graviton

$J = 2$

graviton MASS

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 = 1.783×10^{-33} g = 1.957×10^{-6} m_e; $\lambda\!\!\!^{-}_C = (1.973 \times 10^{-7}\ \text{m}) \times (1\ \text{eV}/m_g)$.

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. • • •				
$<8 \times 10^{-34}$	[2] DEFELICE	21	MGRV	Normal branch Minimal Theory of Massive Gravity
$<3.2 \times 10^{-23}$	[3] BERNUS	20	YUKA	Planetary ephemeris INPOP19a
$<2 \times 10^{-28}$	[4] SHAO	20	DISP	Binary pulsar Galileon radiation
$<4.7 \times 10^{-23}$	[5] ABBOTT	19	DISP	LIGO Virgo catalog GWTC-1
$<7 \times 10^{-23}$	[6] BERNUS	19	YUKA	Planetary ephemeris INPOP17b
$<3.1 \times 10^{-20}$	[7] MIAO	19	DISP	Binary pulsar orbital decay rate
$<1.4 \times 10^{-29}$	[8] DESAI	18	YUKA	Gal cluster Abell 1689
$<5 \times 10^{-30}$	[9] GUPTA	18	YUKA	Using SPT-SZ
$<3 \times 10^{-30}$	[9] GUPTA	18	YUKA	Using Planck all-sky SZ
$<1.3 \times 10^{-29}$	[9] GUPTA	18	YUKA	Using redMaPPer SDSS-DR8
$<6 \times 10^{-30}$	[10] RANA	18	YUKA	Weak lensing in massive clusters
$<8 \times 10^{-30}$	[11] RANA	18	YUKA	SZ effect in massive clusters
$<1.0 \times 10^{-23}$	[12] WILL	18	YUKA	Perihelion advances of planets
$<7 \times 10^{-23}$	[5] ABBOTT	17	DISP	Combined dispersion limit from three BH mergers
$<1.2 \times 10^{-22}$	[5] ABBOTT	16	DISP	Combined dispersion limit from two BH mergers
$<2.9 \times 10^{-21}$	[13] ZAKHAROV	16	YUKA	S2 star orbit
$<5 \times 10^{-23}$	[14] BRITO	13	MGRV	Spinning black holes bounds
$<6 \times 10^{-32}$	[15] GRUZINOV	05	MGRV	Solar System observations
$<6 \times 10^{-32}$	[16] CHOUDHURY	04	YUKA	Weak gravitational lensing
$<9.0 \times 10^{-34}$	[17] GERSHTEIN	04	MGRV	From Ω_{tot} value assuming RTG
$<8 \times 10^{-20}$	[18,19] FINN	02	DISP	Binary pulsar orbital period decrease

<7	$\times 10^{-23}$	TALMADGE	88	YUKA	Solar system planetary astrometric data
<1.3	$\times 10^{-29}$	[20] GOLDHABER	74	YUKA	Rich clusters
<7	$\times 10^{-28}$	HARE	73	YUKA	Galaxy
<8	$\times 10^{4}$	HARE	73	YUKA	2γ decay

[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.

[2] 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.

[3] 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.

[4] 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.

[5] ABBOTT 19, ABBOTT 17, and ABBOTT 16 assumed modified gravitational waves dispersion to establish limits on graviton mass.

[6] 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.

[7] 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 $\ln(m_g)$.

[8] DESAI 18 limit based on dynamical mass models of galaxy cluster Abell 1689.

[9] GUPTA 18 obtains graviton mass limits using stacked clusters from 3 disparate surveys.

[10] 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.

[11] 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.

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

[13] 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 $\delta = 100$.

[14] BRITO 13 explore massive graviton (spin-2) fluctuations around rotating black holes.

[15] 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.

[16] 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.

[17] 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.

[18] 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.

[19] As of 2020, limits on dP/dt are now about 0.1% (see T. Damour, "Experimental tests of gravitational theory," in this *Review*).

[20] GOLDHABER 74 establish this limit considering the binding of galactic clusters, corrected to Planck $h_0 = 0.67$.

graviton REFERENCES

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