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Valleytronics and Nematicity in bulk bismuth

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In bismuth, a low-carrier-density and high-mobility semi-metal, the three rotationally equivalent electron pockets (valleys) have a Dirac-like dispersion and can be confined to their lowest Landau level with a relatively small magnetic field. A magnetic field rotating in the binary-bisectrix plays the role of a valley valve tuning the contribution of each valley to the total conductivity along trigonal axis [1]. An extensive study of angle-dependent transverse magnetoresistance quantifies the mobility tensor of both electrons and holes [2]. The temperature dependence of mobility indicates that inelastic resistivity is dominated by carrier-carrier scattering. The C3 symmetry of the underlying lattice is suddenly lost at low temperature and high magnetic field [1, 2]. This may be caused by a valley-nematic phase transition [3] driven by the large anisotropy in the effective mass of electrons. By extending the measurements to still higher magnetic fields (far beyond the quantum limit), we found that one (when the field is oriented along the bisectrix axis) or two (when it is along the binary axis) valleys become totally empty. Drying up a Fermi sea leads to a dramatic enhancement in electric conductance. We attribute this enhancement to transfer of carriers between valleys with highly anisotropic mobilites. The non-interacting picture can explain most of the data. However, Coulomb interaction may play a role in shaping the fine details [4]. 1. Z. Zhu et al. Nature Phys 8, 89 (2012) 2. A. Collaudin et al. Phys. Rev. X 5, 021022 (2015) 3. D. A. Abanin et al. , Phys. Rev. B 82, 035428 (2010) 4. Z. Zhu et al. arXiv:1608.06199 (2016)