2D spin systems under femtosecond pulsed laser

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The discovery of two-dimensional (2D) spin materials opens the door for fundamental physics and next-generation spintronics. Here, we report our studies of the manipulation of the spin ordering in 2D spin systems, focusing on ultrafast spin dynamics under the excitation of the femtosecond pulsed lasers. We have established a spin dynamics research platform with fs time-and-spin resolved ARPES system along with Tr-MOKE. The platform is also integrated with MBE, sputtering and PLD for in-situ sample growth. We found that the magnetization and the magnetic anisotropy energy (MAE) of few-layered Fe3GeTe2 (FGT) is strongly modulated by a femtosecond laser pulse [1]. Upon increasing the femtosecond laser excitation intensity, the saturation magnetization increases in an approximately linear way and the coercivity determined by the MAE decreases monotonically, showing unambiguously the effect of the laser pulse on magnetic ordering. This effect observed at room temperature reveals the emergence of light-driven room-temperature ferromagnetism in 2D vdW FGT, as its intrinsic Curie temperature TC is ∼200 K. The light-tunable ferromagnetism is attributed to the changes in the electronic structure due to the optical doping effect occurred within a time scale of 50fs. With time- and angle-resolved ARPES, we have studied experimentally the transient band structure of 2H-MoTe2 at K valley along the K-Γ direction under the excitation of femtosecond laser pulses [2]. We have, for the first time, distinguished the spin splitting valence bands in time domain and determined the temporal evolution characteristics of bandwidth, bandshift and photoexcited electrons in 2H-MoTe2. The electron-hole recombination of the VB2 has been found to be distinct from that of the VB1.The VB1 recombination time is consistent to the recombination behavior of typical indirect semiconductor, while the VB2 recombination time matches the relaxation time of CB extreme at K point. Distinguishing the dynamics of spin splitting bands is crucial to promoting the incorporation of TMDCs into optoelectronic and spintronics devices.

[1] B. Liu, Y. B. Xu, et al, Phys. Rev. Lett. **125**, 267205 (2020).
[2] J. H. Lu, Y.B. Xu, et al, Phys. Rev. B. 2025 (in press).