JOHANNES KEPLER
UNIVERSITÄT LINZ

PHYSIKKOLLOQUIUM
Fachbereich für Physik

Im Rahmen des Physikkolloquiums spricht

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über

Controlling the Strong Light-Matter Interaction

Hybrid light-matter states – polaritons – have attracted considerable scientific interest recently within both physics and chemistry communities. Plenty of nanoscale systems which possess strong coupling dynamics are of high interest due to their remarkable ability of strongly coupled systems to manipulate and interact with light. However, not only the optical response of strongly coupled systems is altered, but also their material properties are modified under the strong coupling regime, e.g., chemical reactivity [1-4] and charge transport [5]. In this talk, I will discuss how such strongly coupled systems can be controlled actively in different platforms.

The first part of my talk will be focused on electrically tunable charged exciton-plasmon polaritons in a hybrid tungsten disulfide monolayer-plasmonic nanoantenna system [6]. In this work, we show that the electrical gating of monolayer WS_2 allows tuning the oscillator strengths of neutral and charged excitons not only at cryogenic, but also at room temperature, both under vacuum and atmospheric pressure. Such electrical control enables a full-range tunable switching from strong neutral exciton-plasmon coupling to strong charged exciton-plasmon coupling. Our experimental findings allow discussing beneficial and limiting factors of charged exciton-plasmon polaritons and offer routes towards the realization of charged polaritonic devices at ambient conditions.

I will also present our recent work on tunable self-assembled Casimir microcavities and their implementation on polaritons [7]. Here we use the combined Casimir and electrostatic interactions in gold nanoflake colloid systems as a means to realize self-assembled and tunable microcavities in aqueous solution and at room temperature. This system forms a self-assembled optical Fabry–Pérot microcavity with a fundamental mode in the visible range (long-range separation distance about 100–200 nanometres) and a tunable equilibrium configuration. Furthermore, by placing an excitonic material in the microcavity region, we realize hybrid light-matter states (polaritons), whose properties, such as coupling strength and eigenstate composition, can be controlled in real-time by the concentration of ligand molecules in the solution and light pressure. These Casimir microcavities could find future use as sensitive and tunable platforms for a variety of applications, including optomechanics, nanomachinery, and cavity-induced polaritonic chemistry.

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[2] Galego *et al*, Nat. Comm. **7** (2016) 13841
[3] Orgiu *et al*, Nat. Mater. **14** (2015) 1123
[4] Munkhbat *et al*, Sci. Adv **4** (2018) 7, eaas9552
[5] Herrera *et al*, Phys. Rev. Lett. **116** (2015) 238301
[6] Munkhbat *et al*, ACS Nano **14** (2020) 1196
[7] Munkhbat *et al*, Nature **597**, (2021) 7875

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