Superconducting Hydride under Extreme Magnetic Fields and Pressure

S. Mozaffari[1], L. Balicas[1], V. S. Minkov[2], D. Knyazev[2], M. I. Eremets[2], M. Einaga[3], K. Shimizu[3], D. Sun[4], F. F. Balakirev[4]

1. National High Magnetic Field Laboratory, Florida State University; 2. Max-Planck-Institut fur Chemie; 3. Osaka University; 4. National High Magnetic Field Laboratory, Los Alamos National Laboratory

Funding Grants: G.S. Boebinger (NSF DMR-1157490, NSF DMR-1644779); Balicas (DoE-BES DE-SC0002613); Eremets(ERC- 267777)

The BCS (Bardeen–Cooper–Schrieffer, 1957) theory of superconductivity suggests that there is room for higher superconducting critical temperatures (T_c) in metals composed of light elements (such as hydrogen). Materials with high values for both a phonon frequency and the electron-phonon coupling constant are favorable candidates in the search for a higher T_c. The recently discovered record T_c of 203 K in hydrogen sulfide at 160 GPa confirmed a major result of BCS theory for conventional (phonon-mediated) superconductors, that might for some material result in a T_c above room temperature.

Measurements of the superconducting phase-diagram under high magnetic fields provide detailed information on the underlying electron-phonon coupling. Here, we report magnetotransport studies in superconducting sulphur hydride, under extremely high pressures, in DC fields up to 35T and pulsed fields up to 65T.

We compare the measured upper critical magnetic field with the BCS formula of Werthamer, Helfand and Hohenberg (WHH), noting deviations from the WHH behavior at the lowest experimental temperatures accessible using 65T magnetic fields. The extrapolated zero-temperature upper critical field H_{c2} surpasses 100T, assuming the WHH formula holds.

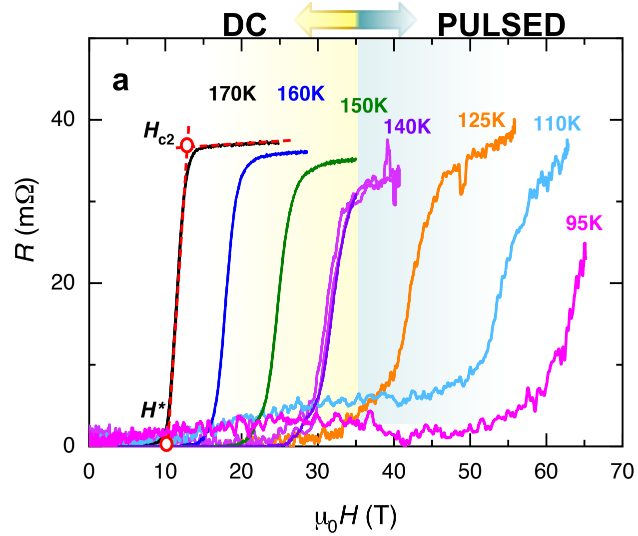

Figure a, Resistance as a function of magnetic field at several temperatures (T) for a sulfur hydride sample under hydrostatic pressure of 170 GPa. Red dashed lines Indicate the definition of H_{c2}, the upper critical magnetic field, and H^*, the superconducting transition onset.

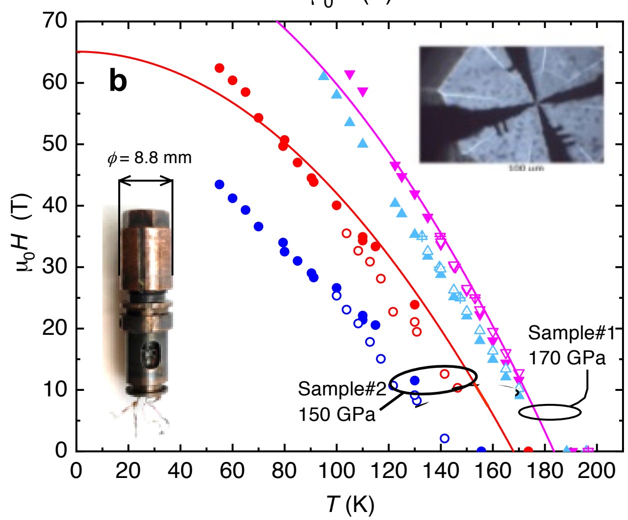

Figure b, Superconducting upper critical fields as a function of temperature for two samples under pressures of 150 and 170 GPa. Open markers are DC field data and solid ones are pulsed field data. For each sample, we show data for H_{c2} (purple and red) and H^* (light and dark blue). Solid lines are fits to the formula: $H_{c2} = H_{c2}(0)[1-(T/Tc)^2]$. Inset photos: the diamond anvil cell and the sample.

Facilities and instrumentation used: DC Facility 35T magnet, Pulsed Facility 65T magnet

Citation: Manuscript in preparation