Soshun Ozaki
Masao Ogata
University of Tokyo, 7-3-1, Bunkyo, Japan

ozaki@hosi.phys.s.u-tokyo.ac.jp

Berry Curvature Contribution to Magnetization in a Honeycomb Lattice Model

In previous researches, it was pointed out that the Berry curvature appears in physical quantities such as anomalous Hall conductivity and orbital magnetism [1,2]. Actually, a few cases are known to show such an effect in models for concrete materials. Here we propose a honeycomb lattice model as a new example of such models, in which the Berry curvature contribution to the magnetic susceptibility is present. Furthermore, it is shown that the behavior of the magnetic susceptibility reflects the Z_2 topological number of the model, which changes by varying parameters.

First, we calculate the magnetic susceptibility of graphene with staggered on-site potential. A similar calculation has been carried out by Raoux et. al. [3] using a tight-binding model. However, the formula used does not give the contributions from the occupied states in the partially-filled band [4]. Here we use a new formula derived from the general Bloch Hamiltonian [5]. In the present model, non-zero Berry curvature appears at K and K' points. However, it does not contribute to the magnetic susceptibility because the integral of the Berry curvature over the whole Brillouin zone vanishes.

Next, we introduce spin-orbit interaction similarly to Kane and Mele [6] in the staggered on-site potential model. Spin-orbit interaction modifies the distribution of the Berry curvature in the momentum space. As a result, the integral of the Berry curvature over the whole Brillouin zone becomes nonzero in a certain parameter region, which leads to the Berry curvature contribution to the magnetic susceptibility. We describe the difference of the magnetic susceptibility in the two parameter regions and discuss the reason for such a difference.

References

[1] R. Karplus and J. M. Luttinger, Phys. Rev. **95**, 1154 (1954).
[2] D. Xiao, M. -C. Chang, and Q. Niu, et al., Rev. Mod. Phys. **82**, 1959 (2010).
[3] A. Raoux, F. Piéchon, J.-N. Fuchs, and G. Montambaux, Phys. Rev. B, **91**, 085120 (2015).
[4] M. Ogata and H. Fukuyama, J. Phys. Soc. Jpn. **84**, 124708 (2015).
[5] M. Ogata, J. Phys. Soc. Jpn. **85**, 104708 (2016).
[6] C. L. Kane and E. J. Mele, Phys. Rev. Lett. **95**, 146802 (2005).