Aulter-Townes Splitting Resonances in Ensemble of Germanium-Vacancy Centers

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Recently, germanium-vacancy centers in diamond (GeVD) have attracted much attention. Like nitrogen-vacancies in diamond (NVD) they have 2-3 orders of magnitude higher dipole moment of the optical transition as compared to the rare-earth doped crystals. At the same time, as compared to NVD, they have ∼20 times stronger zero-phonon line. Stronger zero-phonon line results in more efficient interaction of single photon with a single vacancy. Other advantage of GeVD is a presence of polarization selection rules at the optical transition forming the lambda system and large (160 GHZ) energy levels splitting in the ground state. The last advantage allows for orders of magnitude larger storage bandwidth compared to typically ∼MHz bandwidth in the rare-earth doped solids. The disadvantage of this vacancy center is rather fast decay of the atomic coherence on the order of 100ns. Individual GeVD have been widely studied in view of their promising potential applications for quantum memories, quantum gates, quantum thermometry, etc. Some of these applications could benefit from using ensembles of GeVD. As compared to NVD, they have orders of magnitude less spectral diffusion and inversion symmetry leading to smaller inhomogeneous broadening. A smaller inhomogeneous line broadening favors an ensemble-based interfaces, including realization of an ensemble-based quantum memories. However, while individual vacancies have been widely studied less research was done with the ensembles. The experimental investigation undertaken by our group had shown rather broad homogenously broadened optical lines 30GHz , through still much smaller compared to NV vacancies. At the same time, relatively narrow and quite deep transparency resonances were observed.

The goal of this particular work was to clarify the physical origin of these resonances and to extract the information about the inhomogeneous broadening of the low-frequency (160 GHz transition) caused the spin-orbital splitting. The presented analysis led to conclusion that the physical origin of the observed transparency resonances was an Autler-Townes splitting in each homogenously broadened sub-ensemble. It is shown that the summation of those resonances perfectly mimicked an EIT resonance in the whole inhomogeneously broadened ensemble. As a result of the theoretical fitting of the experimental data the inhomogeneous broadening at the LF transition was estimated at 133 MHz.