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Observation of a Geometric Hall Effect in a Spinor Bose-Einstein Condensate

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When a spin-carrying particle slowly moves in a spatially varying magnetic field and its spin adiabatically follows the field direction, the particle acquires a quantum-mechanical phase known as the Berry phase. This phase originates from the geometrical properties of the parameter space of the system can generate geometric forces which act like magnetic and electric forces on the spin-carrying particle. Emergent electromagnetism of this spin origin can lead to novel spin transport phenomena and recently have been studied in many areas of physics, e.g. to understand the anomalous Hall effect in magnetic materials and for spintronics applications. In this talk, I will introduce spinor Bose-Einstein condensates of neutral atoms with Skrymion spin textures [1,2] and present our experimental observation of a geometric Hall effect in the neutral atomic superfluid system [2]. When the condensate was driven in one direction to oscillate with respect to the spin texture, we observed the development of its transverse motion perpendicular to the driving direction and the effective magnetic field direction, demonstrating the existence of an effective Lorentz force in the system. Under a resonant drive, the center of mass of the condensate showed a circular motion whose direction is determined by the chirality of the spin texture. Quantized vortices were nucleated in the circulating condensate due to the anharmonicity of the trapping potential. The geometric Hall effect in our system was characterized with the vortex nucleation rate.

[1] Phys. Rev. Lett. 108, 035301 (2012).
[2] Phys. Rev. Lett. 111, 245301 (2013).