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In-plane Magnetoelectric Response in Bilayer Graphene

A graphene bilayer shows an unusual magnetoelectric response whose magnitude is controlled by the valley-isospin density, making it possible to link magnetoelectric behavior to valleytronics (cf. Fig. 1) [1-3]. Complementary to previous study [2], we consider the effect of static homogeneous electric and magnetic fields that are oriented parallel to the bilayer's plane [4]. Starting from a tight-binding description and using quasi-degenerate perturbation theory, the low-energy Hamiltonian is derived including all relevant magnetoelectric terms whose prefactors are expressed in terms of tight-binding parameters. We confirm the existence of an expected axion-type pseudoscalar term, which turns out to have the same sign and about twice the magnitude of the previously obtained out-of-plane counterpart. Additionally, small anisotropic corrections to the magnetoelectric tensor are found that are fundamentally related to the skew interlayer hopping parameter γ_4. We discuss possible ways to identify magnetoelectric effects by distinctive features in the optical conductivity.

References

[1] U. Zülicke, R. Winkler, Phys. Rev. B **90**, 125412 (2014)
[2] R. Winkler,U. Zülicke, Phys. Rev. B **91**, 205312 (2015)
[3] U. Zülicke, R. Winkler, J. Phys. Conf. Ser. **864**, 012028 (2017)
[4] M. Kammermeier, P. Wenk, U. Zülicke, arXiv preprint, arXiv:1905.07093 (2018)

Figures

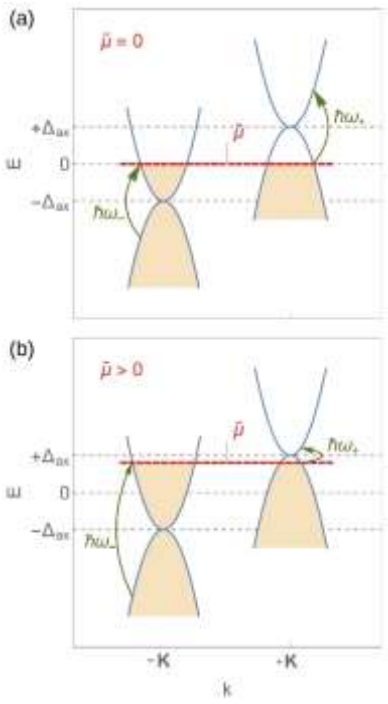

Figure 1: Valley-dependent optical absorption for different chemical potentials μ due to an axion-like energy shift Δ_{ax} as result of magnetoelectric coupling. The minimum transition frequencies ω are (a) identical for μ=0, (b) distinct for finite μ.