Proximity induced ferromagnetism and spin-orbit coupling in graphene

Jing Shi, Z.Y. Wang, C. Tang, B.W. Yang, and Y. Barlas

Department of Physics & Astronomy, University of California, Riverside, CA 92521
jing.shi@ucr.edu

Abstract A topological gap and the associated quantized anomalous Hall effect have been predicted for graphene in the presence of both exchange interaction and spin-orbit coupling. Although standalone graphene has no exchange interaction and negligibly week spin-orbit interaction, due to its open two-dimensional structure, graphene can acquire both interactions by proximity coupling to magnetic insulators or materials with strong spin-orbit interaction such as transition metal dichalcogenides. In this talk, I will present our experimental results on the proximity effects in two types of devices: graphene on yttrium iron garnet and WS_2 on graphene. In the former, graphene is coupled to a magnetic insulator which induces ferromagnetism as revealed by the anomalous Hall effect. The anomalous Hall conductivity reaches ~ 20% of the predicted quantized anomalous Hall conductivity $2e^2/h$. The induced exchange strength is as large as room temperature, but it varies from device to device. In the latter devices, graphene is coupled to layered WS_2 which imparts the spin-orbit interaction to graphene via hybridization. By directly comparing the magnetoresistance data in uncovered and WS_2-covered graphene devices, it is clear that WS_2-covered graphene acquires Rashba spin-orbit coupling. These results indicate that both exchange and spin-orbit interactions can be induced by proximity coupling with neighboring materials. Further tuning of the interaction strength may be possible.

References

[1] Z.Y. Wang, C. Tang, R. Sachs, Y. Balars, and Jing Shi, Phys. Rev. Lett. **114** (2015), 016603.

Figure 1: Anomalous Hall resistivity as a function of the applied magnetic field for different gate voltages in both electron and hole regions.