Effective inertial frame in an atom interferometric test of the equivalence principle

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Stanford University — In an ideal test of the equivalence principle, the test masses fall in a common inertial frame. A real experiment is affected by gravity gradients, which introduce systematic errors by coupling to initial kinematic differences between the test masses. We reduce the sensitivity of a dual-species atom interferometer to initial kinematics by using a frequency shift of the middle pulse to create an effective inertial frame for both atomic species. This suppresses the gravity-gradient-induced dependence of the differential phase on initial kinematic differences by two orders of magnitude and enables a precise measurement of these differences. We realize a relative precision of $3 \times 10^{-11}$ per shot and reduce systematic errors associated with the gravity gradient to below one part in $10^{13}$, paving the way for an atomic test of the equivalence principle at an accuracy comparable with state-of-the-art classical tests.