Zeeman Splitting and Valley Populations of High Mobility Holes in WSe_2

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Introduction

Layered semiconducting transition metal dichalcogenides such as MoS_2 and WSe_2 represent an interesting platform for studying phenomena associated with electron-electron interactions thanks to their large effective mass carriers and strong spin-orbit coupling. We have previously demonstrated the quantum Hall effect in hole-doped mono- and bilayer WSe_2, thanks to the ease of injecting holes using Pt contacts [1].

Experimental

In the past year, we further explored magnetotransport in dual-gated *h*-BN encapsulated mono-, bi-, and trilayer WSe_2 samples [**Fig. 1(a)**]. Magnetotransport measurements in magnetic fields up to B = 35 T and temperatures down to T = 0.3 K were conducted using the Cell 12 resistive magnet at NHMFL in Tallahassee, FL.

Results and Discussion

We uncovered an interesting density-dependent quantum Hall states (QHS) sequence in mono- and bilayer WSe_2, which transitions between predominantly even and odd filling factors as the hole-density (p) is varied [2]. The QHS transitions are due to a density-dependent g-factor which is enhanced over the band g-factor (g_b) as p is reduced. **Figure 1(b)** shows the monolayer WSe_2 effective g-factor (g^*) as a function of the inter-particle distance measured in effective Bohr radius (r_s). Furthermore, we also probed the valley populations of holes in trilayer WSe_2. **Figure 1(c)** shows the longitudinal (R_{xx}), and Hall (R_{xy}) resistance vs B and the R_{xx} Fourier transform (FT) in trilayer WSe_2, which show a beating pattern in the Shubnikov-de Haas (SdH) oscillations and two corresponding FT peaks, indicative of holes populating two subbands, associated with the K and Γ valleys [3].

Conclusions

We studied magnetotransport in mono- and bilayer WSe_2 where we observed electron-electron interaction enhanced Zeeman splitting, and in trilayer WSe_2 where we observed tunable Γ-K valley hole populations.

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References

[1] Fallahazad, B., *et al.*, Phys. Rev. Lett. **116**, 086601 (2016).
[2] Movva, H. C. P., *et al.*, Phys. Rev. Lett. **118**, 247701 (2017).
[3] Movva, H. C. P., *et al.*, Submitted.

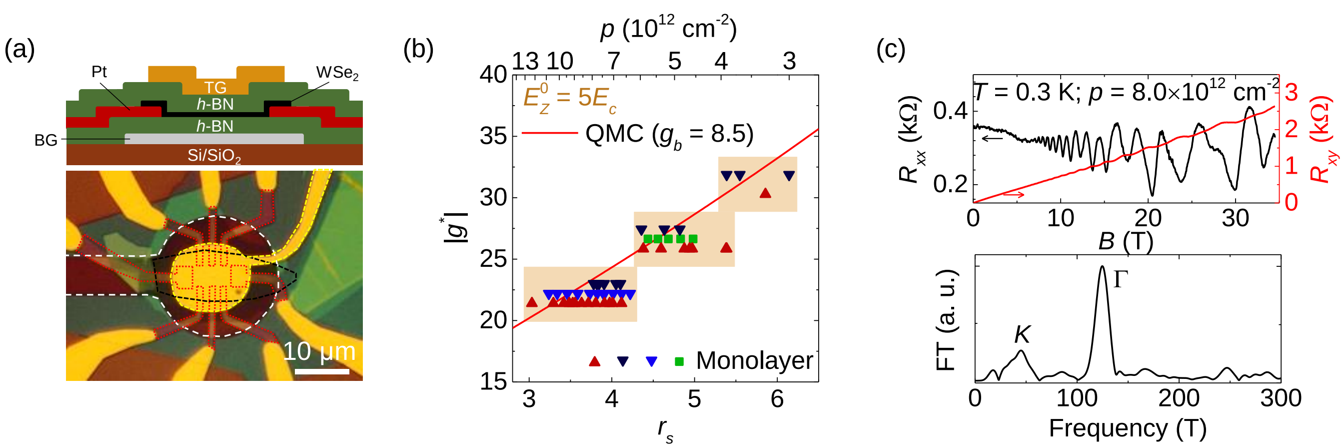

Fig.1 (a) Schematic cross section (top) and optical micrograph (bottom) of an *h*-BN encapsulated WSe_2 Hall bar sample. (b) Monolayer WSe_2 $|g^*|$ vs r_s (bottom axis) or p (top axis) extracted from four samples (symbols), along with quantum Monte Carlo (QMC) calculation (solid line) using g_b = 8.5. The shaded regions represent the error bars. The symbols within a group are vertically offset for clarity. (c) Trilayer WSe_2 R_{xx} and R_{xy} vs B (top) at $p = 8.0\times10^{12}$ cm^{-2} and T = 0.3 K show a beating pattern of the SdH oscillations, indicative of hole population in multiple subbands. The FT spectrum (bottom) shows two principal peaks which originate from holes populating the K and Γ valleys of the valence band.