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Measurement of Gravitational Coupling between Millimeter-Sized Masses HANS HEPACH, TOBIAS WESTPHAL, Austrian Academy of Sciences, JEREMIAS PFAFF, University of Vienna, MARKUS ASPELMEYER, Austrian Academy of Sciences — Gravity is the weakest of all known fundamental forces and continues to pose some of the most outstanding open problems to modern physics: it remains resistant to unification within the standard model of physics and its underlying concepts appear to be fundamentally disconnected from quantum theory. Testing gravity on all scales is therefore an important experimental endeavour. Thus far, these tests involve mainly macroscopic masses on the kg-scale and beyond. Here we show gravitational coupling between two gold spheres of 1mm radius, thereby entering the regime of sub-100mg sources of gravity. Periodic modulation of the source mass position allows us to perform a spatial mapping of the gravitational force. Both linear and quadratic coupling are observed as a consequence of the nonlinearity of the gravitational potential. Our results extend the parameter space of gravity measurements to small single source masses and small gravitational field strengths. Further improvements will enable the isolation of gravity as a coupling force for objects below the Planck mass. This opens the way to a yet unexplored frontier of microscopic source masses, which enables new searches of fundamental interactions and provides a natural path towards exploring the quantum nature of gravity.

Hans Hepach
Austrian Academy of Sciences

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