Tunmay Gerg '25

Summer 2022

During the summer of 2022, I used my Byrne Scholar funds to stay on Dartmouth campus and work with Professor Chandrasekhar Ramanathan in the physics department to study how the nitrogen-vacancy (NV) center can be used as a quantum magnetic field sensor. An NV center is formed by removing two carbon atoms from the diamond lattice structure and replacing them with a nitrogen atom and a vacancy spot. In a typical sample, there are millions of NV-centers. Based on the energy levels inside the band gap of an NV-center, there are three spin states an NV-center can be in, and we can control which state it's in by applying a green laser light and an electromagnetic field with a resonating frequency. The way we know that our electromagnetic field is in resonance is that we would see a reduction in brightness of the red light emitted by the NV-center. In a typical experiment, we would slowly change the frequency of the electromagnetic field and record the brightness of the red light as a function of the frequency. Now, depending on the difference in frequency between two adjacent dips in brightness, we can determine the external magnetic field applied to the NV-center. Thus, in our experiment, we investigated how an NV-center could be used to determine the external magnetic field. The resolution increases as we excite less NV-centers, but this is hard since it requires a smaller focus of the green laser.

During the first half of the summer, I built the apparatus for the experiment. It would shine the green laser light, filter it, and direct it to the sample through a series of mirrors. The apparatus would also collect the red emitted light and feed it into a light sensor. I also attached an antenna to apply the resonating electromagnetic fields and also a CMOS camera to take pictures of the NV-center up-close. After working through all the kinks, during the last half of the summer, I was able to collect data on the brightness of the red light as a function of frequency. Furthermore, I could apply an external magnetic field, and see how the brightness plot changed. This told me about the orientation and strength of the external magnetic field, and showed that we could use the NV-center as a magnetic field sensor! However, this was all done on a large group of NV-centers since I couldn't focus the laser to a small enough spot. I will continue this project into the fall, and will make a better apparatus that can be used to detect information from a single NV-center site in our sample.