Quantum diamond magnetometryfor high pressure sensing

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Diamond anvil cell (DAC) technology has been used for many years to study materials under high-pressure. These materials can exhibit exotic phases of matter such as superconductivity with exceptionally high critical temperatures [1, 2, 3, 4]. The main difficulty with using the DAC lies in their difficulty to measure magnetic properties at high pressure (> 100 GPa) due to the small sample sizes.

In our work, we perform high-pressure magnetometry by using nitrogen-vacancy (NV) centers; atomic defects that can be implanted directly into the culet of the DAC [6]. Due to their spin properties, NV centers are highly sensitive magnetic probes and their atomic size can allow for submicrometer spatial resolution. Using a customized optical microscope, we observe the spin dependent luminescence of diamond defects, to perform a mapping of the magnetic field at the diamond anvil tip. Expulsion of magnetic field lines due to the Meissner effect in a superconductor results in a clear drop of the magnetic field in the close vicinity of the sample, where the NV sensors are located. This direct identification provides an unambiguous diagnosis of superconductivity that does not rely on questionable electrical contacts or indirect probes. This procedure can be performed on any magnetic sample and is compatible with synchrotron X-ray diffraction for structural characterization [5]. Finally, we discuss a unique way maintaining NV fluorescence and contrast above the 100 GPa range by fabricating pillars on the culet surface. This construction increases the range of usable NV high-pressure magnetometry.

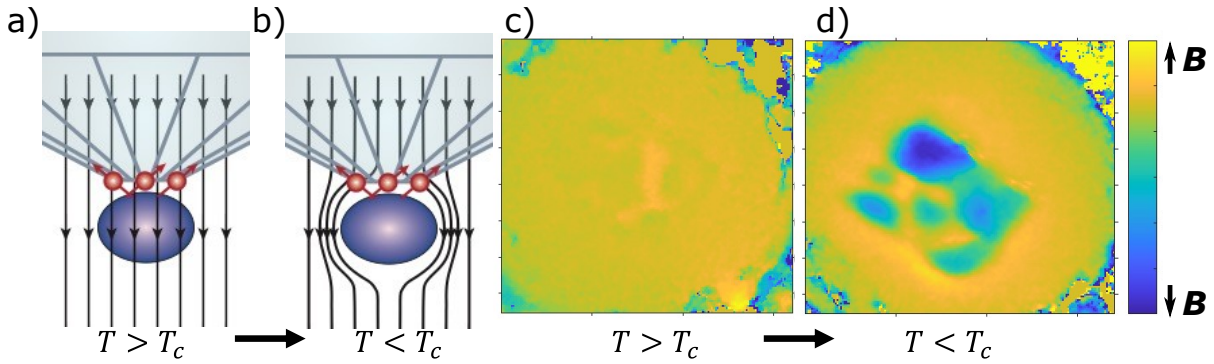

Figure 1: Graphical representation of a cuprate sample in a DAC which is a), not superconducting and b), superconducting. This sample can be imaged by an NV wide-field setup to measure the magnetic field when it is c), not superconducting and d), superconducting by measuring a drop in the magnetic field measured by the NVs.

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