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P4.036 Violation of the leggett-garg inequality in neutrino oscillations

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The Leggett-Garg inequality, an analogue of Bell's inequality involving correlations of measurements on a system at different times, stands as one of the hallmark tests of quantum mechanics against classical predictions. Neutrinos, and in particular the phenomenon of neutrino oscillations, should adhere to quantum-mechanical predictions and provide an observable violation of the Leggett-Garg inequality. We demonstrate how oscillation phenomena can be used to test for violations of the classical bound. A study of the MINOS experiment's data shows a greater than 6σ violation over a distance of 735 km, representing the longest distance over which either the Leggett-Garg inequality or Bell's inequality has been tested. By exploiting stationarity and the prepared-ensemble condition, rather than weak measurements, our results provide strong evidence against "hidden-variable theories" which are deterministic alternatives to quantum mechanics. Several alternative tests of the Leggett-Garg inequality with neutrino oscillations are also discussed.