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# Room-temperature nanosecond spin relaxation in CVD Weyl semimetals

The Weyl semimetal[1,2] $WTe_2$ and $MoTe_2$ are promising to generate large charge-to-spin current conversion as they possess topologically-protected spin-polarized states[3,4] and can carry the tremendous current density[5]. Further, the intrinsic noncentrosymmetry of $WTe_2$ and $MoTe_2$ induces a unique property of crystal symmetry-controlled spin-orbit torques.[6] An important question to be answered for developing spintronic devices is how spins relax in $WTe_2$ and $MoTe_2$. Here, we observe an extremely long spin lifetime (1.2 ns) as shown in Fig. 1(a) at room-temperature in chemical vapor deposition (CVD)-grown $WTe_2$ and $MoTe_2$ thin films using time-resolved Kerr rotation (TRKR) spectroscopy, which is three orders of magnitude longer than GaAs and $Bi_2Se_3$ (a 3D topological insulator). Supported by transient reflectivity spectroscopy and ab initio calculation, we identify a mechanism of long-lived spin polarization resulting from a slow phonon-assisted recombination of electron-hole pairs, and suppression of backscattering required by time-reversal and lattice symmetry operation. Schematic diagram of such a mechanism is shown in Fig. 1(b). In addition, we find the spin polarization is firmly pinned along the strong internal out-of-plane magnetic field (~346 T) induced by the large spin splitting (~40 meV). Our work provides an insight into the physical origin of long-lived spin polarization in Weyl semimetals which could be used to transport spins in a long distance or manipulate spins for a long time at room temperature.

## References

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## Figures

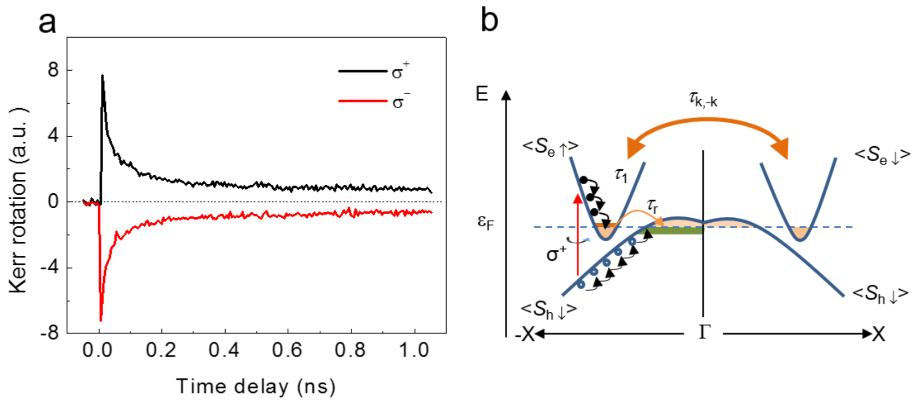


**Figure 1:** Room-temperature long-lived spin lifetime in few-layer Weyl semimetals $WTe_2$. a, TRKR traces under excitation of $\sigma^+$ and $\sigma^-$ pump. The Kerr rotation changes the sign when the helicity of pump pulse is reversed, indicating the Kerr rotation arises from optically induced spin polarization. b, Schematic diagram of WTe2 band structure along Γ-X. The momentum separation between the bottom of the conduction band and the top of the valence band obstructs the recombination of electron-hole pairs. Furthermore, the back-scattering between $k_x$ to $-k_x$ is forbidden due to time-reversal symmetry and lattice symmetry (σzx and $c_{2z}$) operation. The horizontal dashed line shows the position of the Fermi level (εF). <Se▯> and <Se▯> denote spin-up and spin-down polarization of electrons, respectively, while <$S_{h▯}$> and <$S_{h▯}$> label spin-up and spin-down polarization of holes, respectively.