# Chiral Spin Mode on the Surface of a Topological Insulator

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In nonmagnetic materials where inversion symmetry is broken but time-reversal invariance is intact, strong spin-orbit coupling (SOC) may play the role of an effective magnetic field, which locks electron spins and momenta into textures. This phenomenon is encountered in 3D topological insulators (TIs), which harbor topologically protected surface states. An essential aspect of this physics is an interplay between the Coulomb interaction and SOC, which gives rise to a new type of collective spin excitations – chiral spin waves [1]. In the long wavelength limit, these modes are decoupled from the charge channel and thus are distinct from spin plasmons, Dirac plasmons, and surface plasmons in TIs.

We employ polarization-resolved resonant Raman spectroscopy to study collective spin excitations of the chiral surface states in $Bi_2Se_3$. To enhance the signal from the surface states, we tune the energy of incoming photons in resonance with a transition between two sets of chiral surface states: near the Fermi energy and about 1.8 eV above it. We observe a long-lived excitation at 150 meV in the pseudovector symmetry channel of the Raman spectra, which is most pronounced at low temperatures but persists up to room temperature. We identify this excitation as the transverse collective chiral spin mode supported by spin-polarized surface Dirac fermions. Such collective modes are “peeled off” from the continuum of particle-hole excitations by the exchange interaction [2].

The discovery represents a unique way of exploring the dynamical response of surface Dirac fermions in 3D TIs and their collective modes through optical measurements. The findings are essential for developing optoelectronic and magnonics devices making use of TIs.

Work was done in collaboration with H.-H. Kung, S. Maiti, X. Wang, S.-W. Cheong, and D.L. Maslov. Research at Rutgers was supported by NSF DMR-1709161.

**References**

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