Spin-orbit interaction in metal-insulator and magnetic phase transition with effective Hamiltonian approach, and thermoelectric radiation detector based on superconductor and ferromagnet

Subrata Chakraborty
Department of Physics and Nanoscience Center
University of Jyväskylä, P.O. Box 35 (YFL)
FI-40014, Jyväskylä, Finland
schrkmv@gmail.com

This talk would be split into two parts. In the first part, I will present semi-relativistic many-electron Hamiltonian, using the frequency specific Lorentz gauge. Then with a second-quantized many-electron Hamiltonian approach, we show that the spin-orbit interaction provides a mechanism for metal-insulator transition, which is distinct from the Mott-Hubbard (driven by the electron correlation) and the Anderson mechanism (driven by the disorder). Next, with the spin-only Hamiltonian, we demonstrate the spin-orbit interaction to be a reason for the materials to have antiferromagnetic response where the materials are characterized by a ferromagnetic isotropic spin-exchange energy. This is physically distinct from the Neél-Van Vleck-Anderson mechanism, which posits a antiferromagnetic Heisenberg isotropic exchange for the existence of the antiferromagnetic phase, and thus offers a new perspective on quantum magnetism and other analogous complex systems. Finally, we study the role of spin-orbit interaction in complex materials and show the absence of spontaneous magnetization in the systems with quenched spin-orbit interaction.

In the final part of this talk I will present our recent study on the use of a thermoelectric junction as a thermal radiation detector in the calorimetric regime, where single radiation bursts can be separated in time domain. We focus especially on the case of a large thermoelectric figure of merit, ZT, affecting significantly, for example, the relevant thermal time scales. This work is motivated by the use of hybrid superconductor/ferromagnet systems in creating an unprecedentedly high low-temperature ZT even exceeding unity. Besides constructing a very general noise model which takes into account cross correlations between charge and heat noise, we show how the detector signal can be efficiently multiplexed by the use of resonant LC circuits giving a fingerprint to each pixel. We show that for realistic detectors operating at temperatures around 100 to 200 mK, the energy resolution can be as low as 1 meV. This allows for a broadband single-photon resolution at photon frequencies of the order of or below 1 THz.

[1] S. Chakraborty and A. Vijay, *J. Chem. Phys.* **144**, 144107 (2016).
[2] S. Chakraborty and A. Vijay, *J. Magn. Magn. Mater.* **419**, 412 (2016).
[3] S. Chakraborty and A. Vijay, *J. Magn. Magn. Mater.* **432**, 519 (2017).
[4] S. Chakraborty and T. T. Heikkilä, *J. Appl. Phys.* **124,** 123902 (2018).