Identification and manipulation of valley coherence in monolayer WSe_2

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1. Introduction

The monolayer transition metal dichalcogenide (TMDs) are granted with valley degree of freedom due to broken inversion symmetry, and strong spin-orbit coupling. The degenerated states at band-edges of K(K') valley possess information of valley pseudospin, which experiences intervalley decoherence process during emission [1]. With valley decoherence not coupling to any radiative dipole, direct probing or manipulation of valley coherence in the time domain has remain a challenge. Here we propose a method of optically exploring the valley coherence time in the time-domain measurement.

2. Results

We have developed a method of direct measuring valley coherence time of the free exciton in monolayer WSe_2. By employing polarized interferometer, the decoherence process between K and K' valley excitons under various temperature and excitation power are directly measured. **Figure 1(a)** shows the typical interferogram arising from valley coherence. The exacted valley coherence times from the interferogram are plotted in **Figure 1(b)**. It can be seen that the values of valley coherence time remain stable under temperature from 4 to 30 K, which is consistent with the previous result [2]. Moreover, the valley coherence time gradually decreases due to increased exciton-exciton collision with increasing excitation power condition. We also explored the valley coherence of monolayer (1L) WSe_2 device with changing carrier density in the spectral and time domain. A wide tuning range of degree of linear polarization (DOLP) is observed, with the values ranging from nearly 0% under heavily positive doping, to 50% under heavily negative doping conditions. The measured valley coherence time shows the similar trend as the DOLP, which will be further discussed in detail.

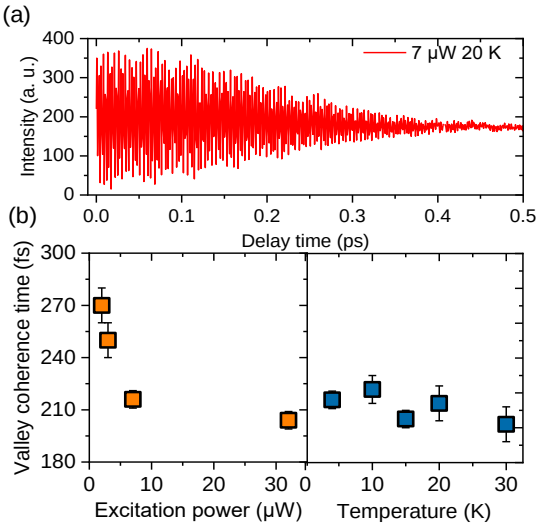

Figure 1 (a) Interferogram of intervalley decoherence process of free exciton in 1L-WSe_2 under 7 μW and 20 K. **(b)** Extracted valley coherence time of free exciton in 1L-WSe_2 under various temperature and excitation power

3. Conclusions

A new direct method of exciton valley coherence has been applied to 1L-WSe_2 in the time-domain. The detail of intervalley decoherence process is explored under various temperature, excitation power and carrier doping condition, which will facilitate further understanding of valleytronics in 1L-TMDs.

References

[1] A. Jones, et al. *Nat. Nanotech* **8**, 634–638 (2013).
[2] K. Hao, et al. *Nat. Phys* **12**, 677–682 (2016).