

Experimental Search for Quantum Gravity

Guide to further reading and discussion topics

Why quantum gravity?

- G. 't Hooft, “*Perturbative Quantum Gravity*,”
<http://www.staff.science.uu.nl/~hooft101/lectures/erice02.pdf>
- J. Donoghue, “*Perturbative dynamics of quantum general relativity*,”
gr-qc/9712070.
- K. Eppley and E. Hannah. “*The Necessity of Quantizing the Gravitational Field*,” *Foundations of Physics*, 7:51-65, (1977).
- J. Mattingly, “*Why Eppley and Hannah’s thought experiment fails*,”
Phys. Rev. D **73**, 064025 (2006) [gr-qc/0601127].
- D. N. Page and C. D. Geilker, “*Indirect Evidence for Quantum Gravity*,” *Phys. Rev. Lett.* **47**, 979 (1981).

Some attempts at quantum gravity

- R. J. Szabo, “*BUSSTEPP lectures on string theory: An Introduction to string theory and D-brane dynamics*,” hep-th/0207142.
- L. Smolin, “*An Invitation to loop quantum gravity*,” [hep-th/0408048].
- J. Ambjorn, J. Jurkiewicz and R. Loll, “*Causal Dynamical Triangulations and the Quest for Quantum Gravity*,” arXiv:1004.0352 [hep-th].
- S. Surya, “*Directions in Causal Set Quantum Gravity*,” arXiv:1103.6272 [gr-qc].
- D. Oriti, “*The microscopic dynamics of quantum space as a group field theory*,” arXiv:1110.5606 [hep-th].
- R. Percacci, “*A Short introduction to asymptotic safety*,” arXiv:1110.6389 [hep-th].

The Planck scale and why it's hard to see quantum gravitational effects

- R. J. Adler, “*Six easy roads to the Planck scale*,” Am. J. Phys. **78**, 925 (2010) [arXiv:1001.1205 [gr-qc]].
- T. Rothman and S. Boughn, “*Can gravitons be detected?*,” Found. Phys. **36**, 1801 (2006) [gr-qc/0601043].

Generalized Uncertainty

- C. A. Mead, “*Possible Connection Between Gravitation and Fundamental Length*,” Phys. Rev. **135**, B849-B862 (1964).
- R. J. Adler and D. I. Santiago, “*On gravity and the uncertainty principle*,” Mod. Phys. Lett. A **14**, 1371 (1999) [gr-qc/9904026].

Extra dimensions

- N. Arkani-Hamed, S. Dimopoulos and G. R. Dvali, “*The hierarchy problem and new dimensions at a millimeter*,” Phys. Lett. B **429**, 263 (1998) [arXiv:hep-ph/9803315].
- I. Antoniadis, N. Arkani-Hamed, S. Dimopoulos and G. R. Dvali, “*New dimensions at a millimeter to a Fermi and superstrings at a TeV*,” Phys. Lett. B **436**, 257 (1998) [arXiv:hep-ph/9804398].
- N. Arkani-Hamed, S. Dimopoulos and G. R. Dvali, “*Phenomenology, astrophysics and cosmology of theories with sub-millimeter dimensions and TeV scale quantum gravity*,” Phys. Rev. D **59**, 086004 (1999) [arXiv:hep-ph/9807344].
- H. C. Cheng, “*2009 TASI Lecture – Introduction to Extra Dimensions*,” arXiv:1003.1162 [hep-ph].
- L. Randall and R. Sundrum, “*A large mass hierarchy from a small extra dimension*,” Phys. Rev. Lett. **83**, 3370 (1999) [arXiv:hep-ph/9905221].
- L. Randall and R. Sundrum, “*An alternative to compactification*,” Phys. Rev. Lett. **83**, 4690 (1999) [arXiv:hep-th/9906064].
- R. Maartens and K. Koyama, “*Brane-World Gravity*,” Living Rev. Rel. **13**, 5 (2010) [arXiv:1004.3962 [hep-th]].

Lorentz Invariance Violation

- D. Mattingly, “*Modern tests of Lorentz invariance*,” Living Rev. Rel. **8**, 5 (2005) [gr-qc/0502097].
- R. C. Myers and M. Pospelov, “*Ultraviolet modifications of dispersion relations in effective field theory*,” Phys. Rev. Lett. **90**, 211601 (2003) [hep-ph/0301124].
- T. Jacobson, S. Liberati and D. Mattingly, “*Threshold effects and Planck scale Lorentz violation: Combined constraints from high-energy astrophysics*,” Phys. Rev. D **67**, 124011 (2003) [hep-ph/0209264].

Deformed Special Relativity

- J. Magueijo and L. Smolin, “*Generalized Lorentz invariance with an invariant energy scale*,” Phys. Rev. D **67**, 044017 (2003) [gr-qc/0207085].
- G. Amelino-Camelia, “*Doubly special relativity: First results and key open problems*,” Int. J. Mod. Phys. D **11**, 1643 (2002) [gr-qc/0210063].
- S. Hossenfelder, “*Interpretation of quantum field theories with a minimal length scale*,” Phys. Rev. D **73**, 105013 (2006) [hep-th/0603032].

Space-time fuzz and Kaons

- L. H. Ford, “*Gravitons and light cone fluctuations*,” Phys. Rev. D **51**, 1692 (1995) [gr-qc/9410047].
- F. Tamburini, C. Cuofano, M. Della Valle and R. Gilmozzi, “*No quantum gravity signature from the farthest quasars*,” Astron. Astrophys. **533**, A71 (2011) [arXiv:1108.6005 [gr-qc]].
- Y. J. Ng, H. van Dam and W. A. Christiansen, “*Probing Planck-scale physics with extragalactic sources?*,” Astrophys. J. **591**, L87 (2003) [astro-ph/0302372].
- J. R. Ellis, N. E. Mavromatos and D. V. Nanopoulos, “*Testing quantum mechanics in the neutral kaon system*,” Phys. Lett. B **293**, 142 (1992) [hep-ph/9207268].
- J. R. Ellis, J. S. Hagelin, D. V. Nanopoulos and M. Srednicki, “*Search for Violations of Quantum Mechanics*,” Nucl. Phys. B **241**, 381 (1984).

Little overview papers on ppg

- S. Hossenfelder, “*Experimental Search for Quantum Gravity*,” arXiv:1010.3420 [gr-qc].
- G. Amelino-Camelia, “*Quantum Gravity Phenomenology*,” arXiv:0806.0339 [gr-qc].

Discussion Topics

- Is it socially responsible to spend money on quantum gravity research? Don't we have better things to do? How could mankind possibly benefit from quantum gravity? Why are you here?
- Can we make any progress on the theory of quantum gravity without connection to experiment? Should we think at all about theories of quantum gravity that do not produce testable predictions? How much time do we grant researchers to come up with predictions?
- What is your favorite approach towards quantum gravity? Why? Should you have a favorite approach at all?
- Is our problem maybe not with the quantization of gravity but with the foundations of quantum mechanics and the process of quantization?
- How plausible is it that gravity remains classical while all the other forces are quantized? Could gravity be neither classical nor quantized?
- How convinced are you that the Planck length is at 10^{-33}cm ? Do you think it is plausible that it is lower? Should we continue looking for it?
- What do you think is the most plausible area to look for quantum gravitational effects and why?
- Do you think that gravity can be successfully quantized without paying attention to unification?
- What is the possible relevance of analog gravity and the gauge-gravity duality?