IAN;LINKAGE=F

[43] BEZERRA 14B is analogous to BEZERRA 14. BEZERRA 14B use the measurement of the normal and lateral Casimir forces between sinusoidally corrugated surfaces of a sphere and a plate to constrain pseudoscalar coupling to nucleons for 1 eV $< m_{A^0} <$ 20 eV. See their Figs. 1–3 for mass-dependent limits. NODE=S029IAN;LINKAGE=G

[44] BEZERRA 14C is analogous to BEZERRA 14. They use the measurement of the gradient of the Casimir force between Au- and Ni-coated surfaces of a sphere and a plate to constrain pseudoscalar coupling to nucleons for 3×10^{-5} eV $< m_{A_0} <$ 1 eV. See their Figs. 1, 3, and 4 for the mass-dependent limits. NODE=S029IAN;LINKAGE=BZ

[45] BLUM 14 studied effects of an oscillating strong *CP* phase induced by axion dark matter on the primordial ^{4}He abundance. See their Fig. 1 for mass-dependent limits. NODE=S029IAN;LINKAGE=I

[46] LEINSON 14 attributes the excessive cooling rate of the neutron star in Cassiopeia A to axion emission from the superfluid core, and found $C_n^2\ m_{A^0}^2 \simeq 5.7 \times 10^{-6}$ eV^2, where C_n is the effective Peccei-Quinn charge of the neutron. NODE=S029IAN;LINKAGE=H

[47] ALESSANDRIA 13 used the CUORE experiment to look for 14.4 keV solar axions produced from the M1 transition of thermally excited ^{57}Fe nuclei in the solar core, using the axio-electric effect. The limit assumes the hadronic axion model. See their Fig. 4 for the limit on product of axion couplings to electrons and nucleons. NODE=S029IAN;LINKAGE=C

[48] ARMENGAUD 13 is analogous to ALESSANDRIA 13. The limit assumes the hadronic axion model. See their Fig. 8 for the limit on product of axion couplings to electrons and nucleons. NODE=S029IAN;LINKAGE=D

[49] BELLI 12 looked for solar axions emitted by the M1 transition of ^{7}Li* (478 keV) after the electron capture of ^{7}Be, using the resonant excitation ^{7}Li in the LiF crystal. The mass bound assumes $m_u/m_d = 0.55$, $m_u/m_s = 0.029$, and the flavor-singlet axial vector matrix element $S = 0.4$. NODE=S029IAN;LINKAGE=BI

[50] BELLINI 12B looked for 5.5 MeV solar axions produced in the $p d \to {}^3$He A^0.The limit assumes the hadronic axion model. See their Figs. 6 and 7 for mass-dependent limits on productsof axion couplings to photons, electrons, and nucleons. NODE=S029IAN;LINKAGE=BN

[51] DERBIN 11 looked for solar axions emitted by the M1 transition of thermally excited ^{57}Fe nuclei in the Sun, using their possible resonant capture on ^{57}Fe in the laboratory. The mass bound assumes $m_u/m_d = 0.56$ and the flavor-singlet axial vector matrix element $S = 3F - D \simeq 0.5$. NODE=S029IAN;LINKAGE=DN

[52] BELLINI 08 consider solar axions emitted in the M1 transition of ^{7}Li* (478 keV) and look for a peak at 478 keV in the energy spectra of the Counting Test Facility (CTF), a Borexino prototype. For $m_{A^0} <$ 450 keV they find mass-dependent limits on products of axion couplings to photons, electrons, and nucleons. NODE=S029IAN;LINKAGE=BE

[53] ADELBERGER 07 use precision tests of Newton's law to constrain a force contribution from the exchange of two pseudoscalars. See their Fig. 5 for limits on the pseudoscalar coupling to nucleons, relevant for m_{A^0} below about 1 meV. NODE=S029IAN;LINKAGE=AD

Axion Limits from *T*-violating Medium-Range Forces

NODE=S029IAT

The limit is for the coupling $g = g_p\ g_s$ in a *T*-violating potential between nucleons, nucleon and electron, or electrons of the form $V = \frac{g\hbar^2}{8\pi m_p}(\boldsymbol{\sigma}\cdot\hat{\boldsymbol{r}})\ (\frac{1}{r^2} + \frac{1}{\lambda r})\ e^{-r/\lambda}$, where g_s and g_p are dimensionless scalar and pseudoscalar coupling constants, m_p is the fermion mass with the pseudoscalar coupling (whereas the mass m_s of the fermion with the scalar coupling does not explicitly appear), and $\lambda = \hbar/(m_A c)$ is the range of the force. NODE=S029IAT

VALUE	DOCUMENT ID	TECN	COMMENT

NODE=S029IAT

• • • We do not use the following data for averages, fits, limits, etc. • • •

[1] AYRES	23	EDM	ultracold neutrons
[2] PODDAR	23	ASTR	solar system
[3] ZHANG	23	NMR	polarized ^{129}Xe and ^{131}Xe
[4] CRESCINI	22	SQID	paramagnetic GSO crystal
[5] FENG	22	NMR	polarized ^{129}Xe and ^{131}Xe
[6] AFACH	21	GNME	Optical magnetometers
[7] DZUBA	18	THEO	atomic EDM
[8] STADNIK	18	THEO	atomic and molecular EDMs
[9] CRESCINI	17	SQID	paramagnetic GSO crystal
[10] AFACH	15		ultracold neutrons
[11] STADNIK	15	THEO	nucleon spin contributions for nuclei
[12] TERRANO	15		torsion pendulum
[13] BULATOWICZ	13	NMR	polarized ^{129}Xe and ^{131}Xe
[14] CHU	13		polarized ^{3}He
[15] TULLNEY	13	SQID	polarized ^{3}He and ^{129}Xe
[16] RAFFELT	12		stellar energy loss
[17] HOEDL	11		torsion pendulum
[18] PETUKHOV	10		polarized ^{3}He
[19] SEREBROV	10		ultracold neutrons
[20] IGNATOVICH	09	RVUE	ultracold neutrons
[21] SEREBROV	09	RVUE	ultracold neutrons
[22] BAESSLER	07		ultracold neutrons
[23] HECKEL	06		torsion pendulum
[24] NI	99		paramagnetic Tb F_3
[25] POSPELOV	98	THEO	neutron EDM
[26] YOUDIN	96		
[27] RITTER	93		torsion pendulum
[28] VENEMA	92		nuclear spin-precession frequencies
[29] WINELAND	91	NMR	

[1] AYRES 23 at PSI use their neutron EDM setup to look for a mm to micron-range spin-dependent force between ultracold spin-polarized neutrons stored in vacuum and the unpolarised nucleons in the surrounding apparatus. They constrain a nucleon-neutron monopole-dipole interaction parameterised by the coupling $g_s^N g_p^n$. They set a limit of $g_s^N g_p^n < 10^{-20}$ (95% CL) for a 1 meV mass axion, see Fig. 6. NODE=S029IAT;LINKAGE=P

[2] PODDAR 23 search for long-range monopole-dipole forces between the polarized population of electrons inside the Earth and the unpolarised nucleons in the Sun, which would affect the precession of orbital perihelion. However, the most competitive limit is obtained by combining the monopole-monopole force constraints on g_s^N from planetary precession with the strongest stellar bound on the pseudoscalar electron coupling (g_p^e), shown in Fig. 5. NODE=S029IAT;LINKAGE=Q

[3] ZHANG 23 look for changes of the ratio of precession frequencies between ^{129}Xe and ^{131}Xe as the bias field is flipped in Earth's gravitational field after Earth roation effect is subtracted. They find $g_p^n g_s^N < 1 \times 10^{-26}$–$3.7 \times 10^{-36}$ for $\lambda = 0.3$–1×10^{10} m. See their Fig. 4 for limits as a function of λ. NODE=S029IAT;LINKAGE=O

[4] CRESCINI 22 is an update of CRESCINI 17, and find $g_p^e g_s^N \leq 5.7 \times 10^{-32}$ and $g_p^e g_s^e \leq 1.6 \times 10^{-31}$ for $\lambda \gtrsim 10$ cm at 95% CL. See their Fig. 4 for limits as a function of λ. NODE=S029IAT;LINKAGE=N

[5] FENG 22 look for changes of the ratio of precession frequencies between ^{129}Xe and ^{131}Xe when a BGO crystal is positioned near the atomic cell. They find $g_p^n g_s^N < 2 \times 10^{-20}$–$3 \times 10^{-24}$ for $\lambda = 0.11$–0.55 mm. See their Fig. 4 for limits as a function of λ. NODE=S029IAT;LINKAGE=M

[6] AFACH 21 look for axion domain walls coupled to atomic spins by using the global network of optical magnetometers. Assuming that the axion domain walls make up all dark matter, they exclude the effective decay constant below 4×10^5 GeV for m_{A^0} in the range of 10^{-15}–10^{-11} eV. See their Fig. 4 for the mass-dependent limits. NODE=S029IAT;LINKAGE=L

[7] DZUBA 18 used atomic EDM measurements to derive limits on the product of the pseudoscalar coupling to nucleon and the scalar coupling to electron, which improved on the laboratory bounds for $m_{A^0} > 0.01$ eV. See their Fig. 1 for mass-dependent limits. NODE=S029IAT;LINKAGE=K

[8] STADNIK 18 used atomic and molecular EDM experiments to derive limits on the product of the pseudoscalar couplings to electron and the scalar coupling to nucleon and electron. See their Fig. 2 for mass-dependent limits, which improved on the laboratory bounds for $m_{A^0} > 0.01$ eV. NODE=S029IAT;LINKAGE=H

[9] CRESCINI 17 use the QUAX-$g_p g_s$ experiment to look for variation of a paramagnetic GSO crystal magnetization when rotating lead disks are positioned near the crystal, and find $g = g_p^e g_s^N < 4.3 \times 10^{-30}$ for $\lambda = 0.1$–0.2 m at 95% CL. See their Fig. 6 for limits as a function of λ. NODE=S029IAT;LINKAGE=I

[10] AFACH 15 look for a change of spin precession frequency of ultracold neutrons when a magnetic field with opposite directions is applied, and find $g < 2.2 \times 10^{-27}$ $(\mathrm{m}/\lambda)^2$ at 95% CL for 1 μm $< \lambda <$ 5 mm. See their Fig. 3 for their limits. NODE=S029IAT;LINKAGE=D

[11] STADNIK 15 studied proton and neutron spin contributions for nuclei and derive the limits $g < 10^{-28}$–10^{-23} for $\lambda > 3 \times 10^{-4}$ m using the data of TULLNEY 13. See their Figs. 1 and 2 for λ-dependent limits. NODE=S029IAT;LINKAGE=F

[12] TERRANO 15 used a torsion pendulum and rotating attractor, and derived a restrictive limit on the product of the pseudoscalar coupling to electron and the scalar coupling to nucleons, $g < 9 \times 10^{-29}$–5×10^{-26} for $m_{A^0} <$ 1.5–400 μeV. See their Fig. 5 for mass-dependent limits. NODE=S029IAT;LINKAGE=G

[13] BULATOWICZ 13 looked for NMR frequency shifts in polarized ^{129}Xe and ^{131}Xe when a zirconia rod is positioned near the NMR cell, and find $g < 1 \times 10^{-19}$–1×10^{-24} for $\lambda = 0.01$–1 cm. See their Fig. 4 for their limits. NODE=S029IAT;LINKAGE=C

[14] CHU 13 look for a shift of the spin precession frequency of polarized ^{3}He in the presence of an unpolarized mass, in analogy to YOUDIN 96. See Fig. 3 for limits on g in the approximate m_{A^0} range 0.02–2 meV. NODE=S029IAT;LINKAGE=CH

[15] TULLNEY 13 look for a shift of the precession frequency difference between the colocated ^{3}He and ^{129}Xe in the presence an unpolarized mass, and derive limits g $< 3\times10^{-29}$–2×10^{-22} for $\lambda > 3 \times 10^{-4}$ m. See their Fig. 3 for λ-dependent limits. NODE=S029IAT;LINKAGE=E

[16] RAFFELT 12 show that the pseudoscalar couplings to electron and nucleon and the scalar coupling to nucleon are individually constrained by stellar energy-loss arguments and searches for anomalous monopole-monopole forces, together providing restrictive constraints on g. See their Figs. 2 and 3 for results. NODE=S029IAT;LINKAGE=RA

[17] HOEDL 11 use a novel torsion pendulum to study the force by the polarized electrons of an external magnet. In their Fig. 3 they show restrictive limits on g in the approximate m_{A^0} range 0.03–10 meV. NODE=S029IAT;LINKAGE=HO

[18] PETUKHOV 10 use spin relaxation of polarized ^{3}He and find $g < 3 \times 10^{-23}$ $(\mathrm{cm}/\lambda)^2$ at 95% CL for the force range $\lambda = 10^{-4}$–1 cm. NODE=S029IAT;LINKAGE=PE

[19] SEREBROV 10 use spin precession of ultracold neutrons close to bulk matter and find $g < 2 \times 10^{-21}$ $(\mathrm{cm}/\lambda)^2$ at 95% CL for the force range $\lambda = 10^{-4}$–1 cm. NODE=S029IAT;LINKAGE=SR

[20] IGNATOVICH 09 use data on depolarization of ultracold neutrons in material traps. They show λ-dependent limits in their Fig. 1. NODE=S029IAT;LINKAGE=IG

[21] SEREBROV 09 uses data on depolarization of ultracold neutrons stored in material traps and finds $g < 2.96 \times 10^{-21}$ $(\mathrm{cm}/\lambda)^2$ for the force range $\lambda = 10^{-3}$–1 cm and $g < 3.9 \times 10^{-22}$ $(\mathrm{cm}/\lambda)^2$ for $\lambda = 10^{-4}$–10^{-3} cm, each time at 95% CL, significantly improving on BAESSLER 07. NODE=S029IAT;LINKAGE=SE

[22] BAESSLER 07 use the observation of quantum states of ultracold neutrons in the Earth's gravitational field to constrain g for an interaction range 1 μm–a few mm. See their Fig. 3 for results. NODE=S029IAT;LINKAGE=BA

[23] HECKEL 06 studied the influence of unpolarized bulk matter, including the laboratory's surroundings or the Sun, on a torsion pendulum containing about 9×10^{22} polarized electrons. See their Fig. 4 for limits on g as a function of interaction range. NODE=S029IAT;LINKAGE=HE

[24] NI 99 searched for a T-violating medium-range force acting on paramagnetic Tb F_3 salt. See their Fig. 1 for the result. NODE=S029IAT;LINKAGE=NI

[25] POSPELOV 98 studied the possible contribution of T-violating Medium-Range Force to the neutron electric dipole moment, which is possible when axion interactions violate CP. The size of the force among nucleons must be smaller than gravity by a factor of 2×10^{-10} $(1\,\mathrm{cm}/\lambda_A)$, where $\lambda_A = \hbar/m_A c$. NODE=S029IAT;LINKAGE=B

[26] YOUDIN 96 compared the precession frequencies of atomic ^{199}Hg and Cs when a large mass is positioned near the cells, relative to an applied magnetic field. See Fig. 3 for their limits. NODE=S029IAT;LINKAGE=A

[27] RITTER 93 studied the influence of bulk mass with polarized electrons on an unpolarized torsion pendulum, providing limits in the interaction range from 1 to 100 cm. NODE=S029IAT;LINKAGE=RI

[28] VENEMA 92 looked for an effect of Earth's gravity on nuclear spin-precession frequencies of ^{199}Hg and ^{201}Hg atoms. NODE=S029IAT;LINKAGE=VE

[29] WINELAND 91 looked for an effect of bulk matter with aligned electron spins on atomic hyperfine resonances in stored $^9\mathrm{Be}^+$ ions using nuclear magnetic resonance. NODE=S029IAT;LINKAGE=WE

Hidden Photons: Kinetic Mixing Parameter Limits

NODE=S029HPH

Limits are on the kinetic mixing parameter χ which is defined by the Lagrangian NODE=S029HPH

$$L = -\frac{1}{4}\, F_{\mu\nu}F^{\mu\nu} - \frac{1}{4}\, F'_{\mu\nu}F'^{\mu\nu} - \frac{\chi}{2}\, F_{\mu\nu}F'^{\mu\nu} + \frac{m^2_{\gamma'}}{2} A'_{\mu}A'^{\mu},$$

where A_μ and A'_μ are the photon and hidden-photon fields with field strengths $F_{\mu\nu}$ and $F'_{\mu\nu}$, respectively, and $m_{\gamma'}$ is the hidden-photon mass.

NODE=S029HPH

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<3 \times 10^{-3}$	90	[1] ABLIKIM	25CL	BES3	$m_{\gamma'} = 1 \times 10^{-2}$–0.525 GeV
$<8 \times 10^{-15}$	90	[2] ALBAKRY	25	CDMS	$m_{\gamma'} = 1.2$–23.3 eV

$<1 \times 10^{-14}$	95	[3] AN	25	ASTR	$m_{\gamma'} = 1\times10^{-10}$–$8\times10^{-8}$ eV
$<4 \times 10^{-5}$	90	[4] ANDREEV	25	NA64	$m_{\gamma'} = 1\times10^{-3}$–0.4 GeV
$<2 \times 10^{-16}$	90	[5] APRILE	25A	XENT	$m_{\gamma'} = 0.01$–0.4 keV
$>5 \times 10^{-3}$	90	[6] ASWATHI	25	ASTR	$m_{\gamma'} = 1\times10^{-14}$–$1.8\times10^{-12}$ eV
$<1 \times 10^{-10}$	95	[7] BAUDIS	25	QRCD	$m_{\gamma'} = 0.1$–30 eV
$<4 \times 10^{-13}$	90	[8] BLOCH	25	SNSE	$m_{\gamma'} = 1$–8 eV
$<7 \times 10^{-10}$		[9] CAPUTO	25	ASTR	$m_{\gamma'} = 0.1$–0.4 MeV
$<1 \times 10^{-6}$	90	[10] CHOI	25	NEON	$m_{\gamma'} = 0.003$–3 MeV
$<4 \times 10^{-8}$	90	[11] CORTINA-GIL	25A	NA62	$m_{\gamma'} = 0.1$–1.5 GeV
$<1 \times 10^{-4}$	90	[12] CORTINA-GIL	25B	NA62	$m_{\gamma'} = 0.01$–0.26 GeV
$<1.1 \times 10^{-13}$	95	[13] EGGE	25	MDMX	$m_{\gamma'} = 78.62$–83.95 μeV
$<2.3 \times 10^{-13}$	90	[14] LI	25	PNDX	$m_{\gamma'} = 0.03$–1 MeV
$<3 \times 10^{-19}$	95	[15] LINDEN	25	ASTR	$m_{\gamma'} = 90$–1022 keV
<0.2	95	[16] MELO-GALIN...	25	ASTR	$m_{\gamma'} = 6\times10^{-8}$–$1\times10^{-5}$ eV
$<1 \times 10^{-9}$		[17] MIRASOLA	25	ASTR	$m_{\gamma'} = 2\times10^{-13}$–$1.4\times10^{-12}$ eV
$<3 \times 10^{-4}$		[18] ROMERO-JOR...	25	HION	$m_{\gamma'} = 0.01$–2 GeV
$<4 \times 10^{-15}$	95	[19] TROST	25	COSM	$m_{\gamma'} = 6\times10^{-14}$–$4\times10^{-13}$ eV
$<2 \times 10^{-16}$	90	[20] ZENG	25	PNDX	$m_{\gamma'} = 1$–30 keV
$<8.2 \times 10^{-15}$	95	[21] ZHAO	25	DM	$m_{\gamma'} = 23.4575$–23.5485 μeV
$<2.7 \times 10^{-9}$	95	[22] ZHAO	25A	DM	$m_{\gamma'} = 2\times10^{-17}$–$3\times10^{-14}$ eV
$<3 \times 10^{-8}$	90	[23] AAD	24AS	ATLS	$m_{\gamma'} = 0.01$–10 GeV
$<3 \times 10^{-5}$	90	[24] ABRATENKO	24A	MBNE	$m_{\gamma'} = 0.01$–0.2 GeV
$<4 \times 10^{-6}$	90	[25] ABREU	24	FASR	$m_{\gamma'} \simeq 50$ MeV
$<0.5 \times 10^{-10}$	95	[26] ADACHI	24C	DORR	$m_{\gamma'} = 41$–74 μeV
$<3 \times 10^{-12}$	90	[27] AGOSTINI	24A	GRDA	$m_{\gamma'} = 65$–1021 keV
$<4.35 \times 10^{-13}$	90	[28] AGRAWAL	24	DM	$m_{\gamma'} = 24.67$ μeV
$<5 \times 10^{-6}$	90	[29] ANDREEV	24A	NA64	$m_{\gamma'} = 0.001$–1 GeV
$<1.8 \times 10^{-3}$	90	[30] ANDREEV	24E	NA64	$m_{\gamma'} = 1\times10^{-3}$–1 GeV
$<8 \times 10^{-7}$	95	[31] ARAMBURO...	24	CMB	$m_{\gamma'} = 3\times10^{-15}$–$3\times10^{-12}$ eV
$<1.4 \times 10^{-15}$	90	[32] ARNQUIST	24	MAJD	$m_{\gamma'} = 1$–100 keV
$<1.5 \times 10^{-16}$	90	[33] CERVANTES	24	SRPH	$m_{\gamma'} = 5.35$ μeV
$<5 \times 10^{-7}$	90	[34] CORTINA-GIL	24A	NA62	$m_{\gamma'} = 5$–500 MeV
$<3 \times 10^{-16}$	90	[35] DOLAN	24	STAR	$m_{\gamma'} = 0.5$–16 keV
$<3.7 \times 10^{-13}$	90	[36] HE	24	DM	$m_{\gamma'} = 29.5$ μeV
$<1 \times 10^{-12}$	90	[37] KNIRCK	24	BRED	$m_{\gamma'} = 44$–52 μeV
$<6 \times 10^{-15}$	95	[38] LEVINE	24	DER	$m_{\gamma'} = 0.21$–1.24 μeV
$<1 \times 10^{-6}$	95	[39] LIU	24	DM	$m_{\gamma'} = 2\times10^{-2}$–$1\times10^{4}$ eV
$<4.5 \times 10^{-8}$	95	[40] MCCARTHY	24	CMB	$m_{\gamma'} = 10^{-13}$–10^{-11} eV
$<2.2 \times 10^{-16}$	90	[41] TANG	24	SHNE	$m_{\gamma'} = 5.367$–5.373 μeV
$<3 \times 10^{-3}$	95	[42] YAN	24A	ASTR	$m_{\gamma'} = 3\times10^{-18}$–$3\times10^{-14}$ eV
$<1 \times 10^{-3}$	90	[43] AAD	23BO	ATLS	$m_{\gamma'} = 5$–40 GeV
$<1.3 \times 10^{-8}$	90	[44] AAD	23I	ATLS	$m_{\gamma'} = 0.017$–15 GeV
		[45] AAD	23T	ATLS	$m_{\gamma'} \lesssim 40$ GeV
$<1 \times 10^{-16}$	90	[46] AALBERS	23A	LZ	$m_{\gamma'} = 1$–17 keV
$<1.6 \times 10^{-3}$	90	[47] ABLIKIM	23AF	BES3	$m_{\gamma'} = 1.5$–2.9 GeV
		[48] ABUDINEN	23B	BEL2	$m_{\gamma'} = 4$–9.7 GeV
$<1.61 \times 10^{-14}$	90	[49] ADHIKARI	23	C100	$m_{\gamma'} = 215$ eV

$<6 \times 10^{-14}$	90	[50] ADHIKARI	23A	C100	$m_{\gamma'} = 10\text{–}1000$ keV	
$<2.1 \times 10^{-3}$	95	[51] ADRIAN	23	HPS	$m_{\gamma'} = 19\text{–}81$ MeV	
$<1.1 \times 10^{-16}$	90	[52] AGNES	23A	DS50	$m_{\gamma'} = 0.03\text{–}20$ keV	
$<2 \times 10^{-12}$	95	[53] AN	23A		$m_{\gamma'} = 4.1\text{–}6.2\ \mu$eV	
$<5 \times 10^{-6}$	90	[54] ANDREEV	23	NA64	$m_{\gamma'} = 10^{-3}\text{–}1.5$ GeV	
$<5.0 \times 10^{-14}$	68	[55] BAJJALI	23	BRAS	$m_{\gamma'} = 49.63\text{–}74.44\ \mu$eV	
$<2 \times 10^{-7}$	90	[56] CORTINA-GIL	23C	NA62	$m_{\gamma'} = 10\text{–}700$ MeV	
$<2.2 \times 10^{-3}$	90	[57] HAYRAPETY...	23G	CMS	$m_{\gamma'} = 1.1\text{–}7.9$ GeV	
$<3 \times 10^{-11}$	95	[58] KOTAKA	23	DORR	$m_{\gamma'} = 74\text{–}110\ \mu$eV	
$<2 \times 10^{-15}$		[59] LI	23I	ASTR	$m_{\gamma'} = 10^{-3}\text{–}10^{5}$ eV	
$<7.9 \times 10^{-13}$	95	[60] RAMANATH...	23	QULP	$m_{\gamma'} = 19.7\text{–}30.5\ \mu$eV	
$<1.6 \times 10^{-9}$	95	[61] ROMANENKO	23	LSW	$m_{\gamma'} = 0.21\text{–}5.7\ \mu$eV	
		[62] XIA	23	ASTR	$m_{\gamma'} \lesssim 10^{-23}$eV	
		[63] AAD	22J	ATLS	$m_{\gamma'} = 1\text{–}60$ GeV	
		[64] AAD	22S	ATLS	$m_{\gamma'} \lesssim 10$ GeV	
$<2 \times 10^{-14}$	90	[65] APRILE	22	XE1T	$m_{\gamma'} = 0.9$ keV	
$<2 \times 10^{-15}$	90	[66] APRILE	22	XE1T	$m_{\gamma'} = 0.01\text{–}0.4$ keV	OCCUR=2
$<5 \times 10^{-17}$	90	[67] APRILE	22B	XENT	$m_{\gamma'} = 1\text{–}39, 44\text{–}140$ keV	
$<1 \times 10^{-2}$	90	[68] BATTAGLIERI	22	BDMP	$m_{\gamma'} = 3\text{–}100$ MeV	
$(4.6^{+0.5}_{-0.4}) \times 10^{-15}$	68	[69] BOLTON	22	ASTR	$m_{\gamma'} = (8.4 \pm 0.6) \times 10^{-14}$ eV	
$<1 \times 10^{-13}$	90	[70] CERVANTES	22	ORPH	$m_{\gamma'} = 65.5\text{–}69.3\ \mu$eV	
$<1 \times 10^{-12}$	90	[71] CHILES	22		$m_{\gamma'} = 0.7\text{–}0.8$ eV	
$<8.7 \times 10^{-11}$	95	[72] HOCHBERG	22	SNSP	$m_{\gamma'} = 0.73\text{–}30$ eV	
		[73] LEES	22	BABR	$m_{\gamma'} = 1 \times 10^{-3}\text{–}3.16$ GeV	
$<7.97 \times 10^{-9}$	95	[74] LU	22	ASTR	$m_{\gamma'} \lesssim 3 \times 10^{-5}$ eV	
$<6.86 \times 10^{-11}$	90	[75] MANENTI	22	MDHI	$m_{\gamma'} = 1.61$ eV	
$<3 \times 10^{-2}$	95	[76] THOMAS	22		$m_{\gamma'} = 1\text{–}80$ GeV	
		[77] TUMASYAN	22AH	CMS	$m_{\gamma'} = 4\text{–}62.5$ GeV	
		[78] TUMASYAN	22N	CMS	$m_{\gamma'} = 0.6\text{–}49$ GeV	
		[79] WU	22A	PPTA	$m_{\gamma'} \lesssim 10^{-23}$eV	
$<8 \times 10^{-6}$	90	[80] ANDREEV	21	NA64	$m_{\gamma'} = 1 \times 10^{-3}\text{–}1$ GeV	
$<2.3 \times 10^{-4}$	90	[81] ANDREEV	21A	NA64	$m_{\gamma'} = 0.1\text{–}0.35$ GeV	
$<1.6 \times 10^{-4}$	95	[82] BI	21	ASTR	$m_{\gamma'} = 0.03\text{–}0.06$ eV	
$<3 \times 10^{-5}$	90	[83] CAZZANIGA	21	NA64	$m_{\gamma'} = 10\text{–}390$ MeV	
$<1.68 \times 10^{-15}$	90	[84] DIXIT	21	CNTR	$m_{\gamma'} = 24.86\ \mu$eV	
$<2 \times 10^{-16}$	90	[85] GHOSH	21	RVUE	$m_{\gamma'} = 2\text{–}30\ \mu$eV	
$<1.8 \times 10^{-13}$		[86] GODFREY	21	DER	$m_{\gamma'} = 0.2637\text{–}0.2648\ \mu$eV	
$<3 \times 10^{-12}$	95	[87] KOPYLOV	21A	CNTR	$m_{\gamma'} = 9\text{–}40$ eV	
$<2 \times 10^{-2}$	95	[88] KRIBS	21		$m_{\gamma'} \lesssim 10$ GeV	
		[89] SCHMIDT	21	THEO	$m_{\gamma'} < 0.6$ GeV	
$<3 \times 10^{-8}$	90	[90] TSAI	21	BDMP	$m_{\gamma'} = 0.78$ GeV	
$<1 \times 10^{-4}$	90	[91] AAIJ	20C	LHCB	$m_{\gamma'} = 214$ MeV	
		[92] AAIJ	20C	LHCB	$m_{\gamma'} = 218\text{–}315$ MeV	OCCUR=2
		[93] ABLIKIM	20AB	BES3	$m_{\gamma'} = 0.2\text{–}2.1$ GeV	
$<4.1 \times 10^{-12}$	90	[94] AGOSTINI	20	HPGE	$m_{\gamma'} = 60$ keV – 1 MeV	
$<3.3 \times 10^{-14}$	90	[95] AMARAL	20	SCDM	$m_{\gamma'} = 1.2\text{–}50$ eV	
$<1.2 \times 10^{-14}$	90	[96] AN	20	XE1T	$m_{\gamma'} = 200$ eV	
$<6.72 \times 10^{-13}$	95	[97] ANDRIANAV...	20	FUNK	$m_{\gamma'} = 1.95\text{–}8.55$ eV	
$<1 \times 10^{-16}$	90	[98] APRILE	20	XE1T	$m_{\gamma'} = 1\text{–}200$ keV	
$<9 \times 10^{-16}$	90	[99] ARALIS	20	SCDM	$m_{\gamma'} = 0.04\text{–}500$ keV	
$<3 \times 10^{-5}$	90	[100] ARGUELLES	20	THEO	$m_{\gamma'} = 0.01$ GeV	

<7	$\times 10^{-14}$	90	[101] ARNAUD	20	EDEL	$m_{\gamma'} = 1$–40 eV	
<8.2	$\times 10^{-5}$	90	[102] BANERJEE	20	NA64	$m_{\gamma'} = 1.5$–24 MeV	
<7	$\times 10^{-15}$	90	[103] BARAK	20	SENS	$m_{\gamma'} = 1.2$–12.8 eV	
			[104] KRASNIKOV	20	RVUE	$m_{\gamma'} = 16.7$ MeV	
<1.4	$\times 10^{-14}$	90	[105] SHE	20	CDEX	$m_{\gamma'} = 10$–300 eV	
<1.3	$\times 10^{-15}$	90	[106] SHE	20	CDEX	$m_{\gamma'} = 0.1$–4 keV	OCCUR=2
<1	$\times 10^{-3}$	90	[107] SIRUNYAN	20AQ	CMS	$m_{\gamma'} = 11.5$–75 GeV, 110–200 GeV	
<4.3	$\times 10^{-10}$	95	[108] TOMITA	20		$m_{\gamma'} = 115.79$–115.85 μeV	
<9	$\times 10^{-16}$	90	[109] WANG	20A	CDEX	$m_{\gamma'} = 0.185$–10 keV	
			[110] AABOUD	19G	ATLS	$m_{\gamma'} = 20$–60 GeV	
<6	$\times 10^{-3}$	90	[111] ABLIKIM	19A	BES3	$m_{\gamma'} = 0.01$–2.4 GeV	
<3.4	$\times 10^{-3}$	90	[112] ABLIKIM	19H	BES3	$m_{\gamma'} = 0.1$–2.1 GeV	
<8	$\times 10^{-15}$	90	[113] AGUILAR-AR...	19A	DAMC	$m_{\gamma'} = 1.2$–30 eV	
<9	$\times 10^{-17}$	90	[114] APRILE	19D	XE1T	$m_{\gamma'} = 0.186$–5 keV	
<7.5	$\times 10^{-6}$	90	[115] BANERJEE	19	NA64	$m_{\gamma'} = 1$–200 MeV	
<2	$\times 10^{-11}$		[116] BHOONAH	19	ASTR	$m_{\gamma'} = 10^{-22}$–10^{-10} eV	
<5	$\times 10^{-12}$	95	[117] BRUN	19	SHUK	$m_{\gamma'} = 20.8$–28.3 μeV	
<4.4	$\times 10^{-4}$	90	[118] CORTINA-GIL	19	NA62	$m_{\gamma'} = 60$–110 MeV	
<3	$\times 10^{-5}$	95	[119] DANILOV	19	TEXO	$m_{\gamma'} = 20$ eV - 1 MeV	
<6	$\times 10^{-9}$	95	[120] HOCHBERG	19		$m_{\gamma'} = 0.8$–4 eV	
<1	$\times 10^{-11}$	95	[121] KOPYLOV	19	CNTR	$m_{\gamma'} = 9$–40 eV	
<1.5	$\times 10^{-9}$		[122] KOVETZ	19	COSM	$m_{\gamma'} = 10^{-23}$–10^{-13} eV	
<3	$\times 10^{-14}$	95	[123] NGUYEN	19	WDMX	$m_{\gamma'} = 6$ neV – 2.07 μeV	
<4.5	$\times 10^{-14}$	90	[124] ABE	18F	XMAS	$m_{\gamma'} = 40$–120 keV	
<2.5	$\times 10^{-3}$	95	[125] ADRIAN	18	HPS	$m_{\gamma'} = 19$–81 MeV	
<4.4	$\times 10^{-4}$	90	[126] ANASTASI	18B	KLOE	$m_{\gamma'} = 519$–987 MeV	
<4	$\times 10^{-15}$	90	[127] ARMENGAUD	18	EDE3	$m_{\gamma'} = 0.8$–500 keV	
			[128] BANERJEE	18	NA64	$m_{\gamma'} = 1$–23 MeV	
<1.8	$\times 10^{-5}$	90	[129] BANERJEE	18A	NA64	$m_{\gamma'} = 1$–100 MeV	
<1	$\times 10^{-8}$	90	[130] KNIRCK	18		$m_{\gamma'} = 0.67$–0.92 meV	
<3.1	$\times 10^{-14}$	90	[131] ABGRALL	17	HPGE	$m_{\gamma'} = 11.8$ keV	
<6	$\times 10^{-4}$	90	[132] ABLIKIM	17AA	BES3	$m_{\gamma'} = 1.5$–3.4 GeV	
<7	$\times 10^{-15}$	90	[133] ANGLOHER	17	CRES	$m_{\gamma'} = 0.3$–0.7 keV	
<1.2	$\times 10^{-4}$	90	[134] BANERJEE	17	NA64	$m_{\gamma'} = 0.002$–0.4 GeV	
<2	$\times 10^{-11}$		[135] CHANG	17	ASTR	$m_{\gamma'} = 15$ MeV	
<4.5	$\times 10^{-3}$	90	[136] DUBININA	17	EMUL	$m_{\gamma'} = 1.1$–24 MeV	
<4	$\times 10^{-4}$	90	[137] LEES	17E	BABR	$m_{\gamma'} = 4.7$ GeV	
			[138] AAD	16AG	ATLS	$m_{\gamma'} = 0.1$–2 GeV	
<4.4	$\times 10^{-4}$	90	[139] ANASTASI	16	KLOE	$m_{\gamma'} = 527$–987 MeV	
<1.7	$\times 10^{-6}$	95	[140] KHACHATRY...	16	CMS	$m_{\gamma'} = 2$ GeV	
<4	$\times 10^{-2}$	95	[141] AAD	15CD	ATLS	$m_{\gamma'} = 15$–55 GeV	
<1.4	$\times 10^{-3}$	90	[142] ADARE	15		$m_{\gamma'} = 30$–90 MeV	
			[143] AN	15A		$m_{\gamma'} = 12$ eV - 40 keV	
			[144] ANASTASI	15	KLOE	$m_{\gamma'} = 2m_{\mu}$ - 1 GeV	
<1.7	$\times 10^{-3}$	90	[145] ANASTASI	15A	KLOE	$m_{\gamma'} = 5$–320 MeV	
<4.2	$\times 10^{-4}$	90	[146] BATLEY	15A	NA48	$m_{\gamma'} = 36$ MeV	
			[147] JAEGLE	15	BELL	$m_{\gamma'} = 0.1$–3.5 GeV	
<3	$\times 10^{-13}$		[148] KAZANAS	15	ASTR	$m_{\gamma'} = 2m_e$ – 100 MeV	
<6	$\times 10^{-12}$		[149] SUZUKI	15		$m_{\gamma'} = 1.9$–4.3 eV	
<2.3	$\times 10^{-13}$	99.7	[150] VINYOLES	15	ASTR	$m_{\gamma'} = 8$ eV	
<2	$\times 10^{-13}$		[151] ABE	14F	XMAS	$m_{\gamma'} = 40$–120 keV	

$<1.8 \times 10^{-3}$	90	[152] AGAKISHIEV	14	HDES	$m_{\gamma'} = 63$ MeV	
$<9.0 \times 10^{-4}$	90	[153] BABUSCI	14	KLOE	$m_{\gamma'} = 969$ MeV	
		[154] BATELL	14	BDMP	$m_{\gamma'} = 10^{-3}$–1 GeV	
$<1.3 \times 10^{-7}$	95	[155] BLUEMLEIN	14	BDMP	$m_{\gamma'} = 0.6$ GeV	
$<3 \times 10^{-18}$		[156] FRADETTE	14	COSM	$m_{\gamma'} = 50$–300 MeV	
$<3.5 \times 10^{-4}$	90	[157] LEES	14J	BABR	$m_{\gamma'} = 0.2$ GeV	
$<9 \times 10^{-4}$	95	[158] MERKEL	14	A1	$m_{\gamma'} = 40$–300 MeV	
$<3 \times 10^{-15}$		[159] AN	13B	ASTR	$m_{\gamma'} = 2$ keV	
$<7 \times 10^{-14}$		[160] AN	13C	XE10	$m_{\gamma'} = 100$ eV	
$<8 \times 10^{-4}$		[161] DIAMOND	13	BDMP	$m_{\gamma'} = 30$–250 MeV	
$<2 \times 10^{-3}$	90	[162] GNINENKO	13	BDMP	$m_{\gamma'} = 25$–120 MeV	
$<2.2 \times 10^{-13}$		[163] HORVAT	13	HPGE	$m_{\gamma'} = 230$ eV	
$<8.06 \times 10^{-5}$	95	[164] INADA	13	LSW	$m_{\gamma'} = 0.04$ eV–26 keV	
$<2 \times 10^{-10}$	95	[165] MIZUMOTO	13		$m_{\gamma'} = 1$ eV	
$<1.7 \times 10^{-7}$		[166] PARKER	13	LSW	$m_{\gamma'} = 53\ \mu$eV	
$<5.32 \times 10^{-15}$		[167] PARKER	13		$m_{\gamma'} = 53\ \mu$eV	OCCUR=2
$<1 \times 10^{-15}$		[168] REDONDO	13	ASTR	$m_{\gamma'} = 2$ keV	
$<8 \times 10^{-8}$	90	[169] GNINENKO	12A	BDMP	$m_{\gamma'} = 1$–135 MeV	
$<1 \times 10^{-7}$	90	[170] GNINENKO	12B	CHRM	$m_{\gamma'} = 1$–500 MeV	
$<1 \times 10^{-3}$	90	[171] ABRAHAMY...	11		$m_{\gamma'} = 175$–250 MeV	
$<9 \times 10^{-8}$	95	[172] BLUEMLEIN	11	BDMP	$m_{\gamma'} = 70$ MeV	
$<1 \times 10^{-7}$		[173] BJORKEN	09	BDMP	$m_{\gamma'} = 2$–400 MeV	
$<5 \times 10^{-9}$		[174] BJORKEN	09	ASTR	$m_{\gamma'} = 2$–50 MeV	OCCUR=2

[1] ABLIKIM 25CL search for kinetically mixed dark photons using the BESIII detector. They use the sample J/ψ events collected to measure the transition form factor of the η meson. Limits are derived on the branching ratio for $\eta \to \gamma\gamma'$, $\gamma' \to e^+ e^-$ and presented in terms of mass-dependent limits on the kinetic mixing parameter in Fig. 7. NODE=S029HPH;LINKAGE=RF

[2] ALBAKRY 25 report a search with the SuperCDMS detector for hidden photon dark matter absorption on silicon. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=BF

[3] AN 25 search for dark photon dark matter resonantly converting into photons in the solar corona plasma, leading a signal detectable by the STEREO and Parker Solar Probe spacecraft. See their Fig. 2 for mass-dependent limits. NODE=S029HPH;LINKAGE=CF

[4] ANDREEV 25 present the first hidden photon limits from the NA64e experiment using a 70 GeV positron beam. They set constraints on an invisibly decaying hidden photon that kinetically mixes with the photon. See Fig. 14 for various mass-dependent limits, noting the assumed parameter values for the dark gauge coupling and dark matter mass. NODE=S029HPH;LINKAGE=DF

[5] APRILE 25A present results from a search with XENONnT for dark photon dark matter absorption on electrons in liquid xenon. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=EF

[6] ASWATHI 25 use LIGO-VIRGO-KAGRA data from the black hole binary merger events GW231123 and GW190517 to search for evidence of the superradiant build-up of a cloud of vector bosons, which could act to spin down the black holes. They set lower limits on the dark photon kinetic mixing and present mass-dependent limits in Fig. 2. NODE=S029HPH;LINKAGE=SF

[7] BAUDIS 25 presents results from the QROCODILE experiment which uses a superconducting nanowire single photon detector to search for low-mass dark matter. Fig. 2 shows mass-dependent constraints on hidden photon absorption. NODE=S029HPH;LINKAGE=FF

[8] BLOCH 25 present results from a search for single-electron events in the SENSEI low-mass dark matter detector. See their Fig. 4 for mass-dependent limits on dark photon absorption. NODE=S029HPH;LINKAGE=GF

[9] CAPUTO 25 present a new bound on dark photon emission from core-collapse supernovae. They consider the cooling effect of resonant dark photon production behind the shock wave which, if too excessive, can potentially prevent the explosion. In the case of SN1987A, this consideration supersedes the standard supernova cooling argument and leads to a bound that is strongest in the sub-MeV mass region. See their Fig. 2 for mass-dependent limits. NODE=S029HPH;LINKAGE=HF

[10] CHOI 25 place bounds on a dark matter model using the NEON reactor neutrino experiment. They explore a scenario in which the high flux of photons from the nuclear reactor leads to a flux of dark photons; those dark photons can then decay into dark matter particles in the detector that scatter on electrons. See their Fig. 3 for mass-dependent bounds on the dark photon mediator, obtained for the dark matter mass $m_{\gamma'}/3$ and the hidden gauge coupling $\alpha_D = 0.1$. NODE=S029HPH;LINKAGE=JF

[11] CORTINA-GIL 25A search for kinetically mixed hidden photons decaying to hadronic final states in the NA62 beam dump. Quoted limit applies around 0.8 GeV, but does not extend to arbitrarily large kinetic mixing. See their Fig. 7 for mass-dependent limits combining this hadronic analysis and the dilepton channel reported in CORTINA-GIL 24A. NODE=S029HPH;LINKAGE=LF

[12] CORTINA-GIL 25B report limits on an invisibly decaying dark photon produced in the decays of K^+ and π^0 in the NA62 detector. See their Fig. 8 for mass-dependent limits. NODE=S029HPH;LINKAGE=VF

[13] EGGE 25 search for dark photon dark matter using the prototype setup of the MADMAX dielectric disk haloscope. The local density $\rho_{\gamma'}$ = 0.3 GeV/cm^3 is assumed. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=KF

[14] LI 25 search for MeV-mass dark photons making up the dark matter halo of the galaxy that could be absorbed by liquid xenon in the PandaX detector. The local density $\rho_{\gamma'}$ = 0.3 GeV/cm^3 is assumed. The quoted limit is at $m_{\gamma'}$ = 150 keV. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=MF

[15] LINDEN 25 extend limits on dark photons as a dark matter candidate at masses below the electron pair creation threshold. They search for evidence of dark photon-to-three-photon decays using data from the INTEGRAL space telescope. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=NF

[16] MELO-GALINDO 25 search for evidence of mixing between standard model and dark photons imprinted on the TeV gamma-ray spectra of the Crab Nebula and gamma-ray source MGRO J1908+06, using data from HAWC and LHAASO. See their Figs. 3–6 for mass-dependent limits for both sources and under various model assumptions. NODE=S029HPH;LINKAGE=WF

[17] MIRASOLA 25 search for evidence of superradiant clouds of dark photons surrounding black holes, which are expected to produce pulsating radio emissions, and continuous gravitational wave signals that could be observed by LIGO-Virgo-KAGRA. Their bound disfavours dark photons within a specific range of masses and kinetic mixing parameters between 10^{-9}–10^{-7}, subject to uncertainties about the black hole population and details about the cloud's radio emission. See their Fig. 5. NODE=S029HPH;LINKAGE=QF

[18] ROMERO-JORGE 25 set limits on kinetically-mixed dark photons produced through various decays in heavy-ion collisions and then decaying to dileptons. They incorporate a range of heavy ion data from across the SIS, RHIC and LHC. They present various mass-dependent limits in their Fig. 7 for different choices for the dark photon "surplus" - the maximum permissible increase in a dilepton yield from dark photons compared to the Standard Model yield. NODE=S029HPH;LINKAGE=XF

[19] TROST 25 use VLT/UVES observations of the quasar HE0940-1050 to search for resonant conversion of dark photon dark matter into photons, which would heat the intergalactic medium and imprint on the quasar's Lyman-alpha forest spectrum. See their Fig. 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=OF

[20] ZENG 25 place a bound on keV-scale dark photons making up the halo of the galaxy by searching for electron recoil events in the PandaX detector. See Fig. 3(f) for mass-dependent limits. NODE=S029HPH;LINKAGE=PF

[21] ZHAO 25 use a flux-tunable resonant cavity to search for dark photon dark matter in a narrow frequency window around 5.69 GHz, performing microwave single photon detection using a transmon qubit. The quoted limit assumes a local dark matter density of $\rho_{\gamma'}$ = 0.45 GeV/cm^3 NODE=S029HPH;LINKAGE=TF

[22] ZHAO 25A use a single-site, two-sensor array of commercial scalar optically pumped magnetometers to search for dark photon dark matter converting into photons. The relevant observable signal appears in this low-mass regime due to the action of the Earth's ionosphere as transducer. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=UF

[23] AAD 24AS search for hidden photons resulting from Higgs decays in the Falkowski-Ruderman-Volansky-Zupan model. See Fig. 7 for mass-dependent limits, value shown taken from the most constraining point at 10 GeV mass. The limits do not extend to arbitrarily high values of the kinetic mixing, stopping between 10^{-4} and 10^{-7} at the lower and upper end of the mass range respectively. The limit is also dependent on the branching fraction for Higgs decays resulting in dark photons. NODE=S029HPH;LINKAGE=IE

[24] ABRATENKO 24A search for dark trident scattering at a neutrino beam using the MicroBooNE detector. Events involve a pair of particles $\chi\overline{\chi}$ produced from π^0 or η decays mediated by a dark photon, these particles then scatter off Argon in the detector and can produce an additional dark photon which then decays. See Fig. 7 for mass-dependent limits under three possible scenarios for the χ particle. NODE=S029HPH;LINKAGE=JE

[25] ABREU 24 look for hidden photons produced from the pp collision in the decay channel $\gamma' \rightarrow e^+ e^-$, and exclude at 90% CL the region of $\chi = 4 \times 10^{-6}$–2×10^{-4} and $m_{\gamma'}$ = 10–80 MeV, with the newly excluded region near the higher values of χ. See their Fig. 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=DE

[26] ADACHI 24C follows KOTAKA 23 of the DOSUE-RR collaboration, searching for hidden photon dark matter conversion using a millimetre-wave receiver and a radioshielding box. See Fig. 11 for mass dependent limits. NODE=S029HPH;LINKAGE=KE

[27] AGOSTINI 24A report a search for dark photon dark matter absorption and dark Compton scattering on germanium, generating electron events in the GERDA experiment. The quoted limit is at m_{A^0} = 150 keV. See their Fig. 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=WE

[28] AGRAWAL 24 search for hidden photon dark matter via stimulated emission of a photon from a microwave cavity prepared in a non-classical state by a superconducting qubit. NODE=S029HPH;LINKAGE=LE

[29] ANDREEV 24A perform a missing-energy search in the NA64 detector to look for an MeV-scale hidden photon mediator to a stable fermionic dark sector particle. See Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=ME

[30] ANDREEV 24E report results from the NA64μ beam dump experiment, employing a high-intensity muon beam. They set limits on the kinetic mixing parameter of an invisibly decaying hidden photon. See their Fig. 19 for mass-dependent limits. NODE=S029HPH;LINKAGE=XE

[31] ARAMBURO-GARCIA 24 search for evidence of resonant conversion of regular photons into dark photons within the inter-galactic medium using the expected imprint on the CMB anisotropies. Quoted limit is for their "conservative" approach - see their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=YE

[32] ARNQUIST 24 use the MAJORANA DEMONSTRATOR to search for keV-mass hidden photon dark matter absorption by Germanium. See Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=VE

[33] CERVANTES 24 use a superconducting radio frequency cavity at the SQMS Centre (Fermilab) to search for hidden photon dark matter at 1.3 GHz. See their Fig. 3 for limits in context. NODE=S029HPH;LINKAGE=NE

[34] CORTINA-GIL 24A report results from the NA62 beam dump experiment, searching for production and decays of dark photons to lepton pairs. Quoted limit applies around 300 MeV, but does not extend to arbitrarily high kinetic mixing. See their Fig. 4 for mass-dependent limits NODE=S029HPH;LINKAGE=ZE

[35] DOLAN 24 constrain anomalous cooling of globular cluster stars due to the emission of hidden photons. Best limit is taken from the envelope of limits from the R parameter, R2 parameter and Tip of the Red Giant branch. This study includes hidden photon emission in stellar evolution simulation and so supersedes red giant bound in AN 20. NODE=S029HPH;LINKAGE=OE

[36] HE 24 present results from the APEX collaboration. They look for hidden photon dark matter using a radio frequency cavity at 7.139 GHz. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=PE

[37] KNIRCK 24 search for hidden photon dark matter using GigaBREAD, a broadband haloscope operating at room temperature that uses a parabolic reflector and a horn antenna. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=QE

[38] LEVINE 24 search for hidden photon dark matter using Dark E-Field Radio, a broadband haloscope consisting of an E-field antenna inside a shielded room. This is a continuation of their experiment previously reported in GODFREY 21. See their Fig. 12 for mass-dependent limits. NODE=S029HPH;LINKAGE=RE

[39] LIU 24 constrain hidden photon dark matter over a broad mass range using the very high-energy gamma-ray spectrum of blazars Mrk 501 and Mrk 421. See their Fig. 4 for mass-dependent limits which also depend on the density profiles of the host halos of the blazars. Quoted limit is for the case where the host halos have an NFW profile in Fig. 6. NODE=S029HPH;LINKAGE=SE

[40] MCCARTHY 24 search for evidence of photons converting into hidden photons as they traverse large-scale structure, which would lead to a patchy-screening effect observable in CMB anisotropy maps. See their Fig. 3 for mass-dependent limits. This analysis improves upon a similar study by ARAMBURO-GARCIA 24 - see the note added in MCCARTHY 24. NODE=S029HPH;LINKAGE=AF

[41] TANG 24 present results from a hidden photon dark matter search at 1.3 GHz with SHANHE, a tunable superconducting radio frequency cavity. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=TE

[42] YAN 24A use data from the JUNO probe to constrain hidden photons via the way they would modify Jupiter's magnetic field. See their Fig. 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=UE

[43] AAD 23BO look for rare decays of the Z boson, $Z \rightarrow \gamma' + H'$, with dark Higgs decaying into a pair of hidden photons, assuming that at least two of the hidden photons decay into $e^+ e^-$ or $\mu^+ \mu^-$. The quoted limit assumes the hidden fine structure constant $\alpha_D = 0.1$ and the dark Higgs mass ranging 20 to 70 GeV. See their Fig.5 for the mass-dependent limits. NODE=S029HPH;LINKAGE=BE

[44] AAD 23I look for exotic decays of the SM-like Higgs boson, $H \rightarrow \gamma' \gamma'$ with hidden photons decaying into displaced lepton or light quark pairs, and set limits on the kinetic mixing within 1×10^{-4}–1×10^{-8} for the given mass range. The quoted limit is for $m_{A^0} \simeq$ 13 GeV with a branching fraction of 0.1 for the Higgs decaying into hidden photon pairs. See their Fig. 13 for the mass-dependent limits. NODE=S029HPH;LINKAGE=VD

[45] AAD 23T is analogous to AAD 22S, but using the ZH production mode, and set the upper limit on the branching ratio B($H \rightarrow \gamma\gamma'$) within 0.0219–0.0252 (95% CL). NODE=S029HPH;LINKAGE=UD

[46] AALBERS 23A look for an absorption of hidden photon dark matter. The quoted limit is for $m_{\gamma'} = 1.4$ keV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=CE

[47] ABLIKIM 23AF look for invisible decays of hidden photons produced in the reaction $e^+ e^- \rightarrow \gamma\gamma'$. They set limits within the 1.6×10^{-3}–5.7×10^{-3}. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=WD

[48] ABUDINEN 23B look for hidden photons in the dark Higgsstrahlung process, $e^+ e^- \rightarrow \gamma' H'$ ($\gamma' \rightarrow \mu^+ \mu^-$) with H' being invisible. They set upper limits on the product of the kinetic mixing and the hidden gauge coupling, $\chi^2 \cdot \alpha_D$, in the range of 1.7×10^{-8}–2×10^{-6} at 90% CL for a 1 GeV dark Higgs mass. See their Fig. 3 for the mass-dependent limits. NODE=S029HPH;LINKAGE=YD

[49] ADHIKARI 23 look for the annual modulation signal induced by solar flux of hidden photons. See their Fig. 10 for mass-dependent limits. NODE=S029HPH;LINKAGE=TD

[50] ADHIKARI 23A look for absorption and Compton-like processes of hidden photon dark matter. The quoted limit is for $m_{\gamma'} \simeq$ 12 keV. Limits between 6×10^{-14}–3×10^{-11} are obtained. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=ZD

[51] ADRIAN 23 is an update of ADRIAN 18, and use the data from the 2016 engineering run at 2.3 GeV. The quoted limit is at $m_{\gamma'} \simeq$ 74 MeV. See their Fig. 28 for the mass-dependent limits. NODE=S029HPH;LINKAGE=RD

[52] AGNES 23A look for an absorption of hidden photon dark matter. The quoted limit is for $m_{\gamma'} = 0.03$ keV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 2 for mass-dependent limits. NODE=S029HPH;LINKAGE=PD

[53] AN 23A look for absorption of hidden photon dark matter at radio telescopes, setting limits based on data from the FAST telescope. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 1 for mass-dependent limits. NODE=S029HPH;LINKAGE=XD

[54] ANDREEV 23 is an update of ANDREEV 21 and ANDREEV 21A. The quoted limit applies to $m_{\gamma'} = 1$ MeV. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=EE

[55] BAJJALI 23 look for hidden photon dark matter by using a 12–18 GHz dish antenna at U. Hamburg that is sensitive to vertically aligned hidden photon polarizations. They assume a local density of $\rho_{\gamma'} = 0.3$ GeV/cm^3. See their Figure 12 for mass-dependent limits in the range of $m_{\gamma'} = 50$–$75\ \mu eV$ under the assumption of randomly aligned hidden photon polarizations, defined as "1 sigma sensitivity". The run is labelled BRASS-p. NODE=S029HPH;LINKAGE=AE

[56] CORTINA-GIL 23C NA62 beam dump experiment searches for hidden photons decaying to $\mu^+\mu^-$, extending their previous search CORTINA-GIL 19. The quoted limit applies at 300 MeV but does not extend to arbitrarily large kinetic mixing parameters. See Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=HE

[57] HAYRAPETYAN 23G search for kinetically mixed hidden photons in proton-proton collisions at the LHC that would generate a narrow peak in the mass spectrum of dimuon events. The mass window between 2.6 and 4.2 GeV is left unconstrained to avoid J/ψ and $\psi(2S)$ resonances. Mass dependent limits given in their Fig. 6. NODE=S029HPH;LINKAGE=GE

[58] KOTAKA 23 is an update of TOMITA 20, and set limits $\chi < 0.3$–2×10^{-10} for the quoted mass range. The local density $\rho_{\gamma'} = 0.39$ GeV/cm^3 is assumed. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=QD

[59] LI 23I set cooling bounds on the emission of hidden photons from the Sun, red giant, and horizontal branch stars, including emission of both the transverse and longitudinal modes. Cooling bounds are computed assuming a static model as opposed to considering the impact on stellar evolution. The result is comparable to earlier estimates of the same bound e.g. REDONDO 13. Limit applies at the most constraining mass around 200 eV for the solar bound. NODE=S029HPH;LINKAGE=FE

[60] RAMANATHAN 23 look for hidden photon dark matter using a gold-plated copper dish antenna cooled to 20 mK. The local density $\rho_{\gamma'} = 0.45$ GeV/cm^3 is assumed. Limits between 7.9×10^{-13} and 3.81×10^{-12} are obtained. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=OD

[61] ROMANENKO 23 employed two superconducting radio frequency cavities with a high quality factor, optimized for detecting the longitudinal polarization of the hidden photon. The quoted limit is set at $m_{\gamma'} \simeq 5\mu$eV. See their Fig. 4 for the mass-dependent limits. NODE=S029HPH;LINKAGE=ND

[62] XIA 23 is analogous to WU 22A and use the Fermi-LAT pulsar timing array. They set a bound on the local density as $\rho_{\gamma'} \lesssim 7$ GeV/cm^3 for $m_{\gamma'} \lesssim 10^{-23}$ eV at 95% CL, with weaker constraints up to 10^{-22} eV. See their Fig. 1 for the mass-dependent limits. NODE=S029HPH;LINKAGE=SD

[63] AAD 22J look for exotic decays of the SM-like Higgs boson, $H \to \gamma'\gamma' \to 4\ell$ and $H \to Z\gamma' \to 4\ell$, and set limits on the kinetic mixing and the Higgs portal coupling. See their Figs. 19 and 20 for the mass-dependent limits. NODE=S029HPH;LINKAGE=ED

[64] AAD 22S look for decays of a Higgs boson into γ and γ' using the VBF production mode, and set the upper limit on the branching ratio at 0.018 (95% CL) for the 125 GeV Higgs boson. For the quoted mass range, the signal acceptance changes by less than 1%. NODE=S029HPH;LINKAGE=AD

[65] APRILE 22 is analogous to AN 20, and their limit was corrected in the erratum to this paper: APRILE 24B. They set limits $\chi < 2 \times 10^{-12}$ (eV/$m_{\gamma'}$) for $m_{\gamma'} < 3$ eV (90% C.L.). For $m_{\gamma'} > 3$ eV, see Fig. 1 of APRILE 24B. NODE=S029HPH;LINKAGE=BD

[66] APRILE 22 extend APRILE 19 to lower masses by removing the background of ionization signals correlated with high-energy events. The quoted limit applies to $m_{\gamma'} = 0.09$ keV. See their Fig. 15 for mass-dependent limits. NODE=S029HPH;LINKAGE=CD

[67] APRILE 22B is an update of APRILE 20, and set limits $\chi \lesssim 5 \times 10^{-17}$–$2 \times 10^{-13}$. The quoted limit applies to $m_{\gamma'} = 1$ keV. They exclude the XENON1T excess found in APRILE 20. See their Fig. 6 for mass-dependent limits. NODE=S029HPH;LINKAGE=LD

[68] BATTAGLIERI 22 is analogous to BATELL 14, and derived limits from the electron beam dump experiment at Jefferson Lab (BDX-MINI). Limits at the level of 7×10^{-5}–1×10^{-2} are obtained for the dark matter mass $m_{\gamma'}/3$ and the hidden gauge coupling $\alpha_D = 0.1$. See their Fig. 11. NODE=S029HPH;LINKAGE=KD

[69] BOLTON 22 use the Ly-α forest at z $\simeq$ 0.1 as a calorimeter for heating in the intergalactic medium by the resonant conversion of hidden photon dark matter to photons, which is assumed to be responsible for the tension between the predicted and observed Ly-α absorption linewidths. NODE=S029HPH;LINKAGE=JD

[70] CERVANTES 22 use a dielectrically loaded Fabry-Perot open cavity to look for hidden photon dark matter. The local density $\rho_{\gamma'} = 0.45$ GeV/cm^3 is assumed. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=ID

[71] CHILES 22 look for hidden photon dark matter by using a layered dielectric target and a superconducting nanowire single-photon detector. The local density $\rho_{\gamma'} = 0.4$ GeV/cm^3 is assumed. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=DD

[72] HOCHBERG 22 update HOCHBERG 19. The quoted limit applies to $m_{A^0} \simeq 11$ eV. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=HD

[73] LEES 22 look for a hidden fermion-fermion bound state decaying into three hidden photons, which subsequently decay into e^+e^-, $\mu^+\mu^-$, or $\pi^+\pi^-$. For the bound-state mass in the range of 0.05–9.5 GeV, limits at the level of 5×10^{-5}–1×10^{-3} are obtained. See their Fig. 6 for mass-dependent limits. NODE=S029HPH;LINKAGE=TC

[74] LU 22 derive the limit by studying the effect of photons oscillating into hidden photons on the surface luminosity of the neutron star RX J1856.6-3754. NODE=S029HPH;LINKAGE=ZC

[75] MANENTI 22 look for hidden photon dark matter by using a multilayer dielectric haloscope. Limits between 6.86×10^{-11} and 5×10^{-8} are obtained for $m_{\gamma'} \simeq 1.1$–3.1 eV. See their Fig. 11 for mass-dependent limits. NODE=S029HPH;LINKAGE=FD

[76] THOMAS 22 improved KRIBS 21 by taking account of the changes in the parton distribution functions due to the inclusion of hidden photons. The quoted limit is at $m_{\gamma'} \simeq$ 4 GeV. Limits in the range of 3×10^{-2}–9×10^{-2} are obtained for $m_{\gamma'} = 1$–80 GeV. See their Fig. 1 for the limits. NODE=S029HPH;LINKAGE=WC

[77] TUMASYAN 22AH look for exotic decays of the SM-like Higgs boson, $H \rightarrow Z\gamma' \rightarrow 4\ell$, and set limits on the Higgs portal coupling. See their Fig. 6 for the limits. NODE=S029HPH;LINKAGE=XC

[78] TUMASYAN 22N look for exotic decays of the SM-like Higgs boson, $H \rightarrow \gamma'\gamma'$ ($\gamma' \rightarrow \mu^+\mu^-$), and set limits on the branching fraction product. See their Fig. 7 for mass- and lifetime-dependent limits. NODE=S029HPH;LINKAGE=GD

[79] WU 22A look for direction-dependent oscillations in the gravitational potential generated by ultralight hidden photon dark matter, and set a bound on its local density as $\rho_{\gamma'} \lesssim$ 5 GeV/cm^3 for $m_{\gamma'} \lesssim 10^{-23}$ eV at 95% CL. NODE=S029HPH;LINKAGE=MD

[80] ANDREEV 21 is analogous to BANERJEE 18A. The quoted limit applies to $m_{\gamma'} = 1$ MeV. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=MC

[81] ANDREEV 21A extends the limits of BANERJEE 19 by taking account of production through the resonant annihilation of secondary positrons with atomic electrons. The quoted limit is at $m_{\gamma'} = 0.23$ GeV, assuming the fermion dark matter of mass $m_{\gamma'}/3$ and the hidden gauge coupling $\alpha_D = 0.1$. See their Fig.3 for mass-dependent limits. NODE=S029HPH;LINKAGE=RC

[82] BI 21 look for the gamma-ray spectral attenuation due to scattering with hidden photons constituting all dark matter, using the measurements of sub-PeV gamma-rays from the Crab Nebula by the Tibet ASγ and HAWC experiments, together with MAGIC and HEGRA gamma-ray data. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=NC

[83] CAZZANIGA 21 look for semi-visible decays of hidden photons, $\gamma' \rightarrow \chi_1\chi_2$ ($\chi_2 \rightarrow \chi_1 e^+e^-$), where χ_1 and χ_2 are hidden fermions. They exclude $3 \times 10^{-5} \lesssim \chi \lesssim 2\times10^{-2}$ assuming the hidden gauge coupling $\alpha_D = 0.1$, and the fermion masses $m_{\chi_1} = m_{\gamma'}/3$, $(m_{\chi_2} - m_{\chi_1})/m_{\chi_1} = 0.4$. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=SC

[84] DIXIT 21 look for hidden photon dark matter by using a superconducting transmon qubit dispersively coupled to a high Q storage cavity. The local density $\rho_{\gamma'} = 0.4$ GeV/cm^3 is assumed. See their Fig.4 for mass-dependent limits. NODE=S029HPH;LINKAGE=OC

[85] GHOSH 21 use existing haloscope axion search limits to set limits on hidden photon dark matter, considering the polarization of hidden photons. The quoted limit is at $m_{\gamma'} \simeq 3$ μeV. See their Fig. 1 for mass-dependent limits. NODE=S029HPH;LINKAGE=VC

[86] GODFREY 21 look for hidden photon dark matter by using a wideband antenna, and set 5σ limits on χ. The local density $\rho_{\gamma'} = 0.38$ GeV/cm^3 is assumed. See their updated Fig. 12 in arXiv:2101.02805v4 for mass-dependent limits in the range of $m_{\gamma'} = 0.207$–1.24 μeV. NODE=S029HPH;LINKAGE=PC

[87] KOPYLOV 21A is an update of KOPYLOV 19, but use Ne gas instead of Ar. The quoted limit applies to $m_{\gamma'} = 12$ eV. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=UC

[88] KRIBS 21 used the HERA data on neutral current deep inelastic $e\,p$ scattering to derive the limits, which become weaker for heavier masses. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=DC

[89] SCHMIDT 21 use the microscopic Parton-Hadron-String Dynamics approach to extract limits by comparing the theoretically calculated dilepton spectra with the HADES data on the search for $\gamma' \rightarrow e^+e^-$. See their Fig. 5 for the mass-dependent limits for various allowed surplus of the hidden photon contribution over the standard model yield. NODE=S029HPH;LINKAGE=LC

[90] TSAI 21 update the limits from the CHARM and NuCal experiments, taking account of additional production channels from proton bremsstrahlung and η meson decays, respectively. Limits between 3×10^{-8} and 1×10^{-4} are obtained for $0.01 < m_{\gamma'} < 0.8$ GeV (see their Fig. 1). NODE=S029HPH;LINKAGE=KC

[91] AAIJ 20C look for hidden photons produced from the $p\,p$ collision in the decay channel $\gamma' \rightarrow \mu^+\mu^-$. For prompt decaying hidden photons, limits at the level of 10^{-4}–10^{-3} are obtained for $m_{\gamma'} = 0.214$–30 GeV. See their Fig. 2 for mass-dependent limits. NODE=S029HPH;LINKAGE=PB

[92] AAIJ 20C look for hidden photons produced from the $p\,p$ collision in the decay channel $\gamma' \rightarrow \mu^+\mu^-$. For hidden photons with lifetimes of order ps, limits at the level of 10^{-5} are obtained for $m_{\gamma'} = 218$–315 MeV. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=RB

[93] ABLIKIM 20AB search for $J/\psi \to \eta' \gamma'$ ($\gamma' \to \gamma \pi^0$), and set the upper limit on the product branching fraction of order 10^{-7}. See their Fig. 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=EC

[94] AGOSTINI 20 is analogous to ABE 14F. The quoted limit applies to $m_{\gamma'} = 150$ keV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. Their limits in their Fig. 3 were later found to be incorrect due to an error of their Eqs. (1) and (2). See Fig. 3 in AGOSTINI 22A for the corrected limits. NODE=S029HPH;LINKAGE=SB

[95] AMARAL 20 use a second-generation SuperCDMS high-voltage eV-resolution detector to set limits on dark-matter hidden photon absorption. The quoted limit is for $m_{\gamma'} \simeq 17$ eV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=FC

[96] AN 20 updates the direct detection limit of AN 13C on solar flux of hidden photons; $\chi < 1.6 \times 10^{-12}$ (eV/$m_{\gamma'}$) for $m_{\gamma'} < 6$ eV (90% C.L.). For $m_{\gamma'} > 6$ eV, see their Fig. 1 for mass-dependent limits. NODE=S029HPH;LINKAGE=JC

[97] ANDRIANAVALOMAHEFA 20 is analogous to SUZUKI 15, but uses a mirror that is about one order of magnitude larger than in similar studies in the past. Limits at the level of 10^{-12} are obtained for $m_{\gamma'} = 2.5$–7 eV. See their Fig.23 and Table III for mass-dependent limits. NODE=S029HPH;LINKAGE=TB

[98] APRILE 20 is analogous to ABE 14F, and set limits $\chi \lesssim 10^{-16}$–10^{-12}. The quoted limit applies to $m_{\gamma'} = 1$ keV. They also found an excess over known backgrounds, which favors the mass $m_{\gamma'} = 2.3 \pm 0.2$ keV with a 3 σ significance. See their Fig. 10 for mass-dependent limits. NODE=S029HPH;LINKAGE=HC

[99] ARALIS 20 is analogous to ABE 14F. The quoted limit applies to $m_{\gamma'} = 0.1$ keV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. The limits at masses above 3 keV in their Fig. 10 was later found to be incorrect due to an error in their analysis. See Fig. 3 in erratum for the corrected limits. NODE=S029HPH;LINKAGE=UB

[100] ARGUELLES 20 examine hidden-photon production in atmospheric cosmic-ray showers and its decay in IceCube and Super-Kamiokande. The quoted limit assumes a lifetime of $c\tau = 0.1$ km. See their Fig. 16 for mass- and lifetime-dependent limits. NODE=S029HPH;LINKAGE=CC

[101] ARNAUD 20 look for the absorption signal of hidden photon dark matter in a Ge detector. The quoted limit applies to $m_{\gamma'} \simeq 9$ eV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=IC

[102] BANERJEE 20 is an update of BANERJEE 18. They exclude $8.2 \times 10^{-5} \lesssim \chi \lesssim 1 \times 10^{-2}$ for $m_{\gamma'} = 1.5$–24 MeV. In particular, they exclude $\chi = 1.2 \times 10^{-4}$–$6.8 \times 10^{-4}$ for the 16.7 MeV gauge boson. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=VB

[103] BARAK 20 is analogous to AGUILAR-AREVALO 19A, and look for hidden photon dark matter by using the Skipper CCD. The quoted limit applies to $m_{\gamma'} = 12.8$ eV. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=GC

[104] KRASNIKOV 20 showed that the limit of BANERJEE 20 combined with the measured anomalous magnetic moment of the electron exclude the 16.7 MeV gauge boson suggested by the ATOMKI (KRASZNAHORKAY 16) experiment if it has pure vector or axial-vector interactions. NODE=S029HPH;LINKAGE=BC

[105] SHE 20 look for solar hidden photons. The quoted limit applies to $m_{\gamma'} = 180$ eV. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=ZB

[106] SHE 20 look for hidden photon dark matter and set limits $\chi < 1.3 \times 10^{-15}$–$2.8 \times 10^{-14}$ for the quoted mass range. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 6 for mass-dependent limits. NODE=S029HPH;LINKAGE=AC

[107] SIRUNYAN 20AQ look for a narrow resonance decaying into a pair of muons. For $m_{\gamma'} < 45$ GeV, they use dedicated high-rate dimuon triggers to reduce the muon transverse momentum thresholds. The quoted limit applies to $m_{\gamma'} = 50$ GeV, and limits of order 10^{-3} are obtained for the quoted mass range. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=XB

[108] TOMITA 20 look for hidden photon dark matter using a planar metal plate and cryogenic receiver and set limits $\chi < 1.8$–4.3×10^{-10} for the quoted mass range. The local density $\rho_{\gamma'} = 0.39$ GeV/cm^3 is assumed. See their Fig. 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=WB

[109] WANG 20A is analogous to ABE 14F. The quoted limit applies to $m_{\gamma'} = 185$ eV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 11 for mass-dependent limits. NODE=S029HPH;LINKAGE=YB

[110] AABOUD 19G look for $h \to \gamma' \gamma'$ ($\gamma' \to \mu^+ \mu^-$) and exclude a kinetic mixing around 10^{-9}–10^{-8} for B($h \to \gamma' \gamma'$) = 0.01 and 0.1. See their Fig. 9 for mass-dependent limits. NODE=S029HPH;LINKAGE=AB

[111] ABLIKIM 19A look for $J/\psi \to \gamma' \eta$ ($\gamma' \to e^+ e^-$). Limits between 6×10^{-3} and 5×10^{-2} are obtained (see their Fig. 8). NODE=S029HPH;LINKAGE=ZA

[112] ABLIKIM 19H look for $J/\psi \to \gamma' \eta'$ ($\gamma' \to e^+ e^-$). Limits between 3.4×10^{-3} and 2.6×10^{-2} are obtained. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=EB

[113] AGUILAR-AREVALO 19A look for the absorption signal of hidden photon dark matter by using a CCD. The quoted limit applies to $m_{\gamma'} = 17$ eV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=LB

[114] APRILE 19D is analogous to ABE 14F. The quoted limit applies to $m_{\gamma'} = 0.7$ keV. See their Fig. 5(f) for mass-dependent limits. NODE=S029HPH;LINKAGE=MB

[115] BANERJEE 19 is an update of BANERJEE 18A. The quoted limit is at $m_{\gamma'} = 1$ MeV. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=NB

[116] BHOONAH 19 examine heating of Galactic Center gas clouds by hidden photon dark matter. The quoted limit applies to $m_{\gamma'} \simeq 10^{-12}$ eV. See their Fig. 2 for mass-dependent limits. NODE=S029HPH;LINKAGE=GB

[117] BRUN 19 is analogous to SUZUKI 15. The limit is derived under an assumption that hidden photons constitute the local dark matter density $\rho_{\gamma'} = 0.3$ GeV/cm^3. NODE=S029HPH;LINKAGE=FB

[118] CORTINA-GIL 19 look for an invisible hidden photon in the reaction $K^+ \rightarrow \pi^+ \pi^0$ ($\pi^0 \rightarrow \gamma\gamma'$). The quoted limit applies to $m_{\gamma'} = 62.5$–65 MeV. See their Figs. 6 and 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=HB

[119] DANILOV 19 examined the hidden photon production in nuclear reactors, correctly taking account of the effective photon mass in the reactor and detector. The limit gets weaker for $m_{\gamma'}$ less than the effective photon mass in proportion to $1/m^2_{\gamma'}$. See their Fig. 1 for mass-dependent limits. NODE=S029HPH;LINKAGE=DB

[120] HOCHBERG 19 look for the absorption signal of hidden photon dark matter by using superconducting-nanowire single-photon detectors. The quoted limit applies to $m_{\gamma'} \simeq$ 1 eV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=OB

[121] KOPYLOV 19 look for hidden-photon dark matter using a counter with an aluminum cathode and derive limits assuming it constitute all the local dark matter. The quoted limit applies to $m_{\gamma'} = 12$ eV. See their Fig. 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=JB

[122] KOVETZ 19 examine heating of the early Universe plasma by hidden photon dark matter, and derive the limits by requiring that the cosmic mean 21 cm brightness temperature relative to the CMB temperature satisfy $\mathrm{T}_{21} > -100$ mK. The quoted limit applies to $m_{\gamma'} \simeq 2 \times 10^{-14}$ eV. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=IB

[123] NGUYEN 19 look for hidden photon dark matter with a resonant cavity, and set limits $\sim 10^{-12}$ for $m_{\gamma'} = 0.2$–2.07μeV. The quoted limit applies to $m_{\gamma'} = 1.3\ \mu$eV. The local density $\rho_{\gamma'} = 0.3$ GeV/cm^3 is assumed. See their Fig. 19 for mass-dependent limits. NODE=S029HPH;LINKAGE=KB

[124] ABE 18F is an update of ABE 14F. The quoted limit applies to $m_{\gamma'} \simeq 40$ keV. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=BB

[125] ADRIAN 18 look for a hidden photon resonance in the reaction $e^- Z \rightarrow e^- Z \gamma'$ ($\gamma' \rightarrow e^+ e^-$). The quoted limit applies to $m_{\gamma'} = 40$ MeV. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=WA

[126] ANASTASI 18B look for a hidden photon resonance in the reaction $e^+ e^- \rightarrow \gamma' \gamma$ ($\gamma' \rightarrow \mu^+ \mu^-$). The quoted limit is obtained by combining the result of ANASTASI 16 and it applies to $m_{\gamma'} \simeq 519$–987 MeV. See their Fig. 9 for mass-dependent limits. NODE=S029HPH;LINKAGE=XA

[127] ARMENGAUD 18 is analogous to ABE 14F. The quoted limits applies to $m_{\gamma'} = 1.6$ keV. See the right panel of Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=YA

[128] BANERJEE 18 look for hidden photons produced in the reaction $e^- Z \rightarrow e^- Z \gamma'$ ($\gamma' \rightarrow e^+ e^-$), and exclude $9.2 \times 10^{-5} \lesssim \chi \lesssim 1 \times 10^{-2}$ for $m_{\gamma'} = 1$–23 MeV. They also set a limit on the electron coupling to a 16.7 MeV gauge boson suggested by the ATOMKI (KRASZNAHORKAY 16) experiment. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=TA

[129] BANERJEE 18A look for invisible decays of hidden photons produced in the reaction $e^- Z \rightarrow e^- Z \gamma'$. The quoted limit is at $m_{\gamma'} = 1$ MeV. See their Fig. 15 for mass-dependent limits. NODE=S029HPH;LINKAGE=UA

[130] KNIRCK 18 is analogous to SUZUKI 15. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=CB

[131] ABGRALL 17 is analogous to ABE 14F using the MAJORANA DEMONSTRATOR. See their Fig. 3 for limits between 6 keV $< m_{\gamma'} <$ 97 keV. NODE=S029HPH;LINKAGE=NA

[132] ABLIKIM 17AA look for $e^+ e^- \rightarrow \gamma\gamma'$ ($\gamma' \rightarrow e^+ e^-$ or $\mu^+ \mu^-$). Limits between 10^{-3} and 10^{-4} are obtained (see their Fig. 3). NODE=S029HPH;LINKAGE=SA

[133] ANGLOHER 17 is analogous to ABE 14F. The quoted limit is at $m_{\gamma'} = 0.7$ keV. See their Fig. 8 for mass-dependent limits. NODE=S029HPH;LINKAGE=OA

[134] BANERJEE 17 look for invisible decays of hidden photons produced in the reaction $e^- Z \rightarrow e^- Z \gamma'$. The quoted limit applies to $m_{\gamma'} = 2$ MeV. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=GA

[135] CHANG 17 examine the hidden photon emission from SN1987A, including the effects of finite temperature and density on χ and obtain limits $\chi\ (m_{\gamma'}/\mathrm{MeV}) \lesssim 3 \times 10^{-9}$ for $m_{\gamma'} < 15$ MeV and $\chi \lesssim 10^{-9}$ for $m_{\gamma'} = 15$–120 MeV. NODE=S029HPH;LINKAGE=QA

[136] DUBININA 17 look for $\mu^+ \rightarrow e^+ \overline{\nu}_\mu \nu_e \gamma'$ ($\gamma' \rightarrow e^+ e^-$) in a nuclear photoemulsion. The quoted limit applies to $m_{\gamma'}$ = 1.1 MeV. Limits between 4.5×10^{-3} and 10^{-2} are obtained (see their Fig. 3). NODE=S029HPH;LINKAGE=PA

[137] LEES 17E look for invisible decays of hidden photons produced in the reaction $e^+ e^- \rightarrow \gamma\gamma'$. See their Fig. 5 for limits in the mass range $m_{\gamma'} \leq$ 8 GeV. NODE=S029HPH;LINKAGE=RA

[138] AAD 16AG look for hidden photons promptly decaying into collimated electrons and/or muons, assuming that they are produced in the cascade decays of squarks or the Higgs boson. See their Fig. 10 and Fig.13 for their limits on the cross section times branching fractions. NODE=S029HPH;LINKAGE=FA

[139] ANASTASI 16 look for the decay $\gamma' \rightarrow \pi^+ \pi^-$ in the reaction $e^+ e^- \rightarrow \gamma\gamma'$. Limits between 4.3×10^{-3} and 4.4×10^{-4} are obtained for 527 < $m_{\gamma'}$ < 987 MeV (see their Fig. 9). NODE=S029HPH;LINKAGE=EA

[140] KHACHATRYAN 16 look for $\gamma' \rightarrow \mu^+ \mu^-$ in a dark SUSY scenario where the SM-like Higgs boson decays into a pair of the visible lightest neutralinos with mass 10 GeV, both of which decay into γ' and a hidden neutralino with mass 1 GeV. See the right panel in their Fig. 2. NODE=S029HPH;LINKAGE=Z

[141] AAD 15CD look for $H \rightarrow Z\gamma' \rightarrow 4\ell$ with the ATLAS detector at LHC and find χ < 4–17 $\times 10^{-2}$ for $m_{\gamma'}$ = 15–55 GeV. See their Fig. 6. NODE=S029HPH;LINKAGE=V

[142] ADARE 15 look for a hidden photon in π^0, $\eta^0 \rightarrow \gamma e^+ e^-$ at the PHENIX experiment. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=W

[143] AN 15A derived limits from the absence of ionization signals in the XENON10 and XENON100 experiments, assuming hidden photons constitute all the local dark matter. Their best limit is χ < 1.3×10^{-15} at $m_{\gamma'}$ = 18 eV. See their Fig. 1 for mass-dependent limits. NODE=S029HPH;LINKAGE=R

[144] ANASTASI 15 look for a production of a hidden photon and a hidden Higgs boson with the KLOE detector at DAΦNE, where the hidden photon decays into a pair of muons and the hidden Higgs boson lighter than $m_{\gamma'}$ escape detection. See their Figs. 6 and 7 for mass-dependent limits on a product of the hidden fine structure constant and the kinetic mixing. NODE=S029HPH;LINKAGE=T

[145] ANASTASI 15A look for the decay $\gamma' \rightarrow e^+ e^-$ in the reaction $e^+ e^- \rightarrow e^+ e^- \gamma$. Limits between 1.7×10^{-3} and 1×10^{-2} are obtained for $m_{\gamma'}$ = 5–320 MeV (see their Fig. 7). NODE=S029HPH;LINKAGE=U

[146] BATLEY 15A look for $\pi^0 \rightarrow \gamma\gamma'$ ($\gamma' \rightarrow e^+ e^-$) at the NA48/2 experiment. Limits between 4.2×10^{-4} and 8.8×10^{-3} are obtained for $m_{\gamma'}$ = 9–120 MeV (see their Fig. 4). NODE=S029HPH;LINKAGE=X

[147] JAEGLE 15 look for the decay $\gamma' \rightarrow e^+ e^-$, $\mu^+ \mu^-$, or $\pi^+ \pi^-$ in the dark Higgsstrahlung channel, $e^+ e^- \rightarrow \gamma' H'$ ($H' \rightarrow \gamma'\gamma'$) at the BELLE experiment. They set limits on a product of the branching fraction and the Born cross section as well as a product of the hidden fine structure constant and the kinetic mixing. See their Figs. 3 and 4. NODE=S029HPH;LINKAGE=AA

[148] KAZANAS 15 set limits by studying the decay of hidden photons $\gamma' \rightarrow e^+ e^-$ inside and near the progenitor star of SN1987A. See their Fig. 6 for mass-dependent limits. NODE=S029HPH;LINKAGE=M

[149] SUZUKI 15 looked for hidden-photon dark matter with a dish antenna and derived limits assuming they constitute all the local dark matter. Their limits are χ < 6×10^{-12} for $m_{\gamma'}$ = 1.9–4.3 eV. See their Fig. 7 for mass-dependent limits. NODE=S029HPH;LINKAGE=CA

[150] VINYOLES 15 performed a global fit analysis based on helioseismology and solar neutrino observations, and set the limits $\chi m_{\gamma'}$ < 1.8×10^{-12} eV for $m_{\gamma'}$ = 3×10^{-5}–8 eV. See their Fig. 11. NODE=S029HPH;LINKAGE=BA

[151] ABE 14F look for the photoelectric-like interaction in the XMASS detector assuming the hidden photon constitutes all the local dark matter. Limits between 2×10^{-13} and 1×10^{-12} are obtained, where the relation $\chi^2 = \alpha'/\alpha$ is used to translate the original bound on the ratio of the hidden and EM fine-structure constants. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=P

[152] AGAKISHIEV 14 look for hidden photons $\gamma' \rightarrow e^+ e^-$ at the HADES experiment, and set limits on χ for $m_{\gamma'}$ = 0.02–0.6 GeV. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=I

[153] BABUSCI 14 look for the decay $\gamma' \rightarrow \mu^+ \mu^-$ in the reaction $e^+ e^- \rightarrow \mu^+ \mu^- \gamma$. Limits between 4×10^{-3} and 9.0×10^{-4} are obtained for 520 MeV < $m_{\gamma'}$ < 980 MeV (see their Fig. 7). NODE=S029HPH;LINKAGE=J

[154] BATELL 14 derived limits from the electron beam dump experiment at SLAC (E-137) by searching for events with recoil electrons by sub-GeV dark matter produced from the decay of the hidden photon. Limits at the level of 10^{-4}–10^{-1} are obtained for $m_{\gamma'}$ = 10^{-3}–1 GeV, depending on the dark matter mass and the hidden gauge coupling (see their Fig. 2). NODE=S029HPH;LINKAGE=Q

[155] BLUEMLEIN 14 analyzed the beam dump data taken at the U-70 accelerator to look for γ'-bremsstrahlung and the subsequent decay into muon pairs and hadrons. See their Fig. 4 for mass-dependent excluded region. NODE=S029HPH;LINKAGE=O

[156] FRADETTE 14 studied effects of decay of relic hidden photons on BBN and CMB to set constraints on very small values of the kinetic mixing. See their Figs. 4 and 7 for mass-dependent excluded regions. NODE=S029HPH;LINKAGE=N

[157] LEES 14J look for hidden photons in the reaction $e^+ e^- \to \gamma\gamma'$ ($\gamma' \to e^+ e^-$, $\mu^+ \mu^-$). Limits at the level of 10^{-4}–10^{-3} are obtained for 0.02 GeV $< m_{\gamma'} <$ 10.2 GeV. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=K

[158] MERKEL 14 look for $\gamma' \to e^+ e^-$ at the A1 experiment at the Mainz Microtron (MAMI). See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=L

[159] AN 13B examined the stellar production of hidden photons, correcting an important error of the production rate of the longitudinal mode which now dominates. See their Fig. 2 for mass-dependent limits based on solar energy loss. NODE=S029HPH;LINKAGE=G

[160] AN 13C use the solar flux of hidden photons to set a limit on the atomic ionization rate in the XENON10 experiment. They find $\chi\, m_{\gamma'} < 3 \times 10^{-12}$ eV for $m_{\gamma'} <$ 1 eV. See their Fig. 2 for mass-dependent limits. NODE=S029HPH;LINKAGE=H

[161] DIAMOND 13 analyzed the beam dump data taken at the SLAC millicharge experiment to constrain a hidden photon invisibly decaying into lighter long-lived particles, which undergo elastic scattering off nuclei in the detector. Limits between 8×10^{-4}–2×10^{-2} are obtained. The quoted limit is applied when the dark gauge coupling is set equal to the electromagnetic coupling. See their Fig.4 for mass-dependent limits. NODE=S029HPH;LINKAGE=KA

[162] GNINENKO 13 used the data taken at the SINDRUM experiment to constrain the decay, $\pi^0 \to \gamma\gamma'$ ($\gamma' \to e^+ e^-$) to derive limits. See their Fig. 2 for their mass-dependent excluded region. NODE=S029HPH;LINKAGE=QB

[163] HORVAT 13 look for hidden-photo-electric effect in HPGe detectors induced by solar hidden photons. See their Fig. 3 for mass-dependent limits. NODE=S029HPH;LINKAGE=A

[164] INADA 13 search for hidden photons using an intense X-ray beamline at SPring-8. See their Fig. 4 for mass-dependent limits. NODE=S029HPH;LINKAGE=B

[165] MIZUMOTO 13 look for solar hidden photons. See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=E

[166] PARKER 13 look for hidden photons using a cryogenic resonant microwave cavity. See their Fig.5 for mass-dependent limits. NODE=S029HPH;LINKAGE=C

[167] PARKER 13 derived a limit for the hidden photon CDM with a randomly oriented hidden photon field. NODE=S029HPH;LINKAGE=D

[168] REDONDO 13 examined the solar emission of hidden photons including the enhancement factor for the longitudinal mode pointed out by AN 13B, and also updated stellar-energy loss arguments. See their Fig.3 for mass-dependent limits, including a review of the currently best limits from other arguments. NODE=S029HPH;LINKAGE=F

[169] GNINENKO 12A obtained bounds on B($\pi^0 \to \gamma\gamma'$) $\cdot$ B($\gamma' \to e^+ e^-$) from the NOMAD and PS191 neutrino experiments, and derived limits between 8×10^{-8}–2×10^{-4}. See their Fig.4 for mass-dependent excluded regions. NODE=S029HPH;LINKAGE=LA

[170] GNINENKO 12B used the data taken at the CHARM experiment to constrain the decay, $\eta(\eta') \to \gamma\gamma'$ ($\gamma' \to e^+ e^-$), and derived limits between 1×10^{-7}–1×10^{-4}. See their Fig.4 for mass-dependent excluded region. NODE=S029HPH;LINKAGE=MA

[171] ABRAHAMYAN 11 look for $\gamma' \to e^+ e^-$ in the electron-nucelon fixed-target experiment at the Jefferson Laboratory (APEX). See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=HA

[172] BLUEMLEIN 11 analyzed the beam dump data taken at the U-70 accelerator to look for $\pi^0 \to \gamma\gamma'$ ($\gamma' \to e^+ e^-$). See their Fig. 5 for mass-dependent limits. NODE=S029HPH;LINKAGE=Y

[173] BJORKEN 09 analyzed the beam dump data taken at E137, E141, and E774 to constrain a hidden photon produced by bremsstrahlung, subsequently decaying into $e^+ e^-$, and derived limits between 10^{-7} and 10^{-2}. See their Fig. 1 for mass-dependent excluded region. NODE=S029HPH;LINKAGE=IA

[174] BJORKEN 09 required the energy loss in the γ' emission from the core of SN1987A not to exceed 10^{53} erg/s, and derived limits between 5×10^{-9} and 2×10^{-6}. See their Fig. 1 for mass-dependent excluded region. NODE=S029HPH;LINKAGE=JA

REFERENCES FOR Searches for Axions (A^0) and Other Very Light Bosons

NODE=S029

AAD	25AN	EPJ C85 886	G. Aad *et al.*	(ATLAS Collab.)	REFID=63511
AAD	25AT	PL B868 139671	G. Aad *et al.*	(ATLAS Collab.)	REFID=63663
AAD	25AY	PR D112 092001	G. Aad *et al.*	(ATLAS Collab.)	REFID=63682
AAD	25BF	JHEP 2511 061 (errat.)	G. Aad *et al.*	(ATLAS Collab.)	REFID=63715
ABLIKIM	25AV	PR D111 072008	M. Ablikim *et al.*	(BESIII Collab.)	REFID=63388
ABLIKIM	25CL	PR D112 052007	M. Ablikim *et al.*	(BESIII Collab.)	REFID=63671
ABRAHAM	25	JHEP 2501 199	R. Abraham *et al.*	(FASER Collab.)	REFID=63433
ADACHI	25AA	JHEP 2512 109	I. Adachi *et al.*	(BELLE II Collab.)	REFID=63724
ADAMS	25C	PR D112 103044	C.B. Adams *et al.*	(VERITAS Collab.)	REFID=63765
AHYOUNE	25	JHEP 2504 113	S. Ahyoune *et al.*	(RADES Collab.)	REFID=63462
ALBAKRY	25	PR D111 012006	M.F. Albakry *et al.*	(SuperCDMS Collab.)	REFID=63365
ALONSO-GON...	25	PR D111 083019	D. Alonso-Gonzalez *et al.*	(IFT, MADU)	REFID=63391
Also		PR D112 029901 (errat.)	D. Alonso-Gonzalez *et al.*	(IFT, MADU)	REFID=63588
ALONSO-GON...	25A	PR D112 029901 (errat.)	D. Alonso-Gonzalez *et al.*	(IFT, MADU)	REFID=63588
ALRAHMAN	25	PRL 134 151801	F.A. Alrahman *et al.*	(ICARUS Collab.)	REFID=63331
ALTENMULL...	25	JHEP 2512 009	K. Altenmueller *et al.*	(CAST Collab.)	REFID=63775
AN	25	PRL 134 171001	H. An *et al.*		REFID=63231
ANDREEV	25	JHEP 2506 256	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=63484
APRILE	25A	PRL 134 161004	E. Aprile *et al.*	(XENONnT Collab.)	REFID=63335
ARIAS-ARAG...	25	PR D111 043021	F. Arias-Aragon *et al.*		REFID=63561
ASWATHI	25	PR D112 123048	P.S. Aswathi *et al.*		REFID=63745
BAE	25	PRL 135 091804	S. Bae *et al.*	(DMAG Collab.)	REFID=63540
BAI	25	PRL 134 151006	X. Bai *et al.*	(HAYSTAC Collab.)	REFID=63232
BASILICO	25	EPJ C85 1182	D. Basilico *et al.*	(Borexino Collab.)	REFID=63726
BAUDIS	25	PRL 135 081002	L. Baudis *et al.*	(QROCODILE Collab.)	REFID=63536
BLOCH	25	PRL 134 161002	I. Bloch *et al.*	(SENSEI Collab.)	REFID=63333

BRAGGIO	25	PR X15 021031	C. Braggio *et al.*	(QUAX Collab.)	REFID=63521
CANDON	25	PRL 134 171004	F. Candon *et al.*	(ZARA, DESY, SLAC, PADO+)	REFID=63338
CAPUTO	25	PRL 134 151002	A. Caputo *et al.*	(CERN, ROMA, MPIG, IBSD)	REFID=63329
CAROSI	25	PRL 135 191001	G. Carosi *et al.*	(ADMX Collab.)	REFID=63653
CHEKHOVSKY	25	PR D112 012009	V. Chekhovsky *et al.*	(CMS Collab.)	REFID=63417
CHEN	25	PRL 134 241001	Y-X. Chen *et al.*		REFID=63343
CHEN	25A	PR D111 083002	Y-C. Chen *et al.*		REFID=63390
CHEN	25B	PR D111 123019	Y. Chen *et al.*		REFID=63412
CHOI	25	PRL 134 021802	J. Choi *et al.*	(NEON Collab.)	REFID=63300
CORTINA-GIL	25A	EPJ C85 571	E. Cortina Gil *et al.*	(NA62 Collab.)	REFID=63506
CORTINA-GIL	25B	JHEP 2511 143	E. Cortina Gil *et al.*	(NA62 Collab.)	REFID=63769
EGGE	25	PRL 134 151004	J. Egge *et al.*	(MADMAX Collab.)	REFID=63330
FONG	25	PR D112 083052	C. Fong, K.C.Y. Ng, Q. Liu	(CUHK)	REFID=63681
GENG	25	JP G52 115004	X.P. Geng, B. Zhong, Z.H. Zhang		REFID=63731
GOLDSTEIN	25	PRL 134 081001	S. Goldstein *et al.*	(COLU, CAVE, WATER)	REFID=63311
GOODMAN	25	PRL 134 111002	C. Goodman *et al.*	(ADMX Collab.)	REFID=63320
HAYRAPETY...	25Z	JHEP 2508 006	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63491
HOSHINO	25	PRL 134 171002	G. Hoshino *et al.*	(BREAD Collab.)	REFID=63336
IVANEZ-BAL...	25	PR D112 L101301	P. Ivanez-Ballesteros, M.C. Volpe	(UPCIT, CNRS)	REFID=63687
JANISH	25	PRL 134 071002	R. Janish, E. Pinetti	(FNAL, CHIC)	REFID=63572
KAR	25	JCAP 2505 100	A. Kar, S. Roy, P. Sarkar	(SORB, IACS)	REFID=63531
KIRITA	25	JHEP 2506 138	Y. Kirita *et al.*	(SAPPHIRES Collab.)	REFID=63479
LI	25	PRL 134 071004	T. Li *et al.*	(PandaX Collab.)	REFID=63308
LI	25D	CP C49 105107	J. Li *et al.*		REFID=63777
LINDEN	25	PR D112 023026	T. Linden, T.T.Q. Nguyen, T.M.P. Tait	(STOH+)	REFID=63425
MELO-GALIN...	25	PR D112 103049	A. Melo Galindo, S. Hernandez-Cadena, R. Alfaro Molina		REFID=63766;ERROR=1
MIRASOLA	25	PR D111 084032	L. Mirasola *et al.*	(CAGL, PERIM, ROCK+)	REFID=63568
MIRZAKHANI	25	PR D112 032013	M. Mirzakhani *et al.*	(MINER Collab.)	REFID=63546
MONTEFAL...	25	PR D112 023506	G. Montefalcone *et al.*	(TEXA, INFNP)	REFID=63571
NING	25	PRL 134 171003	O. Ning, B. Safdi	(UCB, LBL)	REFID=63337
PARK	25	PRL 134 201002	B.J. Park *et al.*	(NEON Collab.)	REFID=63341
PORAYKO	25	PR D111 062005	N.K. Porayko *et al.*	(EPTA Collab.)	REFID=63564
ROMERO-JOR...	25	PR C112 054905	A.W. Romero Jorge *et al.*	(FRAN, GSI)	REFID=63780
RUZ	25	PRL 135 141001	J. Ruz *et al.*	(ZARA, LLNL, DORT, TURIN+)	REFID=63644
SANTOS-GAR...	25	PRL 135 041001	B.A. Dos Santos Garcia *et al.*	(MADMAX Collab.)	REFID=63350
SARDO-INF...	25	PRL 135 211002	G. Sardo Infirri *et al.*	(QUAX Collab.)	REFID=63656
TODARELLO	25	JCAP 2505 070	E. Todarello, M. Regis	(NOTT, TURIN, INFN)	REFID=63530
TROITSKY	25	JETPL 121 159	S. Troitsky	(INRM, MOSU)	REFID=63513
TROST	25	PR D111 083034	A. Trost *et al.*	(TRST, TRSTI, CERN, BOST+)	REFID=63392
UNO	25	JHEP 2508 155	K. Uno *et al.*	(BELLE Collab.)	REFID=63497
WALTER	25	PR D112 052008	J. Walter *et al.*	(CASPEr-gradient Collab.)	REFID=63672
YIN	25	PRL 134 051004	W. Yin *et al.*	(WINERED Collab.)	REFID=63305
ZENG	25	PRL 134 041001	X. Zeng *et al.*	(PandaX-4T Collab.)	REFID=63303
ZHANG	25A	PRL 135 131001	K.Y. Zhang, L.Y. Wu, H. Yan		REFID=63641
ZHAO	25	PRL 135 201002	F. Zhao *et al.*	(SQUAD Collab.)	REFID=63654
ZHAO	25A	PR D112 112016	P. Zhao *et al.*	(TUM)	REFID=63691
ZIMMER...	25	PRL 134 151001	T. Zimmerman *et al.*	(OSLO, AMST, LOKC+)	REFID=63328
AAD	24AS	EPJ C84 719	G. Aad *et al.*	(ATLAS Collab.)	REFID=62894
AAD	24AT	EPJ C84 742	G. Aad *et al.*	(ATLAS Collab.)	REFID=62896
AAD	24BN	PRL 133 161803	G. Aad *et al.*	(ATLAS Collab.)	REFID=63054
AAD	24BZ	JHEP 2411 036	G. Aad *et al.*	(ATLAS Collab.)	REFID=63134
Also		JHEP 2511 061 (errat.)	G. Aad *et al.*	(ATLAS Collab.)	REFID=63715
AAD	24CD	JHEP 2411 126	G. Aad *et al.*	(ATLAS Collab.)	REFID=63139
AAD	24K	PL B850 138536	G. Aad *et al.*	(ATLAS Collab.)	REFID=62749
ABLIKIM	24AD	PR D110 L031101	M. Ablikim *et al.*	(BESIII Collab.)	REFID=62683
ABLIKIM	24AK	JHEP 2407 135	M. Ablikim *et al.*	(BESIII Collab.)	REFID=62692
ABLIKIM	24G	PR D109 L031102	M. Ablikim *et al.*	(BESIII Collab.)	REFID=62657
ABLIKIM	24M	PR D109 072001	M. Ablikim *et al.*	(BESIII Collab.)	REFID=62663
ABRATENKO	24A	PRL 132 241801	P. Abratenko *et al.*	(MicroBooNE Collab.)	REFID=62732
ABREU	24	PL B848 138378	H. Abreu *et al.*	(FASER Collab.)	REFID=62570
ADACHI	24C	PR D109 012008	S. Adachi *et al.*	(DOSUE-RR Collab.)	REFID=62763
AGOSTINI	24A	EPJ C84 940	M. Agostini *et al.*	(GERDA Collab.)	REFID=63146
AGRAWAL	24	PRL 132 140801	A. Agrawal *et al.*	(CHIC, RUTG, LBNL+)	REFID=62953
AHN	24	PR X14 031023	S. Ahn *et al.*	(CAPP Collab.)	REFID=62950
ALTENMULL...	24	PRL 133 221005	K. Altenmueller *et al.*	(CAST Collab.)	REFID=63067
ANDREEV	24A	PR D109 L031103	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=62768
ANDREEV	24E	PR D110 112015	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=63110
APRILE	24B	PR D110 109903 (errat.)	E. Aprile *et al.*	(XENON1T Collab.)	REFID=63101
ARAMBURO...	24	JCAP 2411 049	A. Aramburo-Garcia *et al.*	(LEID, NORD+)	REFID=63160
ARNQUIST	24	PRL 132 041001	I.J. Arnquist *et al.*	(MAJORANA Collab.)	REFID=62706
AUGIER	24	EPJ C84 925	C. Augier *et al.*	(CUPID-Mo Collab.)	REFID=63145
BAE	24	PRL 133 211803	S. Bae *et al.*	(CAPP Collab.)	REFID=63065
BIANCHINI	24	PR D110 123527	F. Bianchini, G. Grilli di Cortona, M. Valli		REFID=63198;ERROR=2
CERVANTES	24	PR D110 043022	R. Cervantes *et al.*	(FNAL, NIST, PADO+)	REFID=63004
CORTINA-GIL	24	PL B850 138513	E. Cortina Gil *et al.*	(NA62 Collab.)	REFID=62748
CORTINA-GIL	24A	PRL 133 111802	E. Cortina-Gil *et al.*	(NA62 Collab.)	REFID=63047
DAVYDOV	24	PR D110 103022	D. Davydov, A. Libanov	(ASCI, INRM)	REFID=63099
DEV	24	PRL 132 101003	P.S.B. Dev *et al.*	(WUSL, LAVL, WASH+)	REFID=62713
DIAMOND	24	PRL 132 101004	M. Diamond *et al.*		REFID=62714
DOLAN	24	JCAP 2405 099	M.J. Dolan, F.J. Hiskens, R.R. Volkas	(MELB)	REFID=62919
FORDHAM	24	PR D109 123007	D. Fordham, I. Lopes		REFID=62818
GAO	24	PR D109 063003	L.-Q. Gao *et al.*		REFID=62783
GAO	24A	JCAP 2401 026	L.-Q. Gao *et al.*		REFID=62912
GUO	24	PL B852 138631	W.-Q. Guo, Z.-Q. Xia, X. Huang		REFID=62750
HAYRAPETY...	24AZ	JHEP 2412 172	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=63144
HAYRAPETY...	24I	PL B852 138582	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62751
HE	24	PR D110 L021101	D. He *et al.*	(APEX Collab.)	REFID=62825
HEINZE	24	PRL 132 191002	J. Heinze *et al.*	(LIDA Collab.)	REFID=62727
KIM	24	PRL 133 051802	Y. Kim *et al.*	(CAPP Collab.)	REFID=62741
KNIRCK	24	PRL 132 131004	S. Knirck *et al.*	(BREAD Collab.)	REFID=62718
LELLA	24	PR D109 023001	A. Lella *et al.*	(BARI, STOH, INFNL, +)	REFID=62597
LEVINE	24	PR D110 032010	J. Levine *et al.*	(Dark E-Field Radio Collab.)	REFID=62934
LI	24A	PL B850 138531	H.-J. Li *et al.*		REFID=62746
LI	24B	CP C48 065107	J. Li *et al.*		REFID=62908
LI	24D	PL B858 139075	H.J. Li, W. Chao, Y.-F. Zhou	(BEIJ, HIAS)	REFID=63117
LIU	24	EPJ C84 723	T.-C. Liu, M.-X. Lu, X.-S. Hu	(GXU)	REFID=62895
MANZARI	24	PRL 133 211002	C.A. Manzari *et al.*	(UCB, LBL)	REFID=63180
MCCARTHY	24	PRL 133 141003	F. McCarthy *et al.*	(CAMB, NYU, PERIM+)	REFID=63051
PANDEY	24	PRL 133 111003	S. Pandey *et al.*	(MIT)	REFID=63046
PANT	24	PR D109 023011	B.P. Pant	(IITJ)	REFID=62598

PYBUS	24	PL B855 138790	J.R. Pybus *et al.*	(GLUEX Collab.)	REFID=62760
QUISKAMP	24	PRL 132 031601	A. Quiskamp *et al.*	(ORGAN Collab.)	REFID=62704
RAVENSBURG	24	PR D109 023018	E. Ravensberg *et al.*	(STOH, LAPTH, LAPP)	REFID=62766
RETTAROLI	24	PR D110 022008	A. Rettaroli *et al.*	(QUAX Collab.)	REFID=62826
SADOVSKY	24	EPJ C84 266	A.S. Sadovsky *et al.*	(OKA Collab.)	REFID=62887
SU	24	PRL 133 191801	H. Su *et al.*		REFID=63060
TANG	24	PRL 133 021005	Z. Tang *et al.*	(SHANHE Collab.)	REFID=62738
TODARELLO	24	JCAP 2405 043	E. Todarello *et al.*		REFID=62917
TUMASYAN	24C	PR D110 012010	A. Tumasyan *et al.*	(CMS Collab.)	REFID=62979
WANG	24A	PR D110 103007	H. Wang *et al.*	(HSCA, HARV, LBL, BOST+)	REFID=63189
YAN	24A	JHEP 2406 028	S. Yan, L. Li, J.J. Fan	(BROW)	REFID=62987
AAD	23BO	PRL 131 251801	G. Aad *et al.*	(ATLAS Collab.)	REFID=62470
AAD	23I	JHEP 2306 153	G. Aad *et al.*	(ATLAS Collab.)	REFID=62122
AAD	23T	JHEP 2307 133	G. Aad *et al.*	(ATLAS Collab.)	REFID=62144
AALBERS	23A	PR D108 072006	J. Aalbers *et al.*	(LZ Collab.)	REFID=62491
ABLIKIM	23AF	PL B839 137785	M. Ablikim *et al.*	(BESIII Collab.)	REFID=62099
ABLIKIM	23E	PL B838 137698	M. Ablikim *et al.*	(BESIII Collab.)	REFID=62047
ABUDINEN	23B	PRL 130 071804	F. Abudinen *et al.*	(BELLE II Collab.)	REFID=62204
ACCIARRI	23	PRL 130 221802	R. Acciarri *et al.*	(ArgoNeuT Collab.)	REFID=62221
ADACHI	23A	PRL 130 181803	I. Adachi *et al.*	(BELLE II Collab.)	REFID=62218
ADACHI	23D	PR D108 043017	S. Adachi *et al.*	(POLARBEAR Collab.)	REFID=62360
ADACHI	23K	PR D108 L111104	I. Adachi *et al.*	(BELLE II Collab.)	REFID=62512
ADHIKARI	23	PR D107 122004	G. Adhikari *et al.*	(COSINE-100 Collab.)	REFID=62285
ADHIKARI	23A	PR D108 L041301	G. Adhikari *et al.*	(COSINE-100 Collab.)	REFID=62358
ADRIAN	23	PR D108 012015	P.H. Adrian *et al.*	(HPS Collab.)	REFID=62298
AGNES	23A	PRL 130 101002	P. Agnes *et al.*	(DarkSide-50 Collab.)	REFID=62212
AN	23A	PRL 130 181001	H. An *et al.*		REFID=62317
ANDREEV	23	PRL 131 161801	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=62454
APRILE	23B	PR D108 072015	E. Aprile *et al.*	(XENON Collab.)	REFID=62494
AYRES	23	NJP 25 103012	N.J. Ayres *et al.*		REFID=62625
AZZOLINI	23	PR D107 032006	O. Azzolini *et al.*	(CUPID-0 Collab.)	REFID=62248
BAJJALI	23	JCAP 2308 077	F. Bajjali *et al.*	(BRASS Collab.)	REFID=62382
BATTYE	23	PR D108 063001	R. Battye *et al.*		REFID=62484
BEAUFORT	23	PR D108 L081302	C. Beaufort *et al.*		REFID=62496
BERNAL	23	PR D107 103046	J.L. Bernal *et al.*	(JHU, TELA, REHO+)	REFID=62275
BERTUZZO	23	PRL 130 171801	E. Bertuzzo *et al.*	(USP)	REFID=62217
CAPOZZI	23	JCAP 2306 060	F. Capozzi *et al.*		REFID=62403
CAPOZZI	23A	PR D108 075019	F. Capozzi *et al.*		REFID=62495
CHENG	23	PR D107 063021	L.-d. Cheng, H. Zhang, S.-s. Bao	(SHDNQ)	REFID=62263
CORTINA-GIL	23B	PL B846 138193	E. Cortina-Gil *et al.*	(NA62 Collab.)	REFID=62476
CORTINA-GIL	23C	JHEP 2309 035	E. Cortina Gil *et al.*	(NA62 Collab.)	REFID=62522
DAVIES	23	PR D107 083027	J. Davies, M. Meyer, G. Cotter	(OXF, HAMB)	REFID=62268
DELLA-MON...	23	PR D108 L101303	R. Della Monica, I. de Martino		REFID=62505
DERBIN	23	JETPL 118 160	A.V. Derbin *et al.*	(PNPI)	REFID=62557
DIAMOND	23	PR D108 049902	M. Diamond *et al.*		REFID=62411
DI-VORA	23	PR D108 062005	R. Di Vora *et al.*	(QUAX Collab.)	REFID=62483
FILZINGER	23	PRL 130 253001	M. Filzinger *et al.*		REFID=62229
FIORILLO	23	PRL 131 021001	D.F.G. Fiorillo, G.G. Raffelt, E. Vitagliano	(NBI+)	REFID=62232
HAYRAPETY...	23G	JHEP 2312 070	A. Hayrapetyan *et al.*	(CMS Collab.)	REFID=62615
HOOF	23	JCAP 2303 054	S. Hoof, L. Schulz	(KIT, GOET)	REFID=62190
JACOBSEN	23	JCAP 2310 009	S. Jacobsen, T. Linden, K. Freese	(STOH, TEXA+)	REFID=62563
JEWELL	23	PR D107 072007	M.J. Jewell *et al.*	(HAYSTAC Collab.)	REFID=62265
KARANTH	23	PR X13 031004	S. Karanth *et al.*	(JEDI Collab.)	REFID=62309
KIM	23	PRL 130 091602	J. Kim *et al.*	(KAIST, RIKEN, TOKY)	REFID=62209
KOTAKA	23	PRL 130 071805	S. Kotaka *et al.*	(DOSUE-RR Collab.)	REFID=62205
LEE	23	PR X13 011050	J. Lee *et al.*	(ASTAR, PRIN)	REFID=62308
LI	23H	PR D107 063031	H.-J. Li, W. Chao	(BNORM)	REFID=62330
LI	23I	JCAP 2309 009	S.-P. Li, X.-J. Xu	(BHEP)	REFID=62559
NOORDHUIS	23	PRL 131 111004	D. Noordhuis *et al.*	(AMST, PRIN, STAN+)	REFID=62444
NOTARI	23	PRL 131 011004	A. Notari, F. Rompineve, G. Villadoro	(ICCUB+)	REFID=62230
OSHIMA	23	PR D108 072005	Y. Oshima *et al.*	(DANCE Collab.)	REFID=62490
PANT	23	PR D108 023016	B.P. Pant *et al.*	(IITJ)	REFID=62335
PODDAR	23	PR D108 103024	T.K. Poddar, D. Pachhar		REFID=62509
RAMANATH...	23	PRL 130 231001	K. Ramanathan *et al.*	(CIT, JPL)	REFID=62222
ROGERS	23	JCAP 2306 023	K.K. Rogers *et al.*		REFID=62402
ROMANENKO	23	PRL 130 261801	A. Romanenko *et al.*	(FNAL)	REFID=62227
SANDNER	23	EPJ C83 709	S. Sandner, M. Escudero, S.J. Witte	(VALE, CERN+)	REFID=62409
SHERRILL	23	NJP 25 093012	N. Sherrill *et al.*	(SUSS, NPLT)	REFID=62624
SMARRA	23	PRL 131 171001	C. Smarra *et al.*	(EPTA Collab.)	REFID=62456
SULAI	23	PR D108 096026	I. Sulai *et al.*	(SNIPE Hunt Collab.)	REFID=62504
THOMSON	23	PR D107 112003	C.A. Thomson *et al.*	(UPLOAD Collab.)	REFID=62277
WADEKAR	23	PR D107 083011	D. Wadekar, Z. Wang	(IAS, NYU)	REFID=62267
XIA	23	PR D107 L121302	Z.-Q. Xia *et al.*		REFID=62283
YANG	23	PRL 131 081801	B. Yang *et al.*	(CAPP Collab.)	REFID=62324
YAO	23	PR D107 043031	R.-M. Yao *et al.*		REFID=62329
YI	23	PRL 130 071002	A.K. Yi *et al.*	(CAPP Collab.)	REFID=62202
YI	23A	PR D108 L021304	A.K. Yi *et al.*	(CAPP Collab.)	REFID=62304
ZHANG	23	PRL 130 201401	S.-B. Zhang *et al.*	(CST)	REFID=62040
ZHANG	23A	PRL 130 251002	X. Zhang *et al.*	(MAINZ, REHO, UCB, +)	REFID=62224
AAD	22J	JHEP 2203 041	G. Aad *et al.*	(ATLAS Collab.)	REFID=61779
AAD	22S	EPJ C82 105	G. Aad *et al.*	(ATLAS Collab.)	REFID=61823
ADE	22	PR D105 022006	P.A.R. Ade *et al.*	(BICEP/Keck Collab.)	REFID=61713
ADHIKARI	22C	PR D105 052007	S. Adhikari *et al.*	(GLUEX Collab.)	REFID=61729
AGOSTINI	22	JCAP 2212 012	M. Agostini *et al.*	(GERDA Collab.)	REFID=61978
AGOSTINI	22A	PRL 129 089901	M. Agostini *et al.*	(GERDA Collab.)	REFID=61986
ALESINI	22	PR D106 052007	D. Alesini *et al.*	(QUAX Collab.)	REFID=61942
APRILE	22	PR D106 022001	E. Aprile *et al.*	(XENON1T Collab.)	REFID=61760
Also		PR D110 109903 (errat.)	E. Aprile *et al.*	(XENON1T Collab.)	REFID=63101
APRILE	22B	PRL 129 161805	E. Aprile *et al.*	(XENONnT Collab.)	REFID=61920
ARNQUIST	22	PRL 129 081803	I.J. Arnquist *et al.*	(MAJORANA Collab.)	REFID=61985
ARZA	22	PR D105 095007	A. Arza *et al.*	(ITEP, JHU, STAN, CSEB)	REFID=62630
BATTAGLIERI	22	PR D106 072011	M. Battaglieri *et al.*	(BDX-MINI Collab.)	REFID=61947
BATTYE	22	PR D105 L021305	R.A. Battye *et al.*		REFID=61712
BERNAL	22	PRL 129 231301	J.L. Bernal, G. Sato-Polito, M. Kamionkowski	(JHU)	REFID=61929
BOLTON	22	PRL 129 211102	J.S. Bolton *et al.*		REFID=61988
BUSCHMANN	22	PRL 128 091102	M. Buschmann *et al.*	(PRIN, MICH, UCB+)	REFID=61669
CALORE	22	PR D105 063028	F. Calore *et al.*	(LAPTH, STOH, BARI, WROC+)	REFID=61732
CAPUTO	22	PRL 128 221103	A. Caputo *et al.*		REFID=61682
CASTILLO	22	JCAP 2206 014	A. Castillo *et al.*		REFID=61858
CERVANTES	22	PRL 129 201301	R. Cervantes *et al.*	(ADMX Collab.)	REFID=61924

CHANG	22	PRL 129 111802	H. Chang *et al.*	(TASEH Collab.)	REFID=61916
CHILES	22	PRL 128 231802	J. Chiles *et al.*		REFID=61685
COLOMA	22A	JHEP 2207 138	P. Coloma *et al.*	(IFT, CNYIT, ICC, ICREA+)	REFID=61811
CRESCINI	22	PR D105 022007	N. Crescini *et al.*		REFID=61714
DEROCCO	22	PRL 129 101101	W. DeRocco *et al.*		REFID=61710
DESSERT	22	PRL 128 071102	C. Dessert, A.J. Long, B.R. Safdi	(MICH, UCB+)	REFID=61668
DESSERT	22A	PR D105 103034	C. Dessert, D. Dunsky, B.R. Safdi	(UCB, LBL+)	REFID=61748
ECKNER	22	PR D106 083020	C. Eckner, F. Calore	(LAPTH)	REFID=61952
FENG	22	PRL 128 231803	Y.-K. Feng *et al.*		REFID=61686
FERGUSON	22	PR D106 042011	K.R. Ferguson *et al.*	(SPT-3G Collab.)	REFID=61772
FOSTER	22	PRL 129 251102	J.W. Foster *et al.*		REFID=61933
GAVRILYUK	22	JETPL 116 11	Yu.M. Gavrilyuk *et al.*		REFID=61842
HOCHBERG	22	PR D106 112005	Y. Hochberg *et al.*	(SNSPD Collab.)	REFID=61963
IKEDA	22	PR D105 102004	T. Ikeda *et al.*		REFID=61746
JIA	22	PRL 128 081804	S. Jia *et al.*	(BELLE Collab.)	REFID=61657
KIRITA	22	JHEP 2210 176	Y. Kirita *et al.*	(SAPPHIRES Collab.)	REFID=61970
LAGUE	22	JCAP 2201 049	A. Lague *et al.*		REFID=61852
LANGHOFF	22	PRL 129 241101	K. Langhoff, N.J. Outmezguine, N.L. Rodd	(UCB+)	REFID=61930
LEE	22	PRL 128 241805	Y. Lee *et al.*	(CAPP Collab.)	REFID=61688
LEES	22	PRL 128 021802	J.P. Lees *et al.*	(BABAR Collab.)	REFID=61512
LEES	22B	PRL 128 131802	J.P. Lees *et al.*	(BABAR Collab.)	REFID=61671
LI	22	PL B829 137047	H.-J. Li	(BNORM)	REFID=61704
LI	22C	CP C46 085105	H.-J. Li, X.-J. Bi, P.-F. Yin		REFID=61844
LU	22	PR D105 123017	B.-Q. Lu, C.-W. Chiang		REFID=61870
LUCENTE	22	PRL 129 011101	G. Lucente *et al.*		REFID=61689
MANENTI	22	PR D105 052010	L. Manenti *et al.*	(MuDHI Collab.)	REFID=61730
QUISKAMP	22	SADV 8 27	A. Quiskamp *et al.*	(ORGAN Collab.)	REFID=62417
SCHULTHESS	22	PRL 129 191801	I. Schulthess *et al.*	(BERN, ILLG)	REFID=61923
THOMAS	22	PR D105 L031901	A.W. Thomas, X.G. Wang, A.G. Williams	(ADLD)	REFID=61717
TUMASYAN	22AH	EPJ C82 290	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61828
TUMASYAN	22N	JHEP 2204 062	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61785
TUMASYAN	22R	JHEP 2204 087	A. Tumasyan *et al.*	(CMS Collab.)	REFID=61792
WANG	22C	PRL 129 051801	Y. Wang *et al.*		REFID=61697
WU	22A	PR D106 L081101	Y.M. Wu *et al.*	(PPTA Collab.)	REFID=61948
XIAO	22	PR D106 123019	M. Xiao *et al.*		REFID=61966
YOON	22	PR D106 092007	H. Yoon *et al.*		REFID=61957
YUAN	22A	PR D106 023020	C. Yuan, Y. Jiang, Q.-G. Huang		REFID=61761
ZHOU	22	PR D106 083006	Y.-F. Zhou *et al.*	(MeerKAT-Axion Collab.)	REFID=61950
AAD	21F	PR D103 112006	G. Aad *et al.*	(ATLAS Collab.)	REFID=61247
AAD	21K	JHEP 2102 226	G. Aad *et al.*	(ATLAS Collab.)	REFID=61279
AAD	21N	JHEP 2103 243	G. Aad *et al.*	(ATLAS Collab.)	REFID=61286
Also		JHEP 2111 050 (errat.)	G. Aad *et al.*	(ATLAS Collab.)	REFID=61563
ABRATENKO	21	PRL 127 151803	P. Abratenko *et al.*	(MicroBooNE Collab.)	REFID=61500
ADE	21	PR D103 042002	P.A.R. Ade *et al.*	(BICEP/Keck Collab.)	REFID=61214
AFACH	21	NATP 17 1396	S. Afach *et al.*	(GNOME Collab.)	REFID=61578
AGUILAR-AR...	21A	PR D103 052006	A. Aguilar-Arevalo *et al.*	(PIENU Collab.)	REFID=61219
ALESINI	21	PR D103 102004	D. Alesini *et al.*	(QUAX Collab.)	REFID=61241
AL-KHARUSI	21	PR D104 112002	S. Al Kharusi *et al.*	(EXO-200 Collab.)	REFID=61532
ANDREEV	21	PRL 126 211802	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=61186
ANDREEV	21A	PR D104 L091701	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=61526
ANDREEV	21B	PR D104 L111102	Yu.M. Andreev *et al.*	(NA64 Collab.)	REFID=61531
AYBAS	21	PRL 126 141802	D. Aybas *et al.*	(CASPEr Collab.)	REFID=61176
BACKES	21	NAT 590 238	K.M. Backes *et al.*	(HAYSTAC Collab.)	REFID=62415
BANIK	21	JCAP 2110 043	N. Banik *et al.*		REFID=61579
BARTRAM	21A	PRL 127 261803	C. Bartram *et al.*	(ADMX Collab.)	REFID=61507
BASU	21	PRL 126 191102	A. Basu *et al.*	(BIEL, NAGO)	REFID=61184
BAUMHOLZ...	21	JCAP 2105 004	S. Baumholzer, V. Brdar, E. Morgante	(MAINZ, FNAL+)	REFID=61345
BHUSAL	21	PRL 126 091601	A. Bhusal, N. Houston, T. Li	(BEIJ)	REFID=61169
BI	21	PR D103 043018	X.-J. Bi *et al.*	(BHEP, TSIN)	REFID=61215
CALORE	21	PR D104 043016	F. Calore *et al.*	(HEID)	REFID=61381
CARRA	21	PR D104 092005	S. Carra *et al.*		REFID=61527
CAZZANIGA	21	EPJ C81 959	C. Cazzaniga *et al.*	(NA64 Collab.)	REFID=61596
CORTINA-GIL	21	PL B816 136259	E. Cortina Gil *et al.*	(NA62 Collab.)	REFID=61269
CORTINA-GIL	21A	JHEP 2103 058	E. Cortina Gil *et al.*	(NA62 Collab.)	REFID=61291
CORTINA-GIL	21C	JHEP 2102 201	E. Cortina Gil *et al.*	(NA62 Collab.)	REFID=61280
CROON	21	JHEP 2101 107	D. Croon *et al.*	(TRIU, WASH, MIT, FNAL)	REFID=61278
DEVLIN	21	PRL 126 041301	J.A. Devlin *et al.*	(BASE Collab.)	REFID=61036
DIXIT	21	PRL 126 141302	A.V. Dixit *et al.*	(CHIC, RUTG, UCB+)	REFID=61175
DOLAN	21	JHEP 2103 190 (errat.)	M.J. Dolan *et al.*	(MELB, BRCO, DESY)	REFID=61287
DOLAN	21A	JCAP 2109 010	M.J. Dolan, F.J. Hiskens, R.R. Volkas	(MELB)	REFID=61602
FUJIKURA	21	PR D104 123012	K. Fujikura *et al.*		REFID=61536
GHOSH	21	PR D104 092016	S. Ghosh *et al.*		REFID=61590
GODFREY	21	PR D104 012013	B. Godfrey *et al.*	(UCD, CSUS, STAN)	REFID=61414
GRAMOLIN	21	NATP 17 79	A.V. Gramolin *et al.*	(SHAFT Collab.)	REFID=61421
GUO	21	CP C45 025105	J.-G. Guo *et al.*	(BHEP)	REFID=61261
HOMMA	21	JHEP 2112 108	K. Homa *et al.*	(SAPPHIRES Collab.)	REFID=61566
JIANG	21	NATP 17 1402	M. Jiang *et al.*		REFID=61577
KOPYLOV	21A	PPN 52 31	A.V. Kopylov, I.V. Orekhov, V.V. Petukhov	(INRM)	REFID=61607
KRIBS	21	PRL 126 011801	G.D. Kribs, D. McKeen, N. Raj	(OREG, TRIU)	REFID=60964
KWON	21	PRL 126 191802	O. Kwon *et al.*	(CAPP-ACTION Collab.)	REFID=61185
LI	21B	PR D103 083003	H.-J. Li *et al.*	(BHEP)	REFID=61234
LLOYD	21	PR D103 023010	S.J. Lloyd *et al.*	(DURH, OKLA)	REFID=61199
LUCENTE	21	PR D104 103007	G. Lucente, P. Carenza	(BARI)	REFID=61529
Also		PR D110 049901 (errat)	P. Carenza, G. Lucente	(BARI)	REFID=62944
MARTINCAM...	21	PR D103 L121301	J.M. Camalich *et al.*		REFID=61252
MELCON	21	JHEP 2110 075	A.A. Melcon *et al.*	(CAST-RADES Collab.)	REFID=61552
NG	21	PRL 126 151102	K.K.Y. Ng *et al.*	(MIT, ANIK, UTRE, LEUV)	REFID=61177
PARK	21	JHEP 2104 191	S.-H. Park *et al.*	(BELLE Collab.)	REFID=61297
REGIS	21	PL B814 136075	M. Regis *et al.*	(MUSE Collab.)	REFID=61266
ROGERS	21	PRL 126 071302	K.K. Rogers, H.V. Peiris	(STOH, LOUC)	REFID=61164
ROUSSY	21	PRL 126 171301	T.S. Roussy *et al.*	(COLO, MAINZ)	REFID=61180
SALEMI	21	PRL 127 081801	C.P. Salemi *et al.*	(ABRACADABRA Collab.)	REFID=61352
SCHMIDT	21	PR D104 015008	I. Schmidt *et al.*	(FRAN, GSI, +)	REFID=61368
THOMSON	21	PRL 126 081803	C.A. Thomson *et al.*	(WAUS)	REFID=61166
Also		PRL 127 019901 (errat.)	C.A. Thomson *et al.*	(WAUS)	REFID=61419
TSAI	21	PRL 126 181801	Y.-D. Tsai, P. deNiverville, M.X. Liu	(FNAL+)	REFID=61182
TSUKADA	21	PR D103 083005	L. Tsukada *et al.*	(ROMA, TOKY, WATER)	REFID=61235
XIAO	21	PRL 126 031101	M. Xiao *et al.*		REFID=61035
YUAN	21	JCAP 2103 018	G.-W. Yuan *et al.*	(CST)	REFID=61411

ZHANG	21B	PRL 127 161101	J. Zhang *et al.*		REFID=61501
AAIJ	20AL	JHEP 2010 156	R. Aaij *et al.*	(LHCb Collab.)	REFID=60754
AAIJ	20C	PRL 124 041801	R. Aaij *et al.*	(LHCb Collab.)	REFID=60216
ABDELHAME...	20	EPJ C80 376	A.H. Abdelhameed *et al.*		REFID=60433
ABE	20J	PL B815 136174	T. Abe, K. Hamaguchi, N. Nagata	(TOKY)	REFID=61050
ABLIKIM	20AB	PR D102 052005	M. Ablikim *et al.*	(BESIII Collab.)	REFID=60717
ABUDINEN	20	PRL 125 161806	F. Abudinen *et al.*	(BELLE II Collab.)	REFID=60689
AGOSTINI	20	PRL 125 011801	M. Agostini *et al.*	(GERDA Collab.)	REFID=60571
AGUILAR-AR...	20	PR D101 052014	A. Aguilar-Arevalo *et al.*	(PIENU Collab.)	REFID=60277
AMARAL	20	PR D102 091101	D.W. Amaral *et al.*	(SuperCDMS Collab.)	REFID=60731
AN	20	PR D102 115022	H. An *et al.*	(VIEN, MINN, VICT, TSIN)	REFID=60812
ANDRIANAV...	20	PR D102 042001	A. Andrianavalomahefa *et al.*	(FUNK Collab.)	REFID=60359
APRILE	20	PR D102 072004	E. Aprile *et al.*	(XENON Collab.)	REFID=60728
ARALIS	20	PR D101 052008	T. Aralis *et al.*	(SuperCDMS Collab.)	REFID=60271
Also		PR D103 039901 (errat.)	T. Aralis *et al.*	(SuperCDMS Collab.)	REFID=61213
ARGUELLES	20	JHEP 2002 190	C. Arguelles *et al.*	(MIT, VALE)	REFID=60470
ARNAUD	20	PRL 125 141301	Q. Arnaud *et al.*	(EDELWEISS Collab.)	REFID=60685
BALDINI	20	EPJ C80 858	A.M. Baldini *et al.*	(MEG Collab.)	REFID=60768
BANERJEE	20	PR D101 071101	D. Banerjee *et al.*	(NA64 Collab.)	REFID=60287
BANERJEE	20A	PRL 125 081801	D. Banerjee *et al.*	(NA64 Collab.)	REFID=60579
BARAK	20	PRL 125 171802	L. Barak *et al.*	(SENSEI Collab.)	REFID=60691
BRAINE	20	PRL 124 101303	T. Braine *et al.*	(ADMX Collab.)	REFID=60537
BUEHLER	20	JCAP 2009 027	R. Buehler *et al.*	(DESY, MADU)	REFID=60777
CALORE	20	PR D102 123005	F. Calore *et al.*	(LAPP, BARI, HEID, +)	REFID=60816
CAPOZZI	20	PR D102 083007	F. Capozzi, G. Raffelt	(MPIM)	REFID=60794
CARENZA	20	PL B809 135709	P. Carenza *et al.*		REFID=60626
CRESCINI	20	PRL 124 171801	N. Crescini *et al.*	(QUAX Collab.)	REFID=60558
CRISOSTO	20	PRL 124 241101	N. Crisosto *et al.*	(ADMX SLIC Collab.)	REFID=60567
DARLING	20	PRL 125 121103	J. Darling	(COLO)	REFID=60681
DARLING	20A	APJ 900 L28	J. Darling	(COLO)	REFID=61051
DENT	20A	PRL 125 131805	J.B. Dent *et al.*		REFID=60947
DEPTA	20	JCAP 2005 009	P.F. Depta, M. Hufnagel, K. Schmidt-Hoberg	(DESY)	REFID=60375
DESSERT	20A	PRL 125 261102	C. Dessert, J.W. Foster, B.R. Safdi	(MICH)	REFID=60705
ESTEBAN	20	EPJ C80 259	I. Esteban *et al.*		REFID=60429
FOSTER	20	PRL 125 171301	J.W. Foster *et al.*	(MICH, ILL, TOKY+)	REFID=60690
GAO	20	PRL 125 131806	C. Gao *et al.*	(FNAL, EFI, CHIC, ANL+)	REFID=60948
GAVELA	20	PRL 124 051802	M.B. Gavela *et al.*		REFID=60607
GHOSH	20A	JCAP 2010 060	D. Ghosh, D. Sachdeva		REFID=60778
IRSIC	20	PR D101 123518	V. Irsic, H. Xiao, M. McQuinn		REFID=60330
JEONG	20	PRL 125 221302	J. Jeong *et al.*		REFID=60696
KENNEDY	20	PRL 125 201302	C.J. Kennedy *et al.*	(COLO, STAN)	REFID=60695
KLIMCHITSK...	20	PR D101 056013	G.L. Klimchitskaya, P. Kuusk, V.M. Mostepanenko		REFID=60284
KOROCHKIN	20	JCAP 2003 064	A. Korochkin, A. Neronov, D. Semikoz		REFID=60371
KRASNIKOV	20	MPL A35 2050116	N.V. Krasnikov		REFID=60598
LEE	20A	PRL 124 101802	S .Lee *et al.*	(CULTASK Collab.)	REFID=60538
LUCENTE	20A	JCAP 2012 008	G. Lucente *et al.*		REFID=61024
MEYER	20	PRL 124 231101	M. Meyer, T. Petrushevska	(Fermi-LAT Collab.)	REFID=60565
Also		PRL 125 119901 (errat.)	M. Meyer, T. Petrushevska	(Fermi-LAT Collab.)	REFID=60661
PODDAR	20	PR D101 083007	T.K. Poddar, S. Mohanty, S. Jana		REFID=60299
SCHUTZ	20	PR D101 123026	K. Schutz	(MIT)	REFID=60329
SHE	20	PRL 124 111301	Z. She *et al.*	(CDEX Collab.)	REFID=60540
SIRUNYAN	20AQ	PRL 124 131802	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=60549
STRANIERO	20	AA 644 A166	O. Straniero *et al.*	(SASSO, BGNA, GRAN)	REFID=61054
SUN	20	PR D101 063020	L. Sun, R. Brito, M. Isi	(CIT, ROMAI, MIT)	REFID=60613
TOMITA	20	JCAP 2009 012	N. Tomita *et al.*		REFID=60636
WANG	20A	PR D101 052003	Y. Wang *et al.*	(CDEX Collab.)	REFID=60269
YAMAMOTO	20	JCAP 2002 011	R. Yamamoto *et al.*		REFID=60364
AABOUD	19G	PR D99 012001	M. Aaboud *et al.*	(ATLAS Collab.)	REFID=59518
ABLIKIM	19A	PR D99 012006	M. Ablikim *et al.*	(BESIII Collab.)	REFID=59517
Also		PR D104 099901 (errat.)	M. Ablikim *et al.*	(BESIII Collab.)	REFID=61449
ABLIKIM	19H	PR D99 012013	M. Ablikim *et al.*	(BESIII Collab.)	REFID=59604
ADELBERGER	19	PRL 123 169001	E.G. Adelberger, W.A. Terrano	(WASH, PRIN)	REFID=59982
ADHIKARI	19B	ASP 114 101	P. Adhikari *et al.*	(COSINE-100 Collab.)	REFID=59976
AGUILAR-AR...	19A	PRL 123 181802	A. Aguilar-Arevalo *et al.*	(DAMIC Collab.)	REFID=60066
AHN	19	PRL 122 021802	J.K. Ahn *et al.*	(KOTO Collab.)	REFID=59556
ALESINI	19	PR D99 101101	D. Alesini *et al.*	(QUAX Collab.)	REFID=59883
ALONI	19	PRL 123 071801	D. Aloni *et al.*	(REHO, MIT, CERN, HAIF)	REFID=59805
APRILE	19	PRL 122 071301	E. Aprile *et al.*	(XENON1T Collab.)	REFID=59760
APRILE	19D	PRL 123 251801	E. Aprile *et al.*	(XENON1T Collab.)	REFID=60078
ARNOLD	19	EPJ C79 440	R. Arnold *et al.*	(NEMO-3 Collab.)	REFID=59726
BANERJEE	19	PRL 123 121801	D. Banerjee *et al.*	(NA64 Collab.)	REFID=60056
BHOONAH	19	PR D100 023001	A. Bhoonah *et al.*		REFID=59955
BRUN	19	PRL 122 201801	P. Brun, L. Chevalier, C. Flouzat	(SACL)	REFID=59785
CAPUTO	19	PR D100 063515	A. Caputo *et al.*		REFID=60008
CORTINA-GIL	19	JHEP 1905 182	E. Cortina Gil *et al.*	(NA62 Collab.)	REFID=59689
DANILOV	19	PRL 122 041801	M. Danilov, S. Demidov, D. Gorbunov	(LEBD, INRM+)	REFID=59553
DAVOUDIASL	19	PRL 123 021102	H. Davoudiasl, P.B. Denton	(BNL)	REFID=60674
DESSERT	19	PRL 123 061104	C. Dessert, A.J. Long, B.R. Safdi	(MICH)	REFID=59923
FEDDERKE	19	PR D100 015040	M.A. Fedderke, P.W. Graham, S. Rajendran	(STAN+)	REFID=59952
FUJITA	19	PRL 122 191101	T. Fujita, R. Tazaki, K. Toma	(KYOT, GEVA, TOHO)	REFID=59922
HOCHBERG	19	PRL 123 151802	Y. Hochberg *et al.*	(HEBR, MIT, NIST)	REFID=60190
IVANOV	19	JCAP 1902 059	M.M. Ivanov *et al.*		REFID=59967
KOPYLOV	19	JCAP 1907 008	A. Kopylov, I. Orekhov, V. Petukhov	(INRM)	REFID=59974
KOVETZ	19	PR D99 123511	E.D. Kovetz, I. Cholis, D.E. Kaplan	(JHU)	REFID=59950
LEINSON	19	JCAP 1911 031	L.B. Leinson		REFID=60186
LIANG	19	JCAP 1906 042	Y-F. Liang *et al.*		REFID=59973
LLOYD	19	PR D100 063005	S.J. Lloyd *et al.*		REFID=60196
MARSH	19	PRL 123 051103	D.J.E. Marsh, J.C. Niemeyer	(GOET)	REFID=59803
NGUYEN	19	JCAP 1910 014	L.H. Nguyen, A. Lobanov, D. Horns	(WISPDMX Collab.)	REFID=60200
OUELLET	19A	PRL 122 121802	J.L. Ouellet *et al.*	(ABRACADABRA Collab.)	REFID=59767
PALOMBA	19	PRL 123 171101	C. Palomba *et al.*		REFID=60065
SIRUNYAN	19BQ	PL B796 131	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59930
SMORRA	19	NAT 575 310	C. Smorra *et al.*		REFID=60170
TERRANO	19	PRL 122 231301	W. Terrano *et al.*	(WASH)	REFID=59791
WU	19	PRL 122 191302	T. Wu *et al.*	(CASPEr-ZULF Collab.)	REFID=59780
WU	19C	PRL 123 169002	T. Wu *et al.*	(CASPEr-ZULF Collab.)	REFID=59983
ABE	18F	PL B787 153	K. Abe *et al.*	(XMASS Collab.)	REFID=59410
ADRIAN	18	PR D98 091101	P.H. Adrian *et al.*	(HPS Collab.)	REFID=59467
AKHMATOV	18	PPN 49 599	Z.A. Akhmatov *et al.*		REFID=59272

ANASTASI	18B	PL B784 336	A. Anastasi *et al.*	(KLOE-2 Collab.)	REFID=59400
ARMENGAUD	18	PR D98 082004	E. Armengaud *et al.*	(EDELWEISS-III Collab.)	REFID=59465
ARNOLD	18	EPJ C78 821	R. Arnold *et al.*	(NEMO-3 Collab.)	REFID=59320
BANERJEE	18	PRL 120 231802	D. Banerjee *et al.*	(NA64 Collab.)	REFID=58838
BANERJEE	18A	PR D97 072002	D. Banerjee *et al.*	(NA64 Collab.)	REFID=58916
BEZNOGOV	18	PR C98 035802	M.V. Beznogov *et al.*		REFID=59574
BOUTAN	18	PRL 121 261302	C. Boutan *et al.*	(ADMX Collab.)	REFID=59542
CHANG	18	JHEP 1809 051	J.C. Chang, R. Essig, S.D. McDermott		REFID=59339
CRESCINI	18	EPJ C78 703	N. Crescini *et al.*	(QUAX Collab.)	REFID=59254
DU	18	PRL 120 151301	N. Du *et al.*	(ADMX Collab.)	REFID=58820
DZUBA	18	PR D98 035048	V.A. Dzuba *et al.*		REFID=58987
FICEK	18	PRL 120 183002	F. Ficek *et al.*		REFID=58823
FORTIN	18	JHEP 1806 048	J.-F. Fortin, K. Sinha	(LAVL, OKLA)	REFID=59119
GAVRILYUK	18	JETPL 107 589	Yu.M. Gavrilyuk *et al.*		REFID=59264
HAMAGUCHI	18	PR D98 103015	K. Hamaguchi *et al.*		REFID=59492
JAECKEL	18	PR D98 055032	J. Jaeckel, P. C. Malta, J. Redondo		REFID=62410
KNIRCK	18	JCAP 1811 031	S. Knirck *et al.*		REFID=59382
PORAYKO	18	PR D98 102002	N.K. Porayako *et al.*	(PPTA Collab.)	REFID=59488
STADNIK	18	PRL 120 013202	Y.V. Stadnik, V.A. Dzuba, V.V. Flambaum		REFID=58726
YAMAJI	18	PL B782 523	T. Yamaji *et al.*	(TOKY, RIKEN, KEK)	REFID=59028
ZHANG	18	PR D97 063009	C. Zhang *et al.*		REFID=58912
ZHONG	18	PR D97 092001	L. Zhong *et al.*	(HAYSTAC Collab.)	REFID=58935
AAIJ	17AQ	PR D95 071101	R. Aaij *et al.*	(LHCb Collab.)	REFID=57974
ABEL	17	PR X7 041034	C. Abel *et al.*	(nEDM Collab.)	REFID=58378
ABGRALL	17	PRL 118 161801	N. Abgrall *et al.*	(MAJORANA Collab.)	REFID=57924
ABLIKIM	17AA	PL B774 252	M. Ablikim *et al.*	(BESIII Collab.)	REFID=58253
ADE	17	PR D96 102003	P.A.R. Ade *et al.*	(BICEP2/Keck Array Collab.)	REFID=58313
AHN	17	PTEP 2017 021C01	J.K. Ahn *et al.*	(KOTO Collab.)	REFID=57782
AKERIB	17B	PRL 118 261301	D.S. Akerib *et al.*	(LUX Collab.)	REFID=57939
ANASTASSO...	17	NATP 13 584	V. Anastassopoulos *et al.*	(CAST Collab.)	REFID=58035
ANGLOHER	17	EPJ C77 299	G. Angloher *et al.*	(CRESST-II Collab.)	REFID=57857
APRILE	17B	PR D95 029904	E. Aprile *et al.*	(XENON100 Collab.)	REFID=58107
BANERJEE	17	PRL 118 011802	D. Banerjee *et al.*	(NA64 Collab.)	REFID=57649
BATLEY	17	PL B769 67	J.R. Batley *et al.*	(NA48/2 Collab.)	REFID=57895
BRANCA	17	PRL 118 021302	A. Branca *et al.*	(AURIGA Collab.)	REFID=57651
BRUBAKER	17	PRL 118 061302	B.M. Brubaker *et al.*	(YALE, UCB, NIST+)	REFID=57758
CHANG	17	JHEP 1701 107	J.H. Chang, R. Essig, S.D. McDermott	(STON)	REFID=57784
CHOI	17	PR D96 061102	J. Choi *et al.*	(CAPP-ACTION Collab.)	REFID=58227
CRESCINI	17	PL B773 677	N. Crescini *et al.*	(QUAX-gpgs Collab.)	REFID=58241
DAIDO	17	PL B772 127	R. Daido, F. Takahashi		REFID=58258
DOLAN	17	JHEP 1712 094	M.J. Dolan *et al.*		REFID=58543
Also		JHEP 2103 190 (errat.)	M.J. Dolan *et al.*	(MELB, BRCO, DESY)	REFID=61287
DUBININA	17	PAN 80 461	V.V. Dubinina *et al.*		REFID=58162
FICEK	17	PR A95 032505	F. Ficek *et al.*		REFID=58259
FU	17A	PRL 119 181806	C. Fu *et al.*	(PandaX-II Collab.)	REFID=58273
INADA	17	PRL 118 071803	T. Inada *et al.*		REFID=57913
KLIMCHITSK...	17A	PR D95 123013	G.L. Klimchitskaya, V.M. Mostepanenko		REFID=58006
KOHRI	17	PR D96 051701	K. Kohri, H. Kodama	(KEK, KYOT)	REFID=58215
LEES	17E	PRL 119 131804	J.P. Lees *et al.*	(BABAR Collab.)	REFID=58204
LIU	17	PL B766 117	X.-H. Liu	(TINT)	REFID=57881
LIU	17A	PR D95 052006	S.K. Liu *et al.*	(CDEX Collab.)	REFID=57970
LUO	17	PR D96 055028	P. Luo *et al.*		REFID=58225
MARSH	17	JCAP 1712 036	M.C.D. Marsh *et al.*		REFID=58772
MCALLISTER	17	PDU 18 67	B.T. McAllister *et al.*	(WAUS)	REFID=62418
TIWARI	17	PR D95 023005	P. Tiwari	(Technion)	REFID=57753
AAD	16AG	JHEP 1602 062	G. Aad *et al.*	(ATLAS Collab.)	REFID=57317
ABLIKIM	16E	PR D93 052005	M. Ablikim *et al.*	(BESIII Collab.)	REFID=57265
AJELLO	16	PRL 116 161101	M. Ajello *et al.*	(Fermi-LAT Collab.)	REFID=57443
ANASTASI	16	PL B757 356	A. Anastasi *et al.*	(KLOE-2 Collab.)	REFID=57219
BATTICH	16	JCAP 1608 062	T. Battich *et al.*		REFID=57580
BERENJI	16	PR D93 045019	B. Berenji *et al.*		REFID=60219
CORSICO	16	JCAP 1607 036	A.H. Corsico *et al.*		REFID=57479
DELLA-VALLE	16	EPJ C76 24	F. Della Valle *et al.*	(PVLAS Collab.)	REFID=57359
HOSKINS	16	PR D94 082001	J. Hoskins *et al.*	(ADMX Collab.)	REFID=57530
JAECKEL	16	PL B753 482	J. Jaeckel, M. Spannowsky	(HEID, DURH)	REFID=57204
KHACHATRY...	16	PL B752 146	V. Khachatryan *et al.*	(CMS Collab.)	REFID=56960
KRASZNAHO...	16	PRL 116 042501	A.J. Krasznahorkay *et al.*	(HINR, ANIK+)	REFID=59302
LEEFER	16	PRL 117 271601	N. Leefer *et al.*	(MAINZ, BONN, LBL, UCB+)	REFID=57648
WON	16	PR D94 092006	E. Won *et al.*	(BELLE Collab.)	REFID=57721
YOON	16	JHEP 1606 011	Y.S. Yoon *et al.*	(KIMS Collab.)	REFID=57340
AAD	15CD	PR D92 092001	G. Aad *et al.*	(ATLAS Collab.)	REFID=56906
AAIJ	15AZ	PRL 115 161802	R. Aaij *et al.*	(LHCb Collab.)	REFID=56922
ADARE	15	PR C91 031901	A. Adare *et al.*	(PHENIX Collab.)	REFID=56622
AFACH	15	PL B745 58	S. Afach *et al.*	(ETH, PSI, CAEN, +)	REFID=56508
AGOSTINI	15A	EPJ C75 416	M. Agostini *et al.*	(GERDA Collab.)	REFID=56935
AN	15A	PL B747 331	H. An *et al.*	(CIT, VICT, VIEN)	REFID=56521
ANASTASI	15	PL B747 365	A. Anastasi *et al.*	(KLOE-2 Collab.)	REFID=56517
ANASTASI	15A	PL B750 633	A. Anastasi *et al.*	(KLOE-2 Collab.)	REFID=56931
ANASTASSO...	15	PL B749 172	V. Anastassopoulos *et al.*	(CAST Collab.)	REFID=56545
ARIK	15	PR D92 021101	M. Arik *et al.*	(CAST Collab.)	REFID=56606
ARNOLD	15	PR D92 072011	R. Arnold *et al.*	(NEMO-3 Collab.)	REFID=56896
BALLOU	15	PR D92 092002	R. Ballou *et al.*	(OSQAR Collab.)	REFID=56907
BATLEY	15A	PL B746 178	J.R. Batley *et al.*	(NA48/2 Collab.)	REFID=56513
BAYES	15	PR D91 052020	R. Bayes *et al.*	(TWIST Collab.)	REFID=56727
BRAX	15	PR D92 083501	P. Brax, P. Brun, D. Wouters	(SACL, SACL5)	REFID=56904
GAVRILYUK	15	JETPL 101 664	Yu.M. Gavrilyuk *et al.*		REFID=56712
		Translated from ZETFP 101 739.			

HASEBE 15 PTEP 2015 073C01 T. Hasebe *et al.* REFID=56945
JAEGLE 15 PRL 114 211801 I. Jaegle *et al.* (BELLE Collab.) REFID=56471
KAZANAS 15 NP B890 17 D. Kazanas *et al.* REFID=56324
KLIMCHITSK... 15 EPJ C75 164 G.L. Klimchitskaya, V.M. Mostepanenko REFID=56768
MILLEA 15 PR D92 023010 M. Millea, L. Knox, B. Fields (UCD, ILL) REFID=56607
STADNIK 15 EPJ C75 110 Y.V. Stadnik, V.V. Flambaum (SYDN) REFID=56763
SUZUKI 15 JCAP 1509 042 J. Suzuki *et al.* REFID=56846
TERRANO 15 PRL 115 201801 W.A. Terrano *et al.* (WASH) REFID=56925
VANTILBURG 15 PRL 115 011802 K. Van Tilburg *et al.* REFID=56477
VINYOLES 15 JCAP 1510 015 N. Vinyoles *et al.* REFID=56848
ABE 14F PRL 113 121301 K. Abe *et al.* (XMASS Collab.) REFID=55893
AGAKISHIEV 14 PL B731 265 G. Agakishiev *et al.* (HADES Collab.) REFID=55770
ALBERT 14A PR D90 092004 J.B. Albert *et al.* (EXO-200 Collab.) REFID=56156
APRILE 14B PR D90 062009 E. Aprile *et al.* (XENON100 Collab.) REFID=56052
ARIK 14 PRL 112 091302 M. Arik *et al.* (CAST Collab.) REFID=55831
AYALA 14 PRL 113 191302 A. Ayala *et al.* REFID=56116
BABUSCI 14 PL B736 459 D. Babusci *et al.* (KLOE-2 Collab.) REFID=55751
BATELL 14 PRL 113 171802 B. Batell, R. Essig, Z. Surujon (EFI, STON) REFID=56112
BEZERRA 14 PR D89 035010 V.B. Bezerra *et al.* REFID=55797
BEZERRA 14A EPJ C74 2859 V.B. Bezerra *et al.* REFID=56102
BEZERRA 14B PR D90 055013 V.B. Bezerra *et al.* REFID=56133
BEZERRA 14C PR D89 075002 V.B. Bezerra *et al.* REFID=56430
BLUEMLEIN 14 PL B731 320 J. Bluemlein, J. Brunner (CPPM, DESY) REFID=56073
BLUM 14 PL B737 30 K. Blum *et al.* (IAS, PRIN) REFID=56122
DELLA-VALLE 14 PR D90 092003 F. Della Valle *et al.* (PVLAS Collab.) REFID=56219
DERBIN 14 EPJ C74 3035 A.V. Derbin *et al.* REFID=56100
EJLLI 14 PR D90 123527 D. Ejlli REFID=56281
FRADETTE 14 PR D90 035022 A. Fradette *et al.* REFID=56049
LEES 14J PRL 113 201801 J.P. Lees *et al.* (BABAR Collab.) REFID=56107
LEINSON 14 JCAP 1408 031 L. Leinson REFID=55971
MERKEL 14 PRL 112 221802 H. Merkel *et al.* (A1 at MAMI) REFID=55850
MILLER-BER... 14 JCAP 1410 069 M.M. Miller Bertolami *et al.* REFID=56396
PUGNAT 14 EPJ C74 3027 P. Pugnat *et al.* (OSQAR Collab.) REFID=55865
REESMAN 14 JCAP 1408 021 R. Reesman *et al.* (OSU) REFID=56395
ABE 13D PL B724 46 K. Abe *et al.* (XMASS Collab.) REFID=55093
ABRAMOWSKI 13A PR D88 102003 A. Abramowski *et al.* (H.E.S.S. Collab.) REFID=55490
ADLARSON 13 PL B726 187 P. Adlarson *et al.* (WASA-at-COSY Collab.) REFID=55098
ALESSANDRIA 13 JCAP 1305 007 F. Alessandria *et al.* (CUORE Collab.) REFID=55506
AN 13B PL B725 190 H. An, M. Pospelov, J. Pradler REFID=55651
AN 13C PRL 111 041302 H. An, M. Pospelov, J. Pradler REFID=55652
ARCHIDIACO... 13A JCAP 1310 020 M. Archidiacono *et al.* REFID=55516
ARMENGAUD 13 JCAP 1311 067 E. Armengaud *et al.* (EDELWEISS-II Collab.) REFID=55598
BABUSCI 13B PL B720 111 D. Babusci *et al.* (KLOE-2 Collab.) REFID=55068
BARTH 13 JCAP 1305 010 K. Barth *et al.* (CAST Collab.) REFID=55507
BECK 13 PRL 111 231801 C. Beck REFID=55637
BETZ 13 PR D88 075014 M. Betz *et al.* (CROWS Collab.) REFID=55463
BULATOWICZ 13 PRL 111 102001 M. Bulatowicz *et al.* REFID=55226
CHU 13 PR D87 011105 P.-H. Chu *et al.* (DUKE, IND, SJTU) REFID=54923
DERBIN 13 EPJ C73 2490 A. V. Derbin *et al.* REFID=55012
DIAMOND 13 PRL 111 221803 M.D. Diamond, P. Schuster REFID=55494
FRIEDLAND 13 PRL 110 061101 A. Friedland, M. Giannotti, M. Wise REFID=55319
GNINENKO 13 PR D87 035030 S.N. Gninenko (INRM) REFID=55126
HECKEL 13 PRL 111 151802 B. R. Heckel *et al.* REFID=55566
HORVAT 13 PL B721 220 R. Horvat *et al.* REFID=55339
INADA 13 PL B722 301 T. Inada *et al.* REFID=55078
LATTANZI 13 PR D88 063528 M. Lattanzi *et al.* REFID=55449
MEYER 13 PR D87 035027 M. Meyer, D. Horns, M. Raue REFID=55125
MIZUMOTO 13 JCAP 1307 013 T. Mizumoto *et al.* REFID=55510
PARKER 13 PR D88 112004 S. Parker *et al.* REFID=55608
REDONDO 13 JCAP 1308 034 J. Redondo, G. Raffelt REFID=55512
TULLNEY 13 PRL 111 100801 K. Tullney *et al.* REFID=57128
VIAUX 13A PRL 111 231301 N. Viaux *et al.* REFID=55636
WOUTERS 13 APJ 772 44 D. Wouters, P. Brun (SACL) REFID=57164
ABLIKIM 12 PR D85 092012 M. Ablikim *et al.* (BESIII Collab.) REFID=54265
ARCHILLI 12 PL B706 251 F. Archilli *et al.* (KLOE-2 Collab.) REFID=53951
BELLI 12 PL B711 41 P. Belli *et al.* (DAMA-KIEV) REFID=54165
BELLINI 12B PR D85 092003 G. Bellini *et al.* (Borexino Collab.) REFID=54406
CADAMURO 12 JCAP 1202 032 D. Cadamuro *et al.* (MPIM) REFID=54443
CORSICO 12 JCAP 1212 010 A.H. Corsico *et al.* (LAPL, RGSUL, WASH+) REFID=54815
DERBIN 12 JETPL 95 339 A.V. Derbin *et al.* (PNPI) REFID=54141
Translated from ZETFP 95 379.
GANDO 12 PR C86 021601 A. Gando *et al.* (KamLAND-Zen Collab.) REFID=54339
GNINENKO 12A PR D85 055027 S.N. Gninenko (INRM) REFID=54399
GNINENKO 12B PL B713 244 S.N. Gninenko (INRM) REFID=54973
PAYEZ 12 JCAP 1207 041 A. Payez *et al.* (LIEG) REFID=54453
RAFFELT 12 PR D86 015001 G. Raffelt (MPIM) REFID=54503
AALSETH 11 PRL 106 131301 C.E. Aalseth *et al.* (CoGeNT Collab.) REFID=16607
ABRAHAMY... 11 PRL 107 191804 S. Abrahamyan *et al.* REFID=53841
ARIK 11 PRL 107 261302 M. Arik *et al.* (CAST Collab.) REFID=53952
ARNOLD 11 PRL 107 062504 R. Arnold *et al.* (NEMO-3 Collab.) REFID=16661
BLUEMLEIN 11 PL B701 155 J. Bluemlein, J. Brunner (DESY) REFID=16695
CADAMURO 11 JCAP 1102 003 D. Cadamuro *et al.* (MPIM, AARHUS) REFID=53677
DERBIN 11 PAN 74 596 A.V. Derbin *et al.* (PNPI) REFID=16391
Translated from YAF 74 620.
DERBIN 11A PR D83 023505 A.V. Derbin *et al.* (PNPI) REFID=53726
HOEDL 11 PRL 106 041801 S.A. Hoedl *et al.* (WASH) REFID=53685
HOSKINS 11 PR D84 121302 J. Hoskins *et al.* (ADMX Collab.) REFID=53999
ANDRIAMON... 10 JCAP 1003 032 S. Andriamonje *et al.* (CAST Collab.) REFID=53377
ARGYRIADES 10 NP A847 168 J. Argyriades *et al.* (NEMO-3 Collab.) REFID=53491
ASZTALOS 10 PRL 104 041301 S.J. Asztalos *et al.* (ADMX Collab.) REFID=53261
EHRET 10 PL B689 149 K. Ehret *et al.* (ALPS Collab.) REFID=53292
HANNESTAD 10 JCAP 1008 001 S. Hannestad *et al.* REFID=53511
PETUKHOV 10 PRL 105 170401 A.K. Petukhov *et al.* REFID=53676
SEREBROV 10 JETPL 91 6 A.P. Serebrov *et al.* REFID=53242
Translated from ZETFP 91 8.

AHMED	09A	PRL 103 141802	Z. Ahmed *et al.*	(CDMS Collab.)	REFID=53030
ANDRIAMON...	09	JCAP 0912 002	S. Andriamonje *et al.*		REFID=53169
ARGYRIADES	09	PR C80 032501	J. Argyriades *et al.*	(NEMO-3 Collab.)	REFID=53053
ARIK	09	JCAP 0902 008	E. Arik *et al.*	(CAST Collab.)	REFID=52692
BJORKEN	09	PR D80 075018	J. Bjorken *et al.*		REFID=57779
CHOU	09	PRL 102 030402	A.S. Chou *et al.*	(GammeV Collab.)	REFID=52874
DAVOUDIASL	09	PR D79 095024	H. Davoudiasl, P. Huber		REFID=52812
DERBIN	09A	PL B678 181	A.V. Derbin *et al.*		REFID=52913
GONDOLO	09	PR D79 107301	P. Gondolo, G. Raffelt	(UTAH, MPIM)	REFID=52816
IGNATOVICH	09	EPJ C64 19	V.K. Ignatovich, Y.N. Pokotilovski	(JINR)	REFID=53157
KEKEZ	09	PL B671 345	D. Kekez *et al.*		REFID=52619
SEREBROV	09	PL B680 423	A.P. Serebrov	(PNPI)	REFID=53095
AFANASEV	08	PRL 101 120401	A. Afanasev *et al.*		REFID=53172
BELLINI	08	EPJ C54 61	G. Bellini *et al.*	(Borexino Collab.)	REFID=52221
CHOU	08	PRL 100 080402	A.S. Chou *et al.*	(GammeV Collab.)	REFID=52208
FOUCHE	08	PR D78 032013	M. Fouche *et al.*		REFID=52421
HANNESTAD	08	JCAP 0804 019	S. Hannestad *et al.*		REFID=52220
INOUE	08	PL B668 93	Y. Inoue *et al.*		REFID=52468
ZAVATTINI	08	PR D77 032006	E. Zavattini *et al.*	(PVLAS Collab.)	REFID=52207
ADELBERGER	07	PRL 98 131104	E.G. Adelberger *et al.*		REFID=51805
ANDRIAMON...	07	JCAP 0704 010	S. Andriamonje *et al.*	(CAST Collab.)	REFID=51689
BAESSLER	07	PR D75 075006	S. Baessler *et al.*		REFID=51786
CHANG	07	PR D75 052004	H.M. Chang *et al.*	(TEXONO Collab.)	REFID=51690
HANNESTAD	07	JCAP 0708 015	S. Hannestad *et al.*		REFID=52174
JAIN	07	JP G34 129	P.L. Jain, G. Singh		REFID=51531
LESSA	07	PR D75 094001	A.P. Lessa, O.L.G. Peres		REFID=51727
MELCHIORRI	07A	PR D76 041303	A. Melchiorri, O. Mena, A. Slosar		REFID=52041
ROBILLIARD	07	PRL 99 190403	C. Robilliard *et al.*		REFID=52176
ARNOLD	06	NP A765 483	R. Arnold *et al.*	(NEMO-3 Collab.)	REFID=51005
DUFFY	06	PR D74 012006	L.D. Duffy *et al.*		REFID=51294
HECKEL	06	PRL 97 021603	B.R. Heckel *et al.*		REFID=52173
ZAVATTINI	06	PRL 96 110406	E. Zavattini *et al.*	(PVLAS Collab.)	REFID=52175
HANNESTAD	05A	JCAP 0507 002	S. Hannestad, A. Mirizzi, G. Raffelt		REFID=51023
ZIOUTAS	05	PRL 94 121301	K. Zioutas *et al.*	(CAST Collab.)	REFID=50586
ADLER	04	PR D70 037102	S. Adler *et al.*	(BNL E787 Collab.)	REFID=50053
ANISIMOVSK...	04	PRL 93 031801	V.V. Anisimovsky *et al.*	(BNL E949 Collab.)	REFID=49992
ARNOLD	04	JETPL 80 377 Translated from ZETFP 80 429.	R. Arnold *et al.*	(NEMO-3 Collab.)	REFID=50411
ASZTALOS	04	PR D69 011101	S.J. Asztalos *et al.*		REFID=49852
HOFFMANN	04	PR B70 180503	C. Hoffmann *et al.*		REFID=55662
ARNABOLDI	03	PL B557 167	C. Arnaboldi *et al.*		REFID=49258
CIVITARESE	03	NP A729 867	O. Civitarese, J. Suhonen		REFID=49794
DANEVICH	03	PR C68 035501	F.A. Danevich *et al.*		REFID=49600
FARZAN	03	PR D67 073015	Y. Farzan	(SLAC, SISSA)	REFID=49346
ADLER	02C	PL B537 211	S. Adler *et al.*	(BNL E787 Collab.)	REFID=48768
BADERT...	02	PL B542 29	A. Badertscher *et al.*		REFID=48779
BERNABEI	02D	PL B546 23	R. Bernabei *et al.*	(DAMA Collab.)	REFID=48990
DERBIN	02	PAN 65 1302 Translated from YAF 65 1335.	A.V. Derbin *et al.*		REFID=48786
FUSHIMI	02	PL B531 190	K. Fushimi *et al.*	(ELEGANT V Collab.)	REFID=48721
INOUE	02	PL B536 18	Y. Inoue *et al.*		REFID=48693
MORALES	02B	ASP 16 325	A. Morales *et al.*	(COSME Collab.)	REFID=49038
ADLER	01	PR D63 032004	S. Adler *et al.*	(BNL E787 Collab.)	REFID=48050
AMMAR	01B	PRL 87 271801	R. Ammar *et al.*	(CLEO Collab.)	REFID=48534
ASHITKOV	01	JETPL 74 529 Translated from ZETFP 74 601.	V.D. Ashitkov *et al.*		REFID=48730
BERNABEI	01B	PL B515 6	R. Bernabei *et al.*	(DAMA Collab.)	REFID=48278
DANEVICH	01	NP A694 375	F.A. Danevich *et al.*		REFID=48113
DEBOER	01	JP G27 L29	F.W.N. de Boer *et al.*		REFID=48162
STOICA	01	NP A694 269	S. Stoica, H.V. Klapdor-Kleingrothous		REFID=50526
ALESSAND...	00	PL B486 13	A. Alessandrello *et al.*		REFID=47726
ARNOLD	00	NP A678 341	R. Arnold *et al.*		REFID=47804
ASTIER	00B	PL B479 371	P. Astier *et al.*	(NOMAD Collab.)	REFID=47622
DANEVICH	00	PR C62 045501	F.A. Danevich *et al.*		REFID=47810
MASSO	00	PR D61 011701	E. Masso		REFID=47338
ARNOLD	99	NP A658 299	R. Arnold *et al.*	(NEMO Collab.)	REFID=47325
NI	99	PRL 82 2439	W.-T. Ni *et al.*		REFID=46981
SIMKOVIC	99	PR C60 055502	F. Simkovic *et al.*		REFID=50525
ALTEGOER	98	PL B428 197	J. Altegoer *et al.*		REFID=46060
ARNOLD	98	NP A636 209	R. Arnold *et al.*	(NEMO-2 Collab.)	REFID=49250
AVIGNONE	98	PRL 81 5068	F.T. Avignone *et al.*	(Solar Axion Experiment)	REFID=46496
DIAZ	98	NP B527 44	M.A. Diaz *et al.*		REFID=46174
KIM	98	PR D58 055006	J.E. Kim		REFID=46205
LUESCHER	98	PL B434 407	R. Luescher *et al.*		REFID=46132
MORIYAMA	98	PL B434 147	S. Moriyama *et al.*		REFID=46121
MOROI	98	PL B440 69	T. Moroi, H. Murayama		REFID=46514
POSPELOV	98	PR D58 097703	M. Pospelov		REFID=46487
AHMAD	97	PRL 78 618	I. Ahmad *et al.*	(APEX Collab.)	REFID=45229
BORISOV	97	JETP 83 868	A.V. Borisov, V.Y. Grishinia	(MOSU)	REFID=45358
DEBOER	97C	JP G23 L85	F.W.N. de Boer *et al.*		REFID=45706
KACHELRIESS	97	PR D56 1313	M. Kachelriess, C. Wilke, G. Wunner	(BOCH)	REFID=45544
KEIL	97	PR D56 2419	W. Keil *et al.*		REFID=45607
KITCHING	97	PRL 79 4079	P. Kitching *et al.*	(BNL E787 Collab.)	REFID=45721
LEINBERGER	97	PL B394 16	U. Leinberger *et al.*	(ORANGE Collab.)	REFID=45255
ADLER	96	PRL 76 1421	S. Adler *et al.*	(BNL E787 Collab.)	REFID=44723
AMSLER	96B	ZPHY C70 219	C. Amsler *et al.*	(Crystal Barrel Collab.)	REFID=44819
GANZ	96	PL B389 4	R. Ganz *et al.*	(GSI, HEID, FRAN, JAGL+)	REFID=44964
GUENTHER	96	PR D54 3641	M. Gunther *et al.*	(MPIK, SASSO)	REFID=44940
KAMEL	96	PL B368 291	S. Kamel	(SHAMS)	REFID=44827
MITSUI	96	EPL 33 111	T. Mitsui *et al.*	(TOKY)	REFID=44765
YOUDIN	96	PRL 77 2170	A.N. Youdin *et al.*	(AMHT, WASH)	REFID=44925
ALTMANN	95	ZPHY C68 221	M. Altmann *et al.*	(TUM, LAPP, CPPM)	REFID=44463
BASSOMPIE...	95	PL B355 584	G. Bassompierre *et al.*	(LAPP, LCGT, LYON)	REFID=44362
MAENO	95	PL B351 574	T. Maeno *et al.*	(TOKY)	REFID=44226
RAFFELT	95	PR D51 1495	G. Raffelt, A. Weiss	(MPIM, MPIG)	REFID=44144

SKALSEY	95	PR D51 6292	M. Skalsey, R.S. Conti	(MICH)	REFID=44265
TSUNODA	95	EPL 30 273	T. Tsunoda *et al.*	(TOKY)	REFID=44251
ADACHI	94	PR A49 3201	S. Adachi *et al.*	(TMU)	REFID=44592
ALTHERR	94	ASP 2 175	T. Altherr, E. Petitgirard, T. del Rio Gaztelurrutia		REFID=44668;ERROR=3
AMSLER	94B	PL B333 271	C. Amsler *et al.*	(Crystal Barrel Collab.)	REFID=43903
ASAI	94	PL B323 90	S. Asai *et al.*	(TOKY)	REFID=43887
MEIJERDREES	94	PR D49 4937	M.R. Drees *et al.*	(BRCO, OREG, TRIU)	REFID=43858
NI	94	Physica B194 153	W.T. Ni *et al.*	(NTHU)	REFID=44731
VO	94	PR C49 1551	D.T. Vo *et al.*	(ISU, LBL, LLNL, UCD)	REFID=43978
ATIYA	93	PRL 70 2521	M.S. Atiya *et al.*	(BNL E787 Collab.)	REFID=43262
Also		PRL 71 305 (errat.)	M.S. Atiya *et al.*	(BNL E787 Collab.)	REFID=43449
ATIYA	93B	PR D48 1	M.S. Atiya *et al.*	(BNL E787 Collab.)	REFID=43331
BASSOMPIE...	93	EPL 22 239	G. Bassompierre *et al.*	(LAPP, TORI, LYON)	REFID=43335
BECK	93	PRL 70 2853	M. Beck *et al.*	(MPIK, KIAE, SASSO)	REFID=43358
CAMERON	93	PR D47 3707	R.E. Cameron *et al.*	(ROCH, BNL, FNAL+)	REFID=43375
CHANG	93	PL B316 51	S. Chang, K. Choi		REFID=46821
CHUI	93	PRL 71 3247	T.C.P. Chui, W.T. Ni	(NTHU)	REFID=44687
MINOWA	93	PRL 71 4120	M. Minowa *et al.*	(TOKY)	REFID=43643
NG	93	PR D48 2941	K.W. Ng	(AST)	REFID=43529
RITTER	93	PRL 70 701	R.C. Ritter *et al.*		REFID=47480
TANAKA	93	PR D48 5412	J. Tanaka, H. Ejiri	(OSAK)	REFID=43634
ALLIEGRO	92	PRL 68 278	C. Alliegro *et al.*	(BNL, FNAL, PSI+)	REFID=41961
ATIYA	92	PRL 69 733	M.S. Atiya *et al.*	(BNL, LANL, PRIN+)	REFID=42140
BARABASH	92	PL B295 154	L.S. Barabash *et al.*	(JINR, CERN, SERP+)	REFID=43134
BERNATOW...	92	PRL 69 2341	T. Bernatowicz *et al.*	(WUSL, TATA)	REFID=42181
BLUEMLEIN	92	IJMP A7 3835	J. Bluemlein *et al.*	(BERL, BUDA, JINR+)	REFID=42088
HALLIN	92	PR D45 3955	A.L. Hallin *et al.*	(PRIN)	REFID=42069
HENDERSON	92C	PRL 69 1733	S.D. Henderson *et al.*	(YALE, BNL)	REFID=42184
HICKS	92	PL B276 423	K.H. Hicks, D.E. Alburger	(OHIO, BNL)	REFID=41982
LAZARUS	92	PRL 69 2333	D.M. Lazarus *et al.*	(BNL, ROCH, FNAL)	REFID=42180
MEIJERDREES	92	PRL 68 3845	R. Meijer Drees *et al.*	(SINDRUM I Collab.)	REFID=42044
PAN	92	MPL A7 1287	S.S. Pan, W.T. Ni, S.C. Chen	(NTHU)	REFID=44686
RUOSO	92	ZPHY C56 505	G. Ruoso *et al.*	(ROCH, BNL, FNAL, TRST)	REFID=43108
SKALSEY	92	PRL 68 456	M. Skalsey, J.J. Kolata	(MICH, NDAM)	REFID=41962
VENEMA	92	PRL 68 135	B.J. Venema *et al.*		REFID=47479
WANG	92	MPL A7 1497	J. Wang	(ILL)	REFID=42094
WANG	92C	PL B291 97	J. Wang	(ILL)	REFID=42215
WU	92	PRL 69 1729	X.Y. Wu *et al.*	(BNL, YALE, CUNY)	REFID=42183
AKOPYAN	91	PL B272 443	M.V. Akopyan *et al.*	(INRM)	REFID=41973
ASAI	91	PRL 66 2440	S. Asai *et al.*	(ICEPP)	REFID=41480
BERSHADY	91	PRL 66 1398	M.A. Bershady, M.T. Ressell, M.S. Turner	(CHIC+)	REFID=41472
BLUEMLEIN	91	ZPHY C51 341	J. Bluemlein *et al.*	(BERL, BUDA, JINR+)	REFID=41600
BOBRAKOV	91	JETPL 53 294	V.F. Bobrakov *et al.*	(PNPI)	REFID=41511
		Translated from ZETFP 53 283.			
BROSS	91	PRL 67 2942	A.D. Bross *et al.*	(FNAL, ILL)	REFID=41759
KIM	91C	PRL 67 3465	J.E. Kim	(SEOUL)	REFID=41958
RAFFELT	91	PRPL 198 1	G.G. Raffelt	(MPIM)	REFID=41534
RAFFELT	91B	PRL 67 2605	G. Raffelt, D. Seckel	(MPIM, BART)	REFID=41790
RESSELL	91	PR D44 3001	M.T. Ressell	(CHIC, FNAL)	REFID=41728
TRZASKA	91	PL B269 54	W.H. Trzaska *et al.*	(TAMU)	REFID=41760
TSERTOS	91	PL B266 259	H. Tsertos *et al.*	(ILLG, GSI)	REFID=41618
WALKER	91	APJ 376 51	T.P. Walker *et al.*	(HSCA, OSU, CHIC+)	REFID=41879
WIDMANN	91	ZPHY A340 209	E. Widmann *et al.*	(STUT, GSI, STUTM)	REFID=43757
WINELAND	91	PRL 67 1735	D.J. Wineland *et al.*	(NBSB)	REFID=43767
ALBRECHT	90E	PL B246 278	H. Albrecht *et al.*	(ARGUS Collab.)	REFID=41335
ANTREASYAN	90C	PL B251 204	D. Antreasyan *et al.*	(Crystal Ball Collab.)	REFID=41455
ASANUMA	90	PL B237 588	T. Asanuma *et al.*	(TOKY)	REFID=41206
ATIYA	90	PRL 64 21	M.S. Atiya *et al.*	(BNL E787 Collab.)	REFID=40944
ATIYA	90B	PRL 65 1188	M.S. Atiya *et al.*	(BNL E787 Collab.)	REFID=41282
BAUER	90	NIM B50 300	W. Bauer *et al.*	(STUT, VILL, GSI)	REFID=41155
BURROWS	90	PR D42 3297	A. Burrows, M.T. Ressell, M.S. Turner	(ARIZ+)	REFID=41463
DEBOER	90	JP G16 L1	F.W.N. de Boer, J. Lehmann, J. Steyaert	(LOUV)	REFID=41053
ENGEL	90	PRL 65 960	J. Engel, D. Seckel, A.C. Hayes	(BART, LANL)	REFID=41194
GNINENKO	90	PL B237 287	S.N. Gninenko *et al.*	(INRM)	REFID=41205
GUO	90	PR D41 2924	R. Guo *et al.*	(NIU, LANL, FNAL, CASE+)	REFID=41253
HAGMANN	90	PR D42 1297	C. Hagmann *et al.*	(FLOR)	REFID=41264
JUDGE	90	PRL 65 972	S.M. Judge *et al.*	(ILLG, GSI)	REFID=41196
RAFFELT	90D	PR D41 1324	G.G. Raffelt	(MPIM)	REFID=41741
RITTER	90	PR D42 977	R.C. Ritter *et al.*	(UVA)	REFID=43769
SEMERTZIDIS	90	PRL 64 2988	Y.K. Semertzidis *et al.*	(ROCH, BNL, FNAL+)	REFID=41189
TSUCHIAKI	90	PL B236 81	M. Tsuchiaki *et al.*	(ICEPP)	REFID=41199
TURNER	90	PRPL 197 67	M.S. Turner	(FNAL)	REFID=41476
BARABASH	89	PL B223 273	A.S. Barabash *et al.*	(ITEP, INRM)	REFID=40819
BINI	89	PL B221 99	M. Bini *et al.*	(FIRZ, CERN, AARH)	REFID=40815
BURROWS	89	PR D39 1020	A. Burrows, M.S. Turner, R.P. Brinkmann	(ARIZ+)	REFID=41080
Also		PRL 60 1797	M.S. Turner	(FNAL, EFI)	REFID=40604
DEBOER	89B	PRL 62 2639	F.W.N. de Boer, R. van Dantzig	(ANIK)	REFID=40969
ERICSON	89	PL B219 507	T.E.O. Ericson, J.F. Mathiot	(CERN, IPN)	REFID=40811
FAISSNER	89	ZPHY C44 557	H. Faissner *et al.*	(AACH3, BERL, PSI)	REFID=41050
FOX	89	PR C39 288	J.D. Fox *et al.*	(FSU)	REFID=41078
MAYLE	89	PL B219 515	R. Mayle *et al.*	(LLL, CERN, MINN, FNAL+)	REFID=40812
Also		PL B203 188	R. Mayle *et al.*	(LLL, CERN, MINN, FNAL+)	REFID=40635
MINOWA	89	PRL 62 1091	H. Minowa *et al.*	(ICEPP)	REFID=40781
ORITO	89	PRL 63 597	S. Orito *et al.*	(ICEPP)	REFID=41079
PERKINS	89	PRL 62 2638	D.H. Perkins	(OXF)	REFID=40970
TSERTOS	89	PR D40 1397	H. Tsertos *et al.*	(GSI, ILLG)	REFID=41076
VANBIBBER	89	PR D39 2089	K. van Bibber *et al.*	(LLL, TAMU, LBL)	REFID=43765
WUENSCH	89	PR D40 3153	W.U. Wuensch *et al.*	(ROCH, BNL, FNAL)	REFID=40993
Also		PRL 59 839	S. de Panfilis *et al.*	(ROCH, BNL, FNAL)	REFID=40463
AVIGNONE	88	PR D37 618	F.T. Avignone *et al.*	(PRIN, SCUC, ORNL+)	REFID=40666
BALKE	88	PR D37 587	B. Balke *et al.*	(LBL, UCB, COLO, NWES+)	REFID=40665
BJORKEN	88	PR D38 3375	J.D. Bjorken *et al.*	(FNAL, SLAC, VPI)	REFID=40690
BLINOV	88	SJNP 47 563	A.E. Blinov *et al.*	(NOVO)	REFID=40992
		Translated from YAF 47 889.			

BOLTON	88	PR D38 2077	R.D. Bolton *et al.*	(LANL, STAN, CHIC+)	REFID=40683
Also		PRL 56 2461	R.D. Bolton *et al.*	(LANL, STAN, CHIC+)	REFID=10258
Also		PRL 57 3241	D. Grosnick *et al.*	(CHIC, LANL, STAN+)	REFID=40308
CHANDA	88	PR D37 2714	R. Chanda, J.F. Nieves, P.B. Pal	(UMD, UPR+)	REFID=40672
CHOI	88	PR D37 3225	K. Choi *et al.*	(JHU)	REFID=40674
CONNELL	88	PRL 60 2242	S.H. Connell *et al.*	(WITW)	REFID=41077
DATAR	88	PR C37 250	V.M. Datar *et al.*	(IPN)	REFID=41142
DEBOER	88	PRL 61 1274	F.W.N. de Boer, R. van Dantzig	(ANIK)	REFID=40618
Also		PRL 62 2644 (errat.)	F.W.N. de Boer, R. van Dantzig	(ANIK)	REFID=40968
Also		PRL 62 2638	D.H. Perkins	(OXF)	REFID=40970
Also		PRL 62 2639	F.W.N. de Boer, R. van Dantzig	(ANIK)	REFID=40969
DEBOER	88C	JP G14 L131	F.W.N. de Boer *et al.*	(LOUV)	REFID=41066
DOEHNER	88	PR D38 2722	J. Dohner *et al.*	(HEIDP, ANL, ILLG)	REFID=40687
EL-NADI	88	PRL 61 1271	M. el Nadi, O.E. Badawy	(CAIR)	REFID=40617
ENGEL	88	PR C37 731	J. Engel, P. Vogel, M.R. Zirnbauer		REFID=41802
FAISSNER	88	ZPHY C37 231	H. Faissner *et al.*	(AACH3, BERL, SIN)	REFID=40852
HATSUDA	88B	PL B203 469	T. Hatsuda, M. Yoshimura	(KEK)	REFID=40639
LORENZ	88	PL B214 10	E. Lorenz *et al.*	(MPIM, PSI)	REFID=41073
MAYLE	88	PL B203 188	R. Mayle *et al.*	(LLL, CERN, MINN, FNAL+)	REFID=40635
PICCIOTTO	88	PR D37 1131	C.E. Picciotto *et al.*	(TRIU, CNRC)	REFID=40667
RAFFELT	88	PRL 60 1793	G. Raffelt, D. Seckel	(UCB, LLL, UCSC)	REFID=40603
RAFFELT	88B	PR D37 549	G.G. Raffelt, D.S.P. Dearborn	(UCB, LLL)	REFID=40663
SAVAGE	88	PR D37 1134	M.J. Savage, B.W. Filippone, L.W. Mitchell	(CIT)	REFID=40543
TSERTOS	88	PL B207 273	A. Tsertos *et al.*	(GSI, ILLG)	REFID=41074
TSERTOS	88B	ZPHY A331 103	A. Tsertos *et al.*	(GSI, ILLG)	REFID=41075
VANKLINKEN	88	PL B205 223	J. van Klinken *et al.*	(GRON, GSI)	REFID=41072
VANKLINKEN	88B	PRL 60 2442	J. van Klinken	(GRON)	REFID=41070
VONWIMMER...	88	PRL 60 2443	U. von Wimmersperg	(BNL)	REFID=41071
VOROBYOV	88	PL B208 146	P.V. Vorobiev, Y.I. Gitarts	(NOVO)	REFID=43768
DRUZHININ	87	ZPHY C37 1	V.P. Druzhinin *et al.*	(NOVO)	REFID=40448
FRIEMAN	87	PR D36 2201	J.A. Frieman, S. Dimopoulos, M.S. Turner	(SLAC+)	REFID=40878
GOLDMAN	87	PR D36 1543	T. Goldman *et al.*	(LANL, CHIC, STAN+)	REFID=40460
KORENCHE...	87	SJNP 46 192	S.M. Korenchenko *et al.*	(JINR)	REFID=40461
		Translated from YAF 46 313.			
MAIER	87	ZPHY A326 527	K. Maier *et al.*	(STUT, GSI)	REFID=41067
MILLS	87	PR D36 707	A.P. Mills, J. Levy	(BELL)	REFID=40174
RAFFELT	87	PR D36 2211	G.G. Raffelt, D.S.P. Dearborn	(LLL, UCB)	REFID=40877
RIORDAN	87	PRL 59 755	E.M. Riordan *et al.*	(ROCH, CIT+)	REFID=40170
TURNER	87	PRL 59 2489	M.S. Turner	(FNAL, EFI)	REFID=40876
VANBIBBER	87	PRL 59 759	K. van Bibber *et al.*	(LLL, CIT, MIT+)	REFID=43766
VONWIMMER...	87	PRL 59 266	U. von Wimmersperg *et al.*	(WITW)	REFID=41069
BADIER	86	ZPHY C31 21	J. Badier *et al.*	(NA3 Collab.)	REFID=10622
BROWN	86	PRL 57 2101	C.N. Brown *et al.*	(FNAL, WASH, KYOT+)	REFID=40165
BRYMAN	86B	PRL 57 2787	D.A. Bryman, E.T.H. Clifford	(TRIU)	REFID=40167
DAVIER	86	PL B180 295	M. Davier, J. Jeanjean, H. Nguyen Ngoc	(LALO)	REFID=40152
DEARBORN	86	PRL 56 26	D.S.P. Dearborn, D.N. Schramm, G. Steigman	(LLL+)	REFID=40881
EICHLER	86	PL B175 101	R.A. Eichler *et al.*	(SINDRUM Collab.)	REFID=40134
HALLIN	86	PRL 57 2105	A.L. Hallin *et al.*	(PRIN)	REFID=40166
JODIDIO	86	PR D34 1967	A. Jodidio *et al.*	(LBL, NWES, TRIU)	REFID=40309
Also		PR D37 237 (errat.)	A. Jodidio *et al.*	(LBL, NWES, TRIU)	REFID=40467
KETOV	86	JETPL 44 146	S.N. Ketov *et al.*	(KIAE)	REFID=40176
		Translated from ZETFP 44 114.			
KOCH	86	NC 96A 182	H.R. Koch, O.W.B. Schult	(JULI)	REFID=40175
KONAKA	86	PRL 57 659	A. Konaka *et al.*	(KYOT, KEK)	REFID=40164
MAIANI	86	PL B175 359	L. Maiani, R. Petronzio, E. Zavattini	(CERN)	REFID=41633
PECCEI	86	PL B172 435	R.D. Peccei, T.T. Wu, T. Yanagida	(DESY)	REFID=40209
RAFFELT	86	PR D33 897	G.G. Raffelt	(MPIM)	REFID=40880
RAFFELT	86B	PL 166B 402	G.G. Raffelt	(MPIM)	REFID=40879
SAVAGE	86B	PRL 57 178	M.J. Savage *et al.*	(CIT)	REFID=40138
AMALDI	85	PL 153B 444	U. Amaldi *et al.*	(CERN)	REFID=40991
ANANEV	85	SJNP 41 585	V.D. Ananev *et al.*	(JINR)	REFID=12490
		Translated from YAF 41 912.			
BALTRUSAIT...	85	PRL 55 1842	R.M. Baltrusaitis *et al.*	(Mark III Collab.)	REFID=10341
BERGSMA	85	PL 157B 458	F. Bergsma *et al.*	(CHARM Collab.)	REFID=12491
KAPLAN	85	NP B260 215	D.B. Kaplan	(HARV)	REFID=40883
IWAMOTO	84	PRL 53 1198	N. Iwamoto	(UCSB, WUSL)	REFID=40884
YAMAZAKI	84	PRL 52 1089	T. Yamazaki *et al.*	(INUS, KEK)	REFID=12489
ABBOTT	83	PL 120B 133	L.F. Abbott, P. Sikivie	(BRAN, FLOR)	REFID=40886
CARBONI	83	PL 123B 349	G. Carboni, W. Dahme	(CERN, MUNI)	REFID=12482
CAVAIGNAC	83	PL 121B 193	J.F. Cavaignac *et al.*	(ISNG, LAPP)	REFID=12483
DICUS	83	PR D28 1778	D.A. Dicus, V.L. Teplitz	(TEXA, UMD)	REFID=12642
DINE	83	PL 120B 137	M. Dine, W. Fischler	(IAS, PENN)	REFID=40885
ELLIS	83B	NP B223 252	J. Ellis, K.A. Olive	(CERN)	REFID=40888
FAISSNER	83	PR D28 1198	H. Faissner *et al.*	(AACH)	REFID=12484
FAISSNER	83B	PR D28 1787	H. Faissner *et al.*	(AACH3)	REFID=12485
FRANK	83B	PR D28 1790	J.S. Frank *et al.*	(LANL, YALE, LBL+)	REFID=12486
HOFFMAN	83	PR D28 660	C.M. Hoffman *et al.*	(LANL, ARZS)	REFID=12487
PRESKILL	83	PL 120B 127	J. Preskill, M.B. Wise, F. Wilczek	(HARV, UCSBT)	REFID=40887
SIKIVIE	83	PRL 51 1415	P. Sikivie	(FLOR)	REFID=40907
Also		PRL 52 695 (errat.)	P. Sikivie	(FLOR)	REFID=40908
ALEKSEEV	82	JETP 55 591	E.A. Alekseeva *et al.*	(KIAE)	REFID=20130
		Translated from ZETF 82 1007.			
ALEKSEEV	82B	JETPL 36 116	G.D. Alekseev *et al.*	(MOSU, JINR)	REFID=12472
		Translated from ZETFP 36 94.			

ASANO	82	PL 113B 195	Y. Asano *et al.*	(KEK, TOKY, INUS, OSAK)	REFID=11013
BARROSO	82	PL 116B 247	A. Barroso, G.C. Branco	(LISB)	REFID=12474
DATAR	82	PL 114B 63	V.M. Datar *et al.*	(BHAB)	REFID=12475
EDWARDS	82	PRL 48 903	C. Edwards *et al.*	(Crystal Ball Collab.)	REFID=12476
FETSCHER	82	JP G8 L147	W. Fetscher	(ETH)	REFID=12477
FUKUGITA	82	PRL 48 1522	M. Fukugita, S. Watamura, M. Yoshimura	(KEK)	REFID=40890
FUKUGITA	82B	PR D26 1840	M. Fukugita, S. Watamura, M. Yoshimura	(KEK)	REFID=40889
LEHMANN	82	PL 115B 270	P. Lehmann *et al.*	(SACL)	REFID=12478
RAFFELT	82	PL 119B 323	G. Raffelt, L. Stodolsky	(MPIM)	REFID=40185
ZEHNDER	82	PL 110B 419	A. Zehnder, K. Gabathuler, J.L. Vuilleumier	(ETH+)	REFID=12480
ASANO	81B	PL 107B 159	Y. Asano *et al.*	(KEK, TOKY, INUS, OSAK)	REFID=11008
BARROSO	81	PL 106B 91	A. Barroso, N.C. Mukhopadhyay	(SIN)	REFID=40112
FAISSNER	81	ZPHY C10 95	H. Faissner *et al.*	(AACH3)	REFID=12467
FAISSNER	81B	PL 103B 234	H. Faissner *et al.*	(AACH3)	REFID=12468
KIM	81	PL 105B 55	B.R. Kim, C. Stamm	(AACH3)	REFID=12469
VUILLEUMIER	81	PL 101B 341	J.L. Vuilleumier *et al.*	(CIT, MUNI)	REFID=12470
ZEHNDER	81	PL 104B 494	A. Zehnder	(ETH)	REFID=12471
FAISSNER	80	PL 96B 201	H. Faissner *et al.*	(AACH3)	REFID=12463
JACQUES	80	PR D21 1206	P.F. Jacques *et al.*	(RUTG, STEV, COLU)	REFID=12464
SOUKAS	80	PRL 44 564	A. Soukas *et al.*	(BNL, HARV, ORNL, PENN)	REFID=12465
BECHIS	79	PRL 42 1511	D.J. Bechis *et al.*	(UMD, COLU, AFRR)	REFID=12458
CALAPRICE	79	PR D20 2708	F.P. Calaprice *et al.*	(PRIN)	REFID=12459
COTEUS	79	PRL 42 1438	P. Coteus *et al.*	(COLU, ILL, BNL)	REFID=12460
DISHAW	79	PL 85B 142	J.P. Dishaw *et al.*	(SLAC, CIT)	REFID=12461
ZHITNITSKII	79	SJNP 29 517	A.R. Zhitnitsky, Y.I. Skovpen	(NOVO)	REFID=12462
		Translated from YAF 29 1001.			
ALIBRAN	78	PL 74B 134	P. Alibran *et al.*	(Gargamelle Collab.)	REFID=12448
ASRATYAN	78B	PL 79B 497	A.E. Asratyan *et al.*	(ITEP, SERP)	REFID=12449
BELLOTTI	78	PL 76B 223	E. Bellotti, E. Fiorini, L. Zanotti	(MILA)	REFID=12450
BOSETTI	78B	PL 74B 143	P.C. Bosetti *et al.*	(BEBC Collab.)	REFID=12451
DICUS	78C	PR D18 1829	D.A. Dicus *et al.*	(TEXA, VPI, STAN)	REFID=40184
DONNELLY	78	PR D18 1607	T.W. Donnelly *et al.*	(STAN)	REFID=12452
Also		PRL 37 315	F. Reines, H.S. Gurr, H.W. Sobel	(UCI)	REFID=12453
Also		PRL 33 179	H.S. Gurr, F. Reines, H.W. Sobel	(UCI)	REFID=12454
HANSL	78D	PL 74B 139	T. Hansl *et al.*	(CDHS Collab.)	REFID=12455
MICELMAC...	78	LNC 21 441	G.V. Mitselmakher, B. Pontecorvo	(JINR)	REFID=12456
MIKAELIAN	78	PR D18 3605	K.O. Mikaelian	(FNAL, NWES)	REFID=40893
SATO	78	PTP 60 1942	K. Sato	(KYOT)	REFID=40892
VYSOTSKII	78	JETPL 27 502	M.I. Vysotsky *et al.*	(ASCI)	REFID=12457
		Translated from ZETFP 27 533.			
YANG	78	PRL 41 523	T.C. Yang	(MASA)	REFID=40525
PECCEI	77	PR D16 1791	R.D. Peccei, H.R. Quinn	(STAN, SLAC)	REFID=40106
Also		PRL 38 1440	R.D. Peccei, H.R. Quinn	(STAN, SLAC)	REFID=40107
REINES	76	PRL 37 315	F. Reines, H.S. Gurr, H.W. Sobel	(UCI)	REFID=12453
GURR	74	PRL 33 179	H.S. Gurr, F. Reines, H.W. Sobel	(UCI)	REFID=12454
ANAND	53	PRSL A22 183	B.M. Anand		REFID=41166

OTHER RELATED PAPERS

SREDNICKI	85	NP B260 689	M. Srednicki	(UCSB)	REFID=40882
BARDEEN	78	PL 74B 229	W.A. Bardeen, S.-H.H. Tye	(FNAL)	REFID=40891