Magneto-optical Kerr effect in spin split two-dimensional massive Dirac materials

G. Catarina
N. M. R. Peres and J. Fernández-Rossier
International Iberian Nanotechnology Laboratory (INL), Av. Mestre José Veiga 4715-330, Braga, Portugal
goncalo.catarina8@gmail.com

Two-dimensional (2D) massive Dirac electrons possess a finite Berry curvature, with Chern number ±1/2, that entails both a quantized dc Hall response and a subgap full-quarter Kerr rotation [1]. The observation of these effects in 2D massive Dirac materials such as gapped graphene, hexagonal boron nitride or transition metal dichalcogenides (TMDs) is obscured by the fact that Dirac cones come in pairs with opposite sign Berry curvatures, leading to a vanishing Chern number. Here, we show that the presence of spin–orbit interactions, combined with an exchange spin splitting induced either by diluted magnetic impurities [2] or by proximity to a ferromagnetic insulator [3], gives origin to a net magneto-optical Kerr effect in such systems. We focus on the case of TMD monolayers and study the dependence of Kerr rotation on frequency (Fig. 1) and exchange spin splitting. The role of the substrate is included in the theory and found to critically affect the results. Our calculations indicate that state-of-the-art magneto-optical Kerr spectroscopy can detect a single magnetic impurity in diluted magnetic TMDs.

References

[1] W.-K. Tse and A. H. MacDonald, Phys. Rev. Lett., 105 (2010) 057401.
[2] Y. C. Cheng, Y. Z. Zhu, W. B. Mi, Z. B. Guo and U. Schwingenschlögl, Phys. Rev. B, 87 (2013) 100401.
[3] J. Qi, X. Li, Q. Niu and J. Feng, Phys. Rev. B, 92 (2015) 121403(R).

Figures

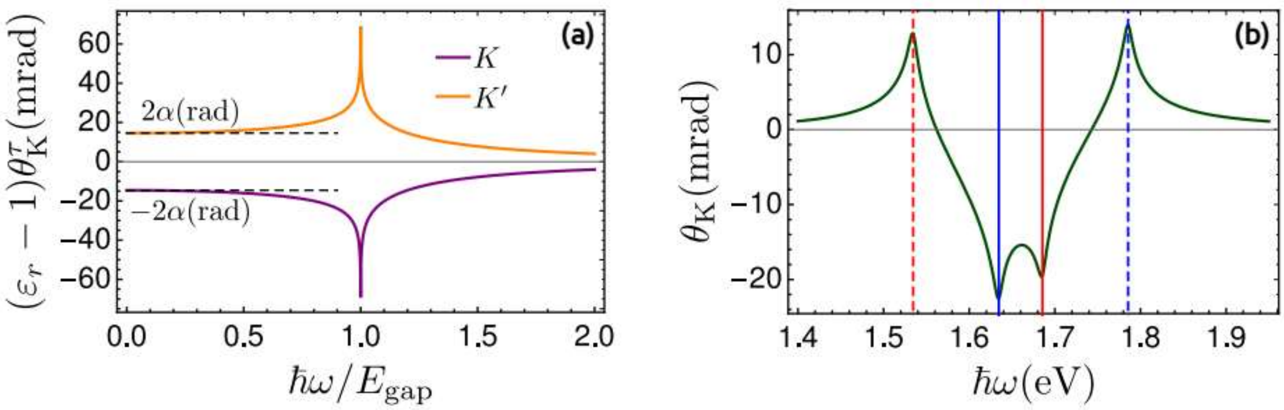

Figure 1: (a) Valley-resolved Kerr rotation θ_K^τ, as a function of the photon energy $\hbar\omega$, for a two-dimensional massive Dirac material, with gap E_{gap}, at charge neutrality and placed on top of a d i e l e c t r i c