Magnetic measurements on micron-size samples under high pressure using designed NV centers

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The latest experimental achievements obtained in the synthesis of remarkable materials at high pressure have emphasized the need for easier and more sensitive characterizations of magnetic properties. A timely example is the search for high-Tc superconductivity in superhydrides. Several superhydrides superconducting phases have been predicted and two recent experiments, on sulfur hydride (T_c=203 K at 150 GPa) [1] and lanthanum hydride (T_c=260 K at 180 GPa) [2-3] have reported record high-T_c. However, the reported experiments emphasize that a reliable measurement of the superconducting properties of these confined materials at high pressure is an experimental challenge. It limits the systematic screening of this novel class of materials in order to progress towards the synthesis of a high-temperature and low-pressure superconductor. In this work [4], we report an easy-to-implement magnetic characterization, based on diamond NV centers, which permits a direct characterization of the Meissner effect related to superconductivity.

Nitrogen Vacancy (NV)-centers are colored centers of diamond consisting in a nitrogen atom substituting a carbon atom in the diamond lattice, adjacent to a vacancy.

Their electronic ground state is a triplet state. The polarization of the ground state can be manipulated, or probed, with an RF field and detected optically. The spectroscopy of the ground state is sensitive to an external magnetic, electric or strain fields. NV centers have been shown to exhibit a great sensitivity to magnetic fields, down to the single electron spin, and to be robust under extreme conditions. It has been shown that NV centers can be detected at least to 60 GPa in the diamond anvil cell [5].

Two experiments illustrate the relevance of this technique, at room and low temperature respectively. First, we characterize the pressure evolution of the magnetization of an iron sample from ambient pressure to 30 GPa. The magnetization is measured quantitatively, and we observe the collapse of ferromagnetism at the alpha-epsilon transition. In a second experiment, the critical temperature of MgB_2 is straightforwardly measured at 7 GPa.

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