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Magnetoelectric effects in superconducting hybrid structures with spin-orbit materials and topological insulators

Spin-orbit interaction provides a coupling between the electron momentum and its spin. It opens a way to magnetoelectric effects. By now it is already realized that the surface (or edge) states of the topological insulator (TI) manifest a unique property of full spin-momentum locking. It leads to the fact that these materials sustain the strongest magnetoelectric effects, what makes them to be of great interest for spintronics applications. I will focus on the fundamental magnetoelectric effects – the Edelstein effect (or the direct magneto-electric effect) and the inverse Edelstein effect (or spin-galvanic effect) in superconducting heterostructures with TI and other spin-orbit coupled materials.

I will discuss two observable manifestations of the direct magnetoelectric effect (focusing on the heterostructures with TI): the generation of the electron spin polarization in response to the applied supercurrent and the giant magnetoelectric behavior of the DOS. The possibility to use it for nonmagnetic supercurrent controllable spin filtering will be discussed.

The inverse magnetoelectric effect in superconducting systems is especially interesting, because it can manifest itself as by the spontaneous current generation, so as by the helical superconducting phase generation and the anomalous phase shift in Josephson junctions under the applying of the exchange field or under the nonequilibrium quasiparticle injection. I will consider different hybrid structures, where all these possibilities can be realized.

References:

- [1] I. V. Bobkova, A. M. Bobkov, A. A. Zyuzin, and M. Alidoust, PRB 94, 134506 (2016).
- [2] I. V. Bobkova, A. M. Bobkov, PRB 95, 184518 (2017).
- [3] I. V. Bobkova and A. M. Bobkov, PRB 96, 224505 (2017).