Experimental study of multi-photon absorption in colour centers in diamond

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An extensive study of diamond colour centers, mainly nitrogen and silicon vacancy centers, owing to their wide absorption/emission spectrum, long coherence times and unique optical spin dynamics, has demonstrated their potential applications in quantum information and computing. The nitrogen vacancy center has two variations: NV^0 and NV^- out of which the latter is most experimented on, since there was no reported optical readout for NV^0 as opposed to the NV^-. The negatively-charged silicon vacancy center (SiV) is characterized as brightest colour center among other diamond centers, with 80% of its emission in the zero-phonon line (ZPL) at 738 nm, even at room temperature, thus making it a promising single photon source.

In this project, we propose a comparative study of fluorescence spectrum of NV^- and SiV colour centers when subjected to entangled two photon absorption. A precursor to this would be to study the fluorescence spectra of NV^- and SiV center for multi-photon excitation under room temperature (296K) and liquid helium temperature (4K). The absorption spectrum of NV^- center extends from 450-650 nm with optimal excitation wavelength being 532 nm for which the emission spectra of NV^- is observed in range 635-800 nm, with the zero phonon line (ZPL) at 637 nm. The multi-photon excitation of NV^- center depends on illuminating NV- center with 1064 nm photons, such that the center absorbs two 1064 nm photons (which matches the energy of a single 532 nm photon) and undergoes photoluminescence emission (PLE). According to the previous research studies, the PLE spectra is supposed to be similar to the fluorescence spectra when NV^- undergoes fluorescence after absorption of a single 532 nm photon. A majority of the previous studies have been done on multi-photon excitation of NV^- using weak coherent laser pulses and there has not been much research on the entangled two photon absorption by diamond colour centers. The entangled two photon absorption spectroscopy scheme is considered as quantum microscopy scheme and has been used majorly for biological or semi-liquid samples for sensing. It would be interesting from scientific development point of view to observe how this affects the diamond colour centers in our proposed study.

At present time, we propose a confocal microscope setup for the samples since it is easy to control with respect to single emitters as well as for any modifications which might be required in the future. For the first phase of the project, we would like to use weak coherent laser pulses to observe the multi-photon excitation phenomenon in diamond colour center. The entangled two photon absorption by diamond colour centers will be a part of the second phase of this project.