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Rydberg atom interferometry for testing the Weak Equivalence Principle with positronium

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Measurements of the acceleration due to Earth's gravity of positronium (Ps) atoms complement tests of anti-matter gravity with antihydrogen at CERN [1], and extend tests of the Weak Equivalent Principle to purely leptonic systems. In its ground state, the annihilation lifetime of Ps of 142ns precludes precise measurements of g. However, when excited to Rydberg states annihilation is suppressed and such excited atoms can have lifetimes of >10μs [2]. These extended lifetimes can be exploited to perform interferometric measurements of g using a scheme we have developed, which is an electric analogue of Stern-Gerlach interferometry [3]. This is implemented by preparing the atoms in superpositions of Rydberg states with different static electric dipole moments, and using inhomogeneous electric fields to exert state dependent forces on them [4]. We will present the scheme and design of a full loop Rydberg-atom interferometer of this kind to be implemented to measure g for helium, and which can subsequently be extended to experiments with Ps.

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