Spontaneous "valley magnetization" in an atomically-thin semiconductor

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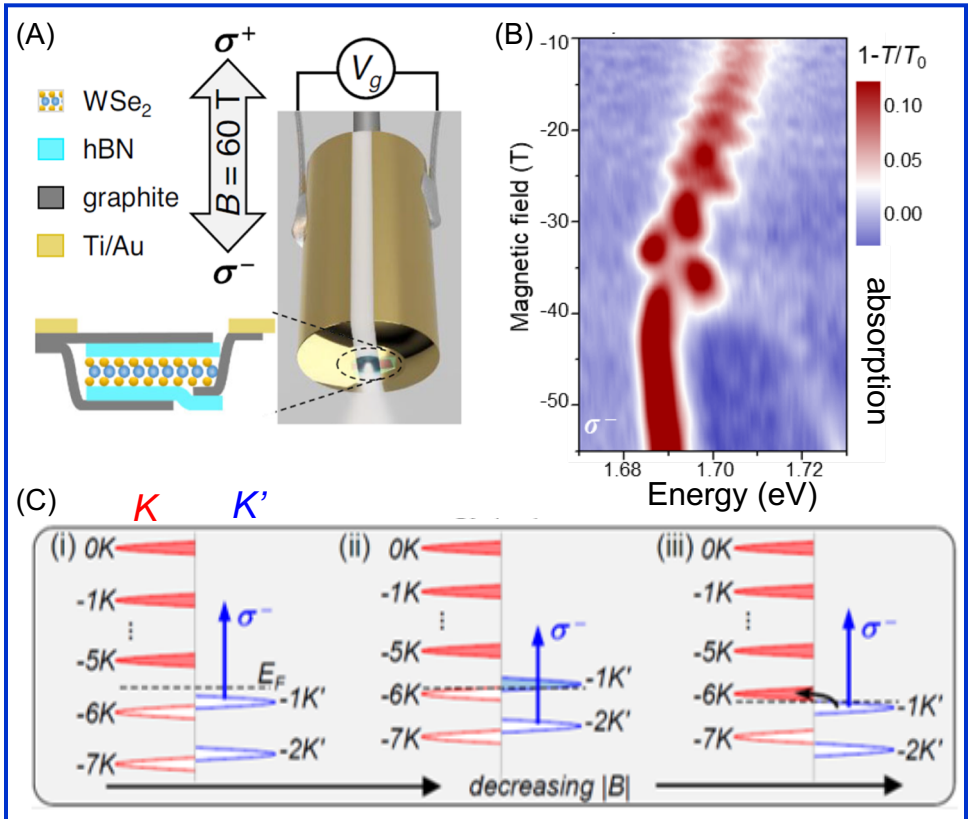
Electron-electron (*e-e*) interactions underpin many interesting phenomena in 2D layers of mobile charges, including the fractional quantum Hall effect, spin textures (like skyrmions), and quantum Hall ferromagnetism. These phenomena arise from Coulomb repulsion between charges, which in turn typically enhances the susceptibility of spin and related "pseudospin" degrees of freedom (like valley degrees of freedom). The e-e interactions can even cause instabilities and spontaneous transitions to broken-symmetry phases.

These studies show that, *in the new family of atomically-thin semiconductors such as WSe_2, e-e interactions can indeed drive instabilities wherein all the charge carriers spontaneously occupy the same "valley pseudospin" state.* In this user experiment, *a dual-gated WSe_2 monolayer was directly assembled over the core of a single-mode optical fiber, enabling circularly-polarized absorption spectroscopy in pulsed fields to 60T.* At certain carrier (hole) densities, Landau levels (LLs) in the *K* and *K'* valleys were brought into near-alignment, at which point discontinuities in the absorption spectra revealed the field-dependent filling and discontinuous emptying of LLs in *K'* valley, indicating spontaneous valley polarization.

This work broadens the scope for future studies in atomically-thin materials in general - and valleytronics in particular - by using carrier density-dependent valley Zeeman energy to create strongly interacting electron systems.



(A) The WSe_2 monolayer-on-fiber assembly used for optical absorption studies in 60T pulsed magnetic fields. (B) Discrete jumps in the absorption of circularly-polarized light as a function of magnetic field indicate filling and spontaneous emptying of Landau levels in the *K'* valley for a hole density of 5.55×10^{12} cm^{-2}. (C) Schematic depicting the filling of the 1K' LL, and its spontaneous emptying due to electron-electron interactions as |B| decreases.

Facilities used: 65 T pulsed magnet in the Pulsed Field Facility.

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