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Spinning Atoms with the Orbital Angular Momentum of Light[1]

WILLIAM D. PHILLIPS[2], Joint Quantum Institute

Atoms in a moving optical lattice can Bragg reflect from that lattice in a completely coherent manner. This transfer of momentum between light and atoms is one of the important tools used to manipulate atoms coherently. Light can also coherently change the internal state of an atom, and the polarization of the light often controls how the angular momentum state of the atoms changes. Light can also carry angular momentum that is not associated with its polarization—orbital angular momentum that is associated with the spatial mode of the light field. We use that orbital angular momentum to coherently manipulate the circulation state of a coherent cloud of atoms (a Bose-Einstein condensate.) The process, rotational Bragg scattering, uses a moving optical lattice in which one of the laser beams forming the lattice is a Laguerre-Gauss beam carrying orbital angular momentum. Using this technique we can deterministically create vortices with various quantized values of angular momentum. Atom interferometry confirms the coherence of this process. By holding a BEC in a toroidal trap and inducing circulation via this rotational Bragg process, we create persistent atom currents that survive more than an order of magnitude longer than similarly created vortices. We propose that with such a geometry we may create atomic analogs of superconducting circuits containing Josephson junctions.

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[2]U. of MD and NIST, Gaithersburg MD