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Quantum gravity with high-energy cosmic neutrinos

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High-energy cosmic neutrinos probe fundamental physics at scales of energy and distance otherwise unreachable, where new physics may manifest. Since the discovery of TeV-PeV cosmic neutrinos in 2013, we have explored this progressively more broadly and more precisely, thanks to a growing number of detected neutrinos and improvements in reconstruction and analysis techniques. Quantum gravity has motivated several of these tests, including changes in the neutrino energy spectrum, flavor mixing, arrival directions, and arrival times, as expected from Lorentz-invariance violation of quantum decoherence. I will survey these efforts, which have led to stringent tests of new physics. I will also touch upon new opportunities made possible by the recent discovery of an ultra-high-energy neutrino, with about 200 PeV, by KM3NeT—with a warning. Looking ahead, I will show two prospects for progress in the next decade, driven by new, upcoming neutrino telescopes: a boost in the detection rate of TeV-PeV neutrinos and the possible detection of more ultra-high-energy neutrinos.

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