Strong suppression of magnetic circular dichroism due to electron mass anisotropy in bismuth

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From magneto-reflectivity and magneto-optical Kerr angle spectra on a high-quality crystal of pure semimetallic bismuth in the far-infrared range we extract the optical conductivity for left- and right-handed circular polarizations [1,2]. The high spectral resolution allows us to separate the intraband Landau level transitions for Dirac-like electrons and parabolic-like holes for every value of magnetic field. Our main observation is that the hole transition exhibits 100% magnetic circular dichroism i.e. it appears only for one polarization as expected for a circular cyclotron orbit. However, the dichroism for electron transitions is reduced to only 13 ± 1%. This suppression is quantitatively explained by the large anisotropy (~ 200) of the effective mass in the electron pockets of the Fermi surface. From a general perspective, one can regard this effect a signature of the mismatch between the metric experienced by the photons and the electrons. Apart from being a contactless measurement of the effective mass anisotropy, it suggests a novel direction towards valley polarized magneto-optical pumping with elliptically polarized light.

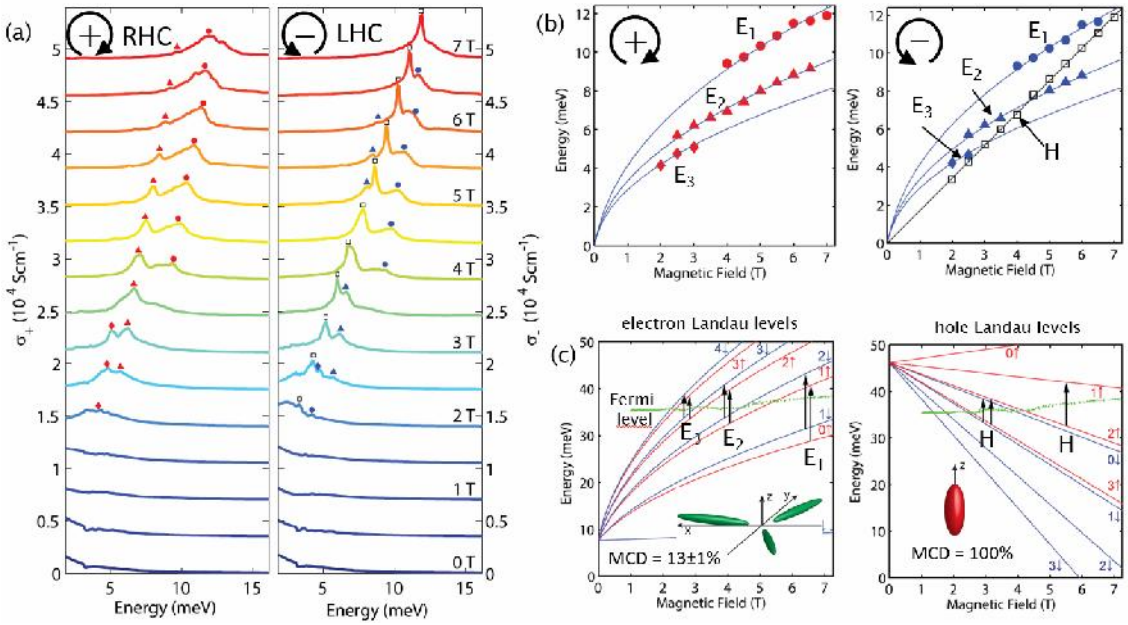

Figure. (a) Measured magneto-optical conductivity for right (RHC) and left (LHC) circularly polarized light from the (111) cleaved surface of Bi. (b) Measured energies of the Landau level transitions as a function of magnetic field for RHC and LHC polarizations. Different symbols in (a) and (b) mark experimental points of different series of transitions. Note that while the hole transitions are only present in LHC, the electron transitions are seen in both polarizations resulting in a strongly reduced MCD. The lines represent the theoretical field dependence for holes and electrons. (c) Energies of the Landau levels for electrons and holes as a function of magnetic field.

References

[1] J. Levallois *et al.* 2015 *Rev. Sci. Instrum.* Vol, **86,** p.033906.
[2] P.J. de Visser, J. Levallois, *et al.* 2016 *Phys. Rev. Lett.* Vol, **117,** p. 017402.