GDR HOWDI 2022 MEETING: QUANTUM OPTICS WITH VAN DER WAALS HETEROSTRUCTURES

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Van-der-Waals materials have attracted a significant attention over the past decade, owing to their interesting optical and electronic properties as well as the versatility of combining different materials into heterostructures exhibiting emergent phenomena. In this tutorial, I will focus on the optical properties of one specific class of van-der-Waals materials: Transition Metal Dichalcogenides (TMD). In the monolayer limit TMDs are semiconductors that exhibit a direct band gap which renders them ideal for optical studies [1]. Due to their almost perfect 2D nature, the low screening of Coulomb interactions leads to the observation of tightly bound excitons, which are strongly coupled to the optical fields. Furthermore, TMD monolayers can easily be doped with electrons or holes by electrical gating [2]. I will discuss optical spectroscopy techniques which allow us to use this versatile platform to study a wide variety of phenomena, ranging from the physics of correlated electrons to interacting excitons. By embedding a TMD monolayer into an optical cavity, we can exploit the strong light matter interactions to observe exciton polaritons: new quasi-particles which are part light (photon), part matter (exciton). This allows us to create large populations of polaritons using a strong pump laser pulse. Using a subsequent weak probe laser pulse we can probe polariton interactions which are governed by their exciton character [3]. Finally, I will lay out how we can use electric field modulations to create quantum confinement for excitons in a TMD monolayer.

References

[1] K. F. Mak, C. Lee, J. Hone, J. Shan, and T. F. Heinz, *Phys. Rev. Lett.*, 105 (2010), pp 136805.

[2] M. Sidler, P. Back, O. Cotleţ, A. Srivastava, T. Fink, M. Kroner, E. Demler and A. Imamoglu, *Nature Physics*, 13 (2016), pp. 255-2 61.

[3] L. B. Tan, O. Cotlet, A. G. Bergschneider, R. Schmidt, P. Back, Y. Shimazaki, M. Kroner and A. Imamoglu *Physical Review X*, 10 (2020), pp. 021011.

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