Magnetic Dependence of Nitrogen-Vacancy Center in Diamond

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Nitrogen-vacancy centers are defects in diamond that have optical properties that lead to a plethora of applications. In nano-diamonds, NV defects can be used as biomarkers in cells, electro-magnetic sensors, and possibly in quantum computing for long spin-coherence times. This summer, we have been mainly investigating the magnetic dependence of NV diamond. We have two specific goals: creating a magnetic sensor with charged NV diamond and exploring magnetic dependence of the transition between the two charge states of the defect, the negatively charged NV- and the neutrally charged NV0.

The first few weeks, I have learned technical skills to set up the experiment such as walking the beam, using taps and dies, using Arduino to control stepper motor, and coding in Matlab to link everything together and automate the data-taking and analyzing process. So far, we have built our own setup of a confocal microscope and imaged NV diamond.

After setting up, we had to make sure that the sample that we are looking at is a diamond with NV centers. Fortunately, confirmation can be reliably judged from looking at the fluorescence of the sample. NV0 and NV- have their signature peaks, zero-phonon lines(ZPL), at 575nm and 637nm, respectively. Once we spot these signature peaks, we can move on to our first goal: creating a magnetic sensor with NV-. Simply put, we have to see changes in the intensity. The fluorescence intensity changes are what we want to see. This can be achieved by exciting electrons with a laser, exposing microwave radiation at 2.87Ghz, and applying magnetic field. In the end, we will scan through different frequencies to find two frequencies at which the intensity contrast is the biggest. The difference between two frequencies can tell us the strength of the magnetic field that is applied to NV diamond. We will then approach our second goal, exploring magnetic dependence of the transition from NV- to NV0, in a different method. We will excite electrons of NV- diamond with a high-power laser to transform into NV0 diamond. We can then compare the ratio between NV- and NV0 by looking at their fluorescence intensity. Then we can play around with two parameters: magnetic field and the power of the laser.

We were able to see ZPL of NV- around 637nm. However, we did not see any signs of change in intensity when we applied microwave to NV diamond. We are suspecting that our laser is not strong enough to excite most of the electrons. So, we decided to saturate the NV centers with a more powerful laser. We are currently testing the laser to observe fluorescence intensity contrast as a function of microwave radiation intensity.

This summer has been such a great experience for me. I started out this summer not knowing much about NV diamond and experimental optics. But now I am at a point where I can understand the data in front of me and have critical opinions about them. Also, I feel more confident about working with NV diamond, spectrometer, cameras, and so many other things. It also has been great to apply my computer science knowledge to set up and automate our equipment. Overall, I believe this will definitely be a stepping stone for my future both because of the useful experience with programming and instrumentation and because of the guidance and helpfulness of my Professor, Dr. Ryan Balili.