Matter-wave interferometry with highly excited atoms

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Highly-excited atoms in which one electron is in a state with a high principal quantum number, n, are know as Rydberg atoms and can exhibit often surprisingly extreme properties. For example, for values of n>55 they can possess fluorescence lifetimes >100 μs, dimensions >100 nm, and static electric dipole moments >10000 D. These properties allow Rydberg atoms to be employed as (i) sensitive quantum probes of static and radio frequency electric fields [1, 2, 3], (ii) model systems with which to study atomic and molecular interactions, including resonant energy transfer [4], at low temperatures, and (iii) for precision tests of fundamental physics [5]. In many of these areas it is beneficial to control the motion of, and trap, these neutral samples. This can be achieved by taking advantage of their large static electric dipole moments to exert forces on them using inhomogeneous electric fields [4].

In this talk I will describe how this is implemented in the laboratory. I will particularly discuss recent work in which the forces exerted by inhomogeneous electric fields on helium atoms in coherent superpositions of Rydberg states, with different static electric dipole moments, have been exploited for matter-wave, or de Broglie-wave, interferometry. The planned application of this approach to Rydberg-atom interferometry in tests of the weak equivalence principle with Rydberg positronium atoms will be briefly outlined.

References

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