Study the valley polarization in monolayer WSe$_2$ by polarization-resolved photoluminescence spectroscopy

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Atomically-thin transition metal dichalcogenides (TMDs) such as MoS$_2$ and WSe$_2$ have attracted much attention as novel 2D semiconductors with remarkable physical properties and applications[1-4]. The monolayers of the TMDs are non-centrosymmetric materials with a direct band-gap located at the energy-degenerate K and K’ valleys in momentum space. The structural inversion asymmetry in the 1L(mono-layer)-TMDs gives rise to coupling of electron spin and valley degree of freedom; this characteristic enables valley-selective optical excitation using circular-polarized incident photons [1]. Therefore, the 1L-TMDs are promising materials for “Valleytronics”, future optoelectronics technology using valley degree of freedom of electrons.

Here we study temperature dependence of polarized photoluminescence (PL) in 1L-WSe$_2$ [2] to understand spin-valley relaxation mechanism between the degenerate K and K’ valleys. In the experiment, circular polarization of the incident photons was set to be $\sigma^+$ polarization (corresponding to selective excitation of K’ valley), and $\sigma^+$ and $\sigma^-$ components of the PL signals were separately detected. Figure 1 shows the polarization-resolved PL spectra at 15 K and the peaks of exciton, trion1, and trion2 are labeled respectively. The PL intensity of the $\sigma^+$ emission is larger than that of $\sigma^-$ emission under the $\sigma^+$ excitation condition, suggesting spin-valley polarization in 1L-WSe$_2$ at 15 K. Temperature dependence of the observed valley polarization and its mechanism will be discussed.