Optical Interaction of the NV^- Centre in Diamond with a Plasmonic Metal Nanoparticle

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The negatively charged nitrogen-vacancy (NV) centre in diamond is one of the most photostable and versatile quantum emitters known to date. It can operate in a wide set of conditions ranging from room temperature to cryogenic environments. It is rapidly becoming a predominant building block and shifting the paradigms of a myriad of quantum technologies such as quantum computing, magnetometry, electrometry, thermometry, piezometry, lasing, biosensing, and medical imaging. An increasing number of companies around the globe (such as Quantum Brilliance, NVision, and QDTI) are already venturing into NV-based diamond quantum technologies.

To the best of our knowledge, all NV-based diamond quantum technologies rely on the optical excitation and readout of the NV centres. Plasmonic metal nanoparticles (MNPs) such as gold and silver possess the ability to localize and modulate optical fields at the nanoscale, providing a robust handle to optically control an NV centre. Despite such promising prospects and intense interest in the NV centre, a rigorous theoretical explanation of NV-plasmon interaction has been long overdue in the literature.

We have developed a rigorous foundational theoretical model [1] for the optical interaction between an NV centre and a plasmonic metal nanoparticle. Our model successfully explains existing experimental emission measurements of NV centres both in the presence and absence of an MNP. We demonstrate that that NV-plasmon interaction enables us to significantly enhance and precisely control the optical emission of an NV centre through changes to the MNP type and size, NV-MNP separation, submerging medium permittivity, input wavelength, input polarization, and NV orientation with respect to the MNP surface. The insights disseminated in this work will enable the designing and control of NV-plasmonic hybrid nanodevices with significantly improved optical readout signal strength, sensitivity, and tunability for the entire array of NV quantum technologies, ranging from quantum computing to medical imaging.

[1] H. Hapuarachchi, F. Campaioli, J. H. Cole, *Optical interaction of the NV-centre in diamond with a plasmonic metal nanoparticle*, arXiv preprint arXiv:2202.04854, (2022)