Enhancement Due to Photonic Coupling in Nanocavity Structures

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Abstract

Plasmon-exciton coupling in photonic nanostructures provides insight into quantum emitters' optical properties and how they can be manipulated via alterations to their electromagnetic environment. The interaction between this environment and any two-level system can result in the spontaneous emission of photons from the emitter. Our goal is to shorten the lifetime of exciton emission via plasmonic nanostructures. Such an alteration depends on the interplay between a photonic cavity focusing the emission fields into a mode volume, and the system. Photon emissions into the cavity are enhanced before their release into free space, the consequence is the potential to enhance previously weak fields and learn more about the material possessing the relevant nanostructure — in our case, (Transition Metal Dichalcogenides) TMD layers with nanocubes.

The premise of this series of experiments is to examine different TMD samples for the effects of weak coupling between plasmonic nanocavities and excitons. We obtain two sets of measurements, one from dark-field spectroscopy and another from a Photoluminescence (PL) setup. Upon imaging the sample using dark field spectroscopy, we can focus on the white light scattering by the nanocavities and consequently measure plasmonic resonances. PL selectively excites the sample at specific wavelengths that make it possible to measure the exciton resonances. With these measurements, we can determine whether an overlap between the plasmonic resonances and exciton excitation exists. A correlation between these resonances would provide evidence for the coupling as it facilitates enhancement.

In this talk, we discuss the findings from the calibration sample — a monolayer TMD resting on gold foil while the cavity and nanocubes lie atop the TMD respectively. After reviewing the setup and inconsistencies within the calibration sample, we then proceed to the results from the subsequent trilayer TMD sample, which contains a lower nanocube density, and compare them to the calibration and ideal case. We aim to see that the enhanced resonances are those with the same polarizations and spectral resonances as the plasmonic resonances. Additionally, we cover factors relevant to where the plasmonic resonances occur as well as factors allowing us to describe the coupling behavior.

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