NODE=G033

graviton

$J = 2$

graviton MASS

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It is likely that the graviton is massless. More than fifty years ago Van Dam and Veltman (VANDAM 70), Iwasaki (IWASAKI 70), and Zakharov (ZAKHAROV 70) almost simultaneously showed that in the linear approximation a theory with a finite graviton mass does not approach GR as the mass approaches zero. Attempts have been made to evade this "vDVZ discontinuity" by invoking modified gravity or nonlinear theory by De Rahm (DE-RHAM 17) and others. More recently, the analysis of gravitational wave dispersion has led to bounds that are largely independent of the underlying model, even if not the strongest. We quote the best of these as our best limit.

Experimental limits have been set based on a Yukawa potential (YUKA), dispersion relation (DISP), or other modified gravity theories (MGRV).

The following conversions are useful: 1 eV $= 1.783 \times 10^{-36}$ kg $= 1.957 \times 10^{-6}$ m_e; $\lambda\!\!\!^{-}_C = (1.973 \times 10^{-7}\ \text{m}) \times (1\ \text{eV}/m_g)$.

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VALUE (eV)	*DOCUMENT ID*		*TECN*	*COMMENT*	
$<1.76 \times 10^{-23}$	[1] ABBOTT	21	DISP	LIGO Virgo catalog GWTC-2	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<6.6 \times 10^{-34}$	[2] DEFELICE	24	MGRV	Extended Minimal Theory of Massive Gravity	
$<3.8 \times 10^{-23}$	[3] WANG	24	PTA	CPTA pulsar timing array	
$<8.6 \times 10^{-24}$	[3] WANG	24	PTA	NANOgrav pulsar timing array	OCCUR=2
$<8 \times 10^{-34}$	[4] DEFELICE	21	MGRV	Normal branch Minimal Theory of Massive Gravity	
$<3.2 \times 10^{-23}$	[5] BERNUS	20	YUKA	Planetary ephemeris INPOP19a	OCCUR=2
$<2 \times 10^{-28}$	[6] SHAO	20	DISP	Binary pulsar Galileon radiation	
$<4.7 \times 10^{-23}$	[7] ABBOTT	19	DISP	LIGO Virgo catalog GWTC-1	OCCUR=2
$<7 \times 10^{-23}$	[8] BERNUS	19	YUKA	Planetary ephemeris INPOP17b	
$<3.1 \times 10^{-20}$	[9] MIAO	19	DISP	Binary pulsar orbital decay rate	
$<1.4 \times 10^{-29}$	[10] DESAI	18	YUKA	Gal cluster Abell 1689	
$<5 \times 10^{-30}$	[11] GUPTA	18	YUKA	Using SPT-SZ	OCCUR=2
$<3 \times 10^{-30}$	[11] GUPTA	18	YUKA	Using Planck all-sky SZ	OCCUR=4
$<1.3 \times 10^{-29}$	[11] GUPTA	18	YUKA	Using redMaPPer SDSS-DR8	OCCUR=5
$<6 \times 10^{-30}$	[12] RANA	18	YUKA	Weak lensing in massive clusters	
$<8 \times 10^{-30}$	[13] RANA	18	YUKA	SZ effect in massive clusters	OCCUR=2
$<1.0 \times 10^{-23}$	[14] WILL	18	YUKA	Perihelion advances of planets	
$<7 \times 10^{-23}$	[7] ABBOTT	17	DISP	Combined dispersion limit from three BH mergers	
$<1.2 \times 10^{-22}$	[7] ABBOTT	16	DISP	Combined dispersion limit from two BH mergers	
$<2.9 \times 10^{-21}$	[15] ZAKHAROV	16	YUKA	S2 star orbit	
$<5 \times 10^{-23}$	[16] BRITO	13	MGRV	Spinning black holes bounds	
$<6 \times 10^{-32}$	[17] GRUZINOV	05	MGRV	Solar System observations	
$<6 \times 10^{-32}$	[18] CHOUDHURY	04	YUKA	Weak gravitational lensing	
$<9.0 \times 10^{-34}$	[19] GERSHTEIN	04	MGRV	From Ω_{tot} value assuming RTG	
$<8 \times 10^{-20}$	[20,21] FINN	02	DISP	Binary pulsar orbital period decrease	
$<7 \times 10^{-23}$	TALMADGE	88	YUKA	Solar system planetary astrometric data	
$<1.3 \times 10^{-29}$	[22] GOLDHABER	74	YUKA	Rich clusters	
$<7 \times 10^{-28}$	HARE	73	YUKA	Galaxy	
$<8 \times 10^{4}$	HARE	73	YUKA	2γ decay	OCCUR=2

[1] ABBOTT 21 assumed modified gravitational-wave dispersion to establish a limit on graviton mass, using LIGO-Virgo O1-O3a binary black hole (BBH) events. NODE=G033M;LINKAGE=AA

[2] DEFELICE 24 limits graviton mass in context of the "extended Minimal Theory of Massive Gravity" recently proposed by two of the authors, using constraints from Planck-CMB, BAO and SNe1a. NODE=G033M;LINKAGE=GA

[3] WANG 24 investigates sensitivity to the graviton mass of overlap reduction functions due to stochastic gravitational wave background in the nano-Hertz band as observed in pulsar timing arrays. NODE=G033M;LINKAGE=HA

[4] DEFELICE 21 studies the normal branch of the Minimal Theory of Massive Gravity (MTMG) to find that after five parameters are adjusted to obtain agreement with all presently available data, today's squared mass $m_g^2 = (2.5^{+4.5}_{-4.8}) \times 10^{-67}$ eV^2 or $m_g < 8.4 \times 10^{-33}$ eV, both at the 95% CL. NODE=G033M;LINKAGE=BA

[5] BERNUS 20 use the latest solution of the ephemeris INPOP (19a) in order to improve the constraint in BERNUS 19 on the existence of a Yukawa suppression to the Newtonian potential, generically associated to a gravitons mass. NODE=G033M;LINKAGE=V

[6] SHAO 20 sets limit, 95% CL, based on non-observation of excess gravitational radiation in 14 well-timed binary pulsars in the context of the cubic Galileon model. NODE=G033M;LINKAGE=R

[7] ABBOTT 19, ABBOTT 17, and ABBOTT 16 assumed modified gravitational waves dispersion to establish limits on graviton mass. NODE=G033M;LINKAGE=F

[8] BERNUS 19 use the planetary ephemeris INPOP 17b to constraint the existence of a Yukawa suppression to the Newtonian potential, generically associated to a gravitons mass. NODE=G033M;LINKAGE=W

[9] MIAO 19 90% CL limit is based on orbital period decay rates of 9 binary pulsars using a Bayesian prior uniform in graviton mass. Limit becomes $< 5.2 \times 10^{-21}$ eV for a prior uniform in $\ln(m_g)$. NODE=G033M;LINKAGE=S

[10] DESAI 18 limit based on dynamical mass models of galaxy cluster Abell 1689. NODE=G033M;LINKAGE=J

[11] GUPTA 18 obtains graviton mass limits using stacked clusters from 3 disparate surveys. NODE=G033M;LINKAGE=O

[12] RANA 18 limit, 68% CL, obtained using weak lensing mass profiles out to the radius at which the cluster density falls to 200 times the critical density of the Universe. Limit is based on the fractional change between Newtonian and Yukawa accelerations for the 50 most massive galaxy clusters in the Local Cluster Substructure Survey. Limits for other CL's and other density cuts are also given. NODE=G033M;LINKAGE=K

[13] RANA 18 limit, 68% CL, obtained using mass measurements via the SZ effect out to the radius at which the cluster density falls to 500 times the critical density of the Universe for 182 optically confirmed galaxy clusters in an Altacama Cosmology Telescope survey. Limits for other CL's and other density cuts are also given. NODE=G033M;LINKAGE=L

[14] WILL 18 limit from perihelion advances of the planets, notably Earth, Mars, and Saturn. Alternate analysis yields $< 6 \times 10^{-24}$. NODE=G033M;LINKAGE=U

[15] ZAKHAROV 16 constrains range of Yukawa gravity interaction from S2 star orbit about black hole at Galactic center. The limit is $< 2.9 \times 10^{-21}$ eV for $\delta = 100$. NODE=G033M;LINKAGE=M

[16] BRITO 13 explore massive graviton (spin-2) fluctuations around rotating black holes. NODE=G033M;LINKAGE=B

[17] GRUZINOV 05 uses the DGP model (DVALI 00) showing that non-perturbative effects restore continuity with Einstein's equations as the gravition mass approaches zero, then bases his limit on Solar System observations. NODE=G033M;LINKAGE=E

[18] CHOUDHURY 04 concludes from a study of weak-lensing data that masses heavier than about the inverse of 100 Mpc seem to be ruled out if the gravitation field has the Yukawa form. NODE=G033M;LINKAGE=CH

[19] GERSHTEIN 04 use non-Einstein field relativistic theory of gravity (RTG), with a massive graviton, to obtain the 95% CL mass limit implied by the value of $\Omega_{tot} = 1.02 \pm 0.02$ current at the time of publication. NODE=G033M;LINKAGE=G

[20] FINN 02 analyze the orbital decay rates of PSR B1913+16 and PSR B1534+12 with a possible graviton mass as a parameter. The combined frequentist mass limit is at 90%CL. NODE=G033M;LINKAGE=FN

[21] As of 2020, limits on dP/dt are now about 0.1% (see T. Damour, "Experimental tests of gravitational theory," in this *Review*). NODE=G033M;LINKAGE=RP

[22] GOLDHABER 74 establish this limit considering the binding of galactic clusters, corrected to Planck $h_0 = 0.67$. NODE=G033M;LINKAGE=Y

graviton REFERENCES

NODE=G033

DEFELICE	24	JCAP 2404 013	A. De Felice *et al.*		REFID=62916
WANG	24	PR D109 L061502	S. Wang, Z-C. Zhao		REFID=62782
ABBOTT	21	PR D103 122002	R. Abbott *et al.*	(LIGO and Virgo Collabs.)	REFID=61226
DEFELICE	21	JCAP 2112 011	A. De Felice, S. Mukohyama, M.C. Pookkillath		REFID=61876
BERNUS	20	PR D102 021501	L. Bernus *et al.*		REFID=60341
SHAO	20	PR D102 024069	L. Shao, N. Wex, S.-Y. Zhou		REFID=60343
ABBOTT	19	PR D100 104036	B.P. Abbott *et al.*	(LIGO and Virgo Collabs.)	REFID=60654
BERNUS	19	PRL 123 161103	L. Bernus *et al.*		REFID=60062
MIAO	19	PR D99 123015	X. Miao, L. Shao, B.-Q. Ma		REFID=60659
DESAI	18	PL B778 325	S. Desai	(HYDER)	REFID=58996
GUPTA	18	ANP 399 85	S. Gupta, S. Desai		REFID=59300
RANA	18	PL B781 220	A. Rana *et al.*	(DELHI)	REFID=59015
WILL	18	CQG 35 17LT01	C.M. Will		REFID=60660
ABBOTT	17	PRL 118 221101	B.P. Abbott *et al.*	(LIGO and Virgo Collabs.)	REFID=57786
DE-RHAM	17	RMP 89 025004	C. de Rham *et al.*		REFID=58165
ABBOTT	16	PRL 116 061102	B.P. Abbott *et al.*	(LIGO and Virgo Collabs.)	REFID=57149
ZAKHAROV	16	JCAP 1605 045	A.F. Zakharov *et al.*		REFID=59292
BRITO	13	PR D88 023514	R. Brito, V. Cardoso, P. Pani	(LISB, MISS, HSCA+)	REFID=55311
GRUZINOV	05	NAST 10 311	A. Gruzinov	(NYU)	REFID=55682
CHOUDHURY	04	ASP 21 559	S.R. Choudhury *et al.*	(DELPH, MELB)	REFID=50208
GERSHTEIN	04	PAN 67 1596	S.S. Gershtein *et al.*	(SERP)	REFID=57145
		Translated from YAF 67 1618.			
FINN	02	PR D65 044022	L.S. Finn, P.J. Sutton		REFID=48874
DVALI	00	PL B485 208	G.R. Dvali, G. Gabadadze, M. Porrati	(NYU)	REFID=55680
TALMADGE	88	PRL 61 1159	C. Talmadge *et al.*	(JPL)	REFID=58184
GOLDHABER	74	PR D9 1119	A.S. Goldhaber, M.M. Nieto	(LANL, STON)	REFID=43497
HARE	73	CJP 51 431	M.G. Hare	(SASK)	REFID=43498
IWASAKI	70	PR D2 2255	Y. Iwasaki		REFID=58181
VANDAM	70	NP B22 397	H. van Dam, M. Veltman	(UTRE)	REFID=43499
ZAKHAROV	70	JETPL 12 312	V.I. Zakharov *et al.*		REFID=58180