Electron scattering by magnetic quantum dots in topological insulators: a path to electron optics with spin-momentum locking

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One of the challenges in modern spintronics is the ability to manipulate electron charge and spin motion with magnetic fields. Although methods of conventional optics based on electron waves are used to achieve this goal, advanced electron optics should include electron spin to control both coupled spin and charge dynamics.

In our work, we consider formation of coupled spin and charge densities resulting from electron scattering by magnetic quantum dots producing a position-dependent Zeeman field in the presence of spin-momentum locking typical for topological insulators.

Using analytical and numerical methods, we study scattering by a single magnetic quantum dot and by a diffraction grating made of such dots. The spin-momentum locking produces strong differences with respect to the spin-diagonal coupling and leads to the scattering asymmetry with nonzero mean scattering angle as determined by only two parameters characterizing the system. These results can be applied for designing magnetic topological insulators-based nanostructures producing required distributions of charge and spin densities.

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