Long-lived Spin Relaxation and Spin Coherence of Electrons in Monolayer MoS$_2$

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Monolayer MoS$_2$ and related transition metal dichalcogenides (TMDs) are direct-gap semiconductors in which strong spin-orbit coupling and a lack of structural inversion symmetry give rise to new coupled spin-valley physics. Although robust spin and valley degrees of freedom have been inferred from polarized photoluminescence (PL) studies of excitons, PL timescales are necessarily constrained by short (3–100 ps) electron-hole recombination. Direct probes of spin/valley dynamics of resident carriers in electron (or hole)-doped TMDs, which may persist long after recombination ceases, are still at an early stage. Here we directly measure the coupled spin-valley dynamics of resident electrons in $n$-type monolayer MoS$_2$ using optical Kerr-rotation spectroscopy [1], and reveal very long spin lifetimes exceeding 3ns at 5K (orders of magnitude longer than typical exciton lifetimes). In contrast with conventional III-V or II-VI semiconductors, spin relaxation accelerates rapidly in small transverse magnetic fields. This suggests a novel mechanism of electron spin dephasing in monolayer TMDs, driven by rapidly-fluctuating internal spin-orbit fields due to fast intervalley scattering. Additionally, a small but very long-lived oscillatory signal is observed, indicating spin coherence of localized states [2]. These studies provide direct insight into the physics underpinning the spin and valley dynamics of electrons in monolayer TMDs. [1] L. Yang et al., Nature Physics 11, 830 (2015). [2] L. Yang et al., submitted.

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