Large effective Landé factor in hole-doped WSe_2 monolayers probed by high field magneto-transport

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We present magneto-transport measurements in WSe_2 monolayers under pulsed magnetic field up to 58 T. WSe_2 monolayers were exfoliated and deposited on h-BN flakes and contacted with platinum electrodes. The samples behave as hole field-effect transistors when back-gated with a negative voltage, which allows us to study the valence band electronic properties. In monolayers, the valence band is made of two valleys at points K and K' of the first Brillouin zone, with spin-valley locking due to strong spin orbit coupling (SOC) and the lack of inversion symmetry. Under high magnetic field, the energy gap between Landau levels is set by the cyclotron energy Ec, while the Zeeman energy $Ez = g^* \mu_B B$ causes the spin/valley splitting of the Landau levels. The effective Landé factor g^* takes unexpectedly large values for valence holes in WSe_2. Indeed, the Zeeman energy stems from magnetic coupling to the hole spin, valley-dependent Berry curvature and SOC, which add. We measured complex quantum oscillations of the magneto-resistance, with irregular energy gaps between up and down spin Landau levels arising from giant (and non-integer) Ez/Ec ratio. To gain further insight, experimental data for different hole concentrations were compared to numerical simulations using the Gaussian model for conductivity. When the carrier density is reduced, the quantum oscillation pattern evolves progressively, reflecting an enhancement of e-e interactions.

References

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Figures

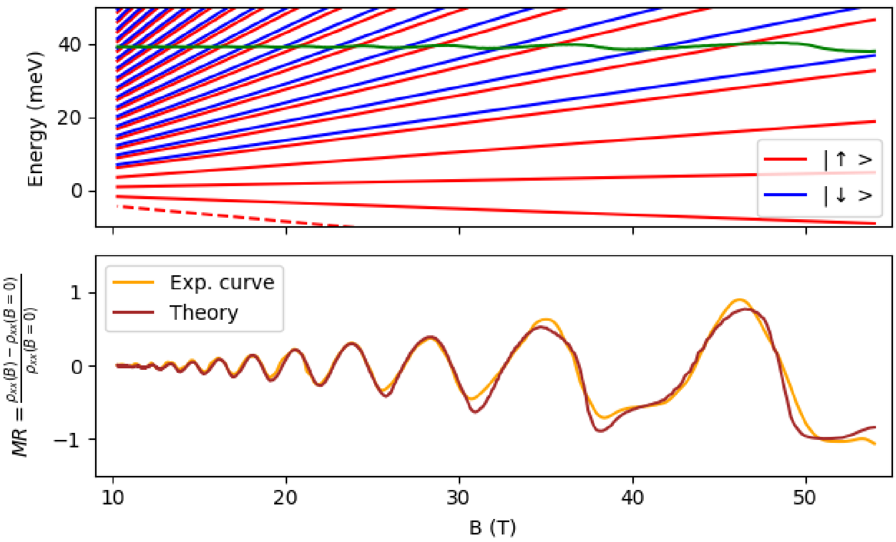

Figure 1: Top panel: Landau levels with spin up (red lines) and down (blue lines) and computed Fermi energy (green line) of a WSe_2 monolayer. Bottom panel: high field magneto-resistance of a WSe_2 monolayer at 4.2 K and Vg = -110V. The complex oscillation pattern is reproduced using the Gaussian model for conductivity, with fitting parameters Ez/Ec = 3.30 and $n = 7.35 \times 10^{12}$ cm^{-2}.