Lessons on quantum gravity from gravitationally induced entanglement

Vasilis Fragkos[1], Michael Kopp[1,2], and Igor Pikovski[1,3]

[1]*Stockholm University, Roslagstullsbacken 21, Stockholm 10691, Sweden*
[2]*Nordita, KTH Royal Institute of Technology and Stockholm University, Hannes Alfvens väg 12, 10691 Stockholm, Sweden*
[3]*Department of Physics, Stevens Institute of Technology, Hoboken, NJ 07030, USA*

Observable signatures of the quantum nature of gravity at low energies have recently emerged as a promising new research field. One prominent avenue is to test for gravitationally induced entanglement between two mesoscopic masses prepared in spatial superposition. Here we analyze such proposals and what one can infer from them about the quantum nature of gravity, as well as the electromagnetic analogues of such tests. We show that it is not possible to draw conclusions about mediators: even within relativistic physics, entanglement generation can equally be described in terms of mediators or in terms of non-local processes [1]. Such indirect tests therefore have limited ability to verify that entanglement is mediated by a quantum channel, as their interpretation is inherently ambiguous. We also show that cosmological observations already demonstrate some aspects of quantization that these proposals aim to test. Nevertheless, the proposed experiments would probe how gravity is sourced by spatial superpositions of matter, an untested new regime of quantum physics.

[1] V. Fragkos, M. Kopp and I. Pikovski, arxiv preprint: 2206.00558