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Valley polarization in bismuth

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The electronic structure of certain crystal lattices can contain multiple degenerate *valleys* for their charge carriers to occupy. The principal challenge in the development of *valleytronics* is to lift the valley degeneracy of charge carriers in a controlled way. In bulk semi-metallic bismuth, the Fermi surface includes three cigar-shaped electron valleys lying almost perpendicular to the high symmetry axis known as the trigonal axis. The in-plane mass anisotropy of each valley exceeds 200 as a consequence of Dirac dispersion, which drastically reduces the effective mass along two out of the three orientations. According to our recent study of angle-dependent magnetoresistance in bismuth [1], a flow of Dirac electrons along the trigonal axis is extremely sensitive to the orientation of in-plane magnetic field. Thus, a rotatable magnetic field can be used as a valley valve to tune the contribution of each valley to the total conductivity. As a consequence of a unique combination of high mobility and extreme mass anisotropy in bismuth, the effect is visible even at room temperature in a magnetic field of 1 T. Thus, a modest magnetic field can be used as a valley valve in bismuth. The results of our recent investigation of angle-dependent magnetoresistance in other semi-metals and doped semiconductors suggest that a rotating magnetic field can behave as a valley valve in a multi-valley system with sizeable mass anisotropy.

[1] Zengwei Zhu, Aurélie Collaudin, Benoît Fauqué, Woun Kang and Kamran Behnia Nature Physics 8, 89-94 (2011)