# Assessment of an NV Magnetometer for Use In Precision Ultracold Neutron Experiments

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## Motivation

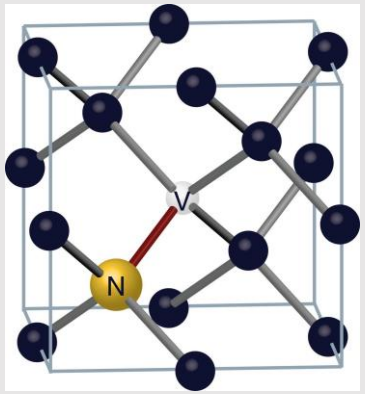
The UCNτ experiment aims to increase precision for measurements of the mean free neutron lifetime. To make these measurements UCNτ utilizes a magneto-gravitational trap to hold and then release neutrons into a detector to be counted. The inside of the trap must maintain an even magnetic field gradient to prevent neutrons from being lost to material interactions before they are counted. This presents a need for an accurate and efficient method for magnetic field gradient measurement. A possible solution comes from Nitrogen-vacancies (NV) in diamond used for Optically detected magnetic resonance (ODMR) .

## Physics

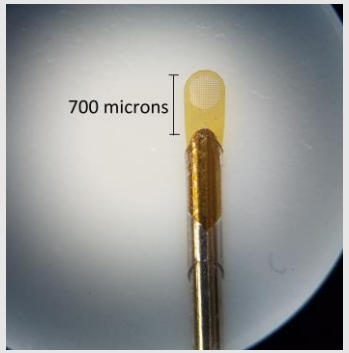
Nitrogen-vacancies are defects in the carbon lattice of diamonds in which two adjacent carbons have been replaced with a single nitrogen leaving a gap which is occupied by shared electron clouds. There is a spin associated with each of these NV centers which, interestingly, interacts strongly with both visible light and microwaves. This state will absorb green light and emit back lower energy red light. When illuminated with green laser light (532 nm), this spin can be subtly manipulated with microwave radiation to produce a measurable change in the intensity of outgoing red light.

## Physics (cont.)

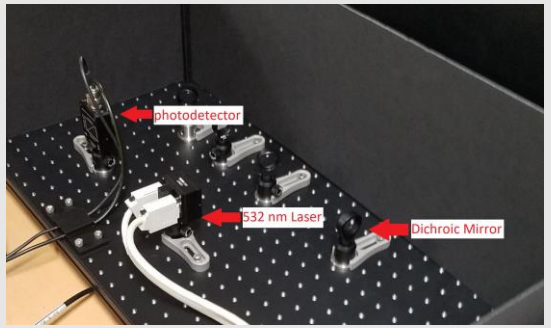
By observing the intensity of the red fluorescence in the presence of an external magnetic field, the strength of that magnetic field can be deduced. This motivates the investigation of such an ODMR device for application to the UCNτ experiment.




A nitrogen Vacancy center in a carbon lattice
Source: Peter Allen




One of the mesh sample holders used.




The optical table used with laser and photodetector in place.

## Construction

An optical table was set up with a dichroic mirror to reflect green laser light onto the sample and to permit red light to pass through to be detected. An objective lens was used to focus green laser light onto the sample and to enhance red fluorescence. Two edge filters are used to clarify and collimate the fluorescence. A photodetector is used to record the data and a camera is used to confirm fluorescence. This setup is enclosed in a quasi-lighttight dark box to improve detection. Samples of diamond are placed onto small pins with a mesh head, these pins are then placed on a 3D printed stage to be illuminated. An FPGA digitizer was implemented to collect data from the photo detector and will be used to send a tuning frequency to the microwave antenna.

## Observations

At this stage fluorescence has been observed. To manipulate this signal and achieve useful measurement a microwave antenna will be constructed and installed near the sample.