Spectroscopic Evidence of a New Scale for Superconductivity in H_3S

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In the last few years, the discovery of a superconducting phase in sulfur hydride under high pressure with a record high critical temperature (above 200 K) has provided a new impetus to the search for even higher Tc. Theory predicted and X-Ray diffraction confirmed that the structure involved is H_3S (Im-3m). It was suggested that the mechanism whereby H_3S becomes superconductors involves electron-phonon interaction. Despite these significant advances, an experimental verification of the superconducting mechanism was still lacking.

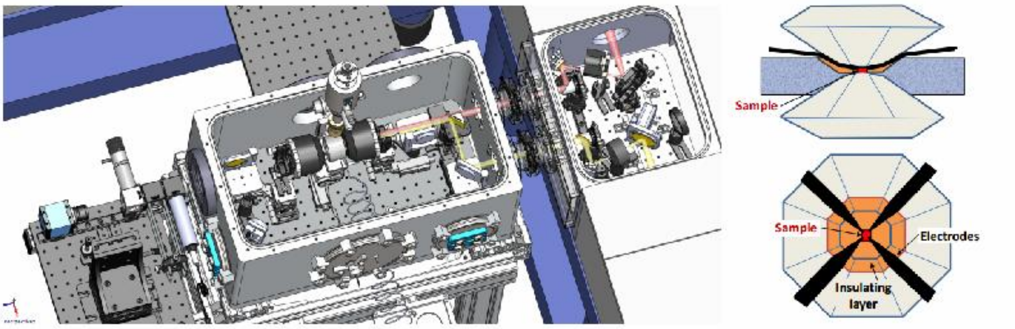

Figure. Schematic view of the ultra-high pressure Low Temperature set-up allowing for measurements of the resistivity (left) and diamond anvil cell showing the diamond anvils, the gasket, the sample and the electrodes

For this purpose, we performed an optical study by infrared spectroscopy which evidences that the high temperature superconductivity in this compound is driven by the electron – phonon interaction [2]. In view of the complexity of the measurement, several problems had to be overcome. Firstly, the experimental setup used combines a control of the temperature just as the one of the pressure (Fig.1) [3]. Moreover, because of the use of a high pressure cell, the formed metallic sample is of the order of 50 micrometers. It implies that reflectivity had to be measured on a sample with a micrometric size. Finally, the expected spectral signatures being of the order of 3% of measured intensity, the system had to present sufficient measurement stability.
The present optical study combined with theoretical calculations based on DFT results for the electron-phonon spectral density and Eliashberg theory, presents foremost steps in the elucidation of the superconductivity mechanism: (i) the energy scale for the bosons involved in the coupling amongst the charge carriers is determined, (ii) the peculiar phonon spectra of H_3S whose strong transition moment points toward the coupling of one phonon with the free carriers, and, (iii) a spectral feature which presents a strong dependence to the superconducting transition appearing at the gap predicted energy.

References

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