Michihisa Yamamoto

RIKEN Center for Emergent Matter Science, Wako 351-0198, Japan

michihisa.yamamoto@riken.jp

Spin-valleytronics in atomic layer materials

Two-dimensional layer materials have electrically tunable intrinsic properties. These properties allow us to control and connect varieties of quantum degrees of freedom including spin and valley. Graphene and transition metal dichalcogenide (TMD) atomic layers have two valleys, K and K'. Using the valley for information carrier is called valleytronics. One of advantages of TMD for valleytronics application is that the spin current can be generated through the valley contrasting intrinsic Hall conductivity and strong spin-orbit interaction in the valence band. On the other hand, graphene has the advantage of large valley relaxation length owing to the high crystal quality. In this talk,we report our recent progress for combing spintronics and valleytronics in 2D materials. In particular, we present our recent attempt to interconnect spin and valley in a graphene device [1].

It was theoretically established that a gapped layer anti-ferromagnetic state appears near the charge neutrality point of bilayer graphene owing to the spontaneous symmetry breaking induced by electron-electron interaction. In this gapped state, non-zero spin and valley contrasting Berry curvature leads to anomalous transport, where the valley current flows opposite direction between the layers hosting opposite spin [2]. We detect experimentally such anomalous transport using dual-gated bilayer graphene encapsulated by hexagonal-Boron Nitride and performing non-local resistance measurement. Since this anomalous transport naturally allows conversion between the valley current and the spin current, being combined with the valley Hall effect [3, 4], it may be used to generate electrically the spin current with high efficiency in bilayer graphene.

References

[1] M. Tanaka, et al., arXiv:1905.03166.
[2] F. Zhang et al., Phys. Rev. Lett. 106 (2011) 156801.
[3] M. Sui, et.al., Nat. Phys., 11 (2015) 1027.
[4] Y. Shimazaki, et.al., Nat. Phys., 11 (2015) 1032.