Valley-Selective Photon-Dressed States in Monolayer Transition Metal Dichalcogenides

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When electronic excitations in a semiconductor interact with light, hybrid light-matter dressed states are formed. This dressed state description spans the regeims of weak coupling to strong interactions with bosonic exciton-polaritons. In monolayer transition metal dichalcogenides, a class of 2D direct bandgap semiconductors, optical excitations selectively populate distinct momentum valleys with correlated spin projection. The combination of this spin-valley locking with photon dressed states can lead to new optical phenomena in these materials. We present spectroscopic measurements of these valley-specific dressed states in monolayer 2D materials in distinct regimes [1, 2].

When a monolayer is embedded in a dielectric microcavity, strong coupling exciton-polaritons are achieved which preserve the valley degree of freedom in monolayers. The cavity-modified dynamics of these valley-sensitive hybrid light-matter quasiparticles is determined by the relative rates of exciton relaxation and intervalley scattering, which can be highly modified in on-resonant cavities, even persisting to room temperature due to the interaction with the microcavity photons [1]. We also show that distinct regimes of valley-polarized exciton-polaritons can be accessed with microcavity engineering by tuning system parameters such as cavity decay rate and exciton-photon coupling strength. Exploring a distinct regime of valley-sensitive dressed states, we show that polarization-sensitive ultrafast Kerr rotation spectroscopy can enable sensitive measurements of the valley optical Stark shift, a light-induced dressed state energy shift, in monolayer semiconductors such as WSe_2 and MoS_2 [2]. These findings across regimes of light-matter coupling demonstrate distinct approaches to manipulating the dynamics of valley-sensitive dressed states in monolayer semiconductors.

References

[1] Y.-J. Chen, T. K. Stanev, J. D. Cain, V. P. Dravid, and N. P. Stern. Authors, Nature Photonics, 11 (2017) 431.

[2] T. LaMountain, H. Bergeron, I. Balla, T. K. Stanev, M. C. Hersam, and N. P. Stern, Physical Review B, 97 (2018) 045307.

Figures

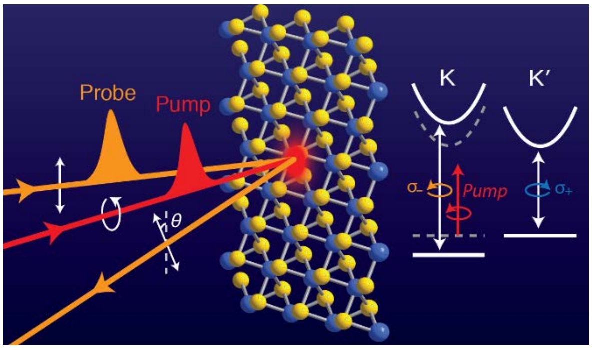

Figure 1: Schematic of pump-probe Kerr rotation spectroscopy for measuring valley-sensitive Stark shift of excitons in a monolayer transition metal dichalcogenide.