MAR12-2011-001583

Abstract for an Invited Paper
for the MAR12 Meeting of
the American Physical Society

Current-driven spin dynamics in spin-orbit coupled superconductors[1]

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The study of the interplay between spin-orbit coupling (SOC) and superconductivity in two-dimensional electron gases (2DEG) has recently gained impetus following the discovery of i) 2DEGs in InAs or GaAs semiconductor heterostructures that are proximized by ordinary s-wave superconducting leads – a class of systems which plays a key role in the quest for Majorana fermions – and ii) 2DEGs that form at interfaces between complex oxides such as $LaAlO_3$ and $SrTiO_3$, which display tunable SOC and, under appropriate conditions, superconductivity. Motivated by this body of experimental and theoretical literature, we investigate the collective spin dynamics of an archetypical 2DEG model Hamiltonian with Rashba SOC in the presence of *repulsive* electron-electron (e-e) interactions. In the absence of superconductivity a Rashba 2DEG exhibits spin oscillations, which, at long wavelength and for weak repulsive interactions, have a frequency $\approx 2\alpha k_{\rm F}$, α being the strength of SOC and $k_{\rm F}$ the usual 2D Fermi wavenumber in the absence of SOC. These oscillations, however, are damped and quickly decay due to the emission of (double) electron-hole pairs, which, in the normal phase, are present at arbitrary low energies. In the presence of superconductivity, collective spin oscillations continue to exist in a wide range of parameters, because the Cooper pairs are mixtures of singlet and triplet components. Further, these excitations are undamped because they lie inside the superconducting gap where no other excitation exists. These spin oscillations can be excited by the application of a magnetic field or a supercurrent and can be used to realize persistent spin oscillators operating in the frequency range of 10 GHz – 1 THz.

Work supported by EU FP7 Programme Grant No. 215368-SEMISPINNET, No. 234970- NANOCTM and No. 248629-SOLID, and by NSF DMR-0705460.

[1]A. Agarwal, M. Polini, R. Fazio, and G. Vignale, Phys. Rev. Lett. **107**, 077004 (2011).