APCTP SEMINAR

Hot Superconducting Superhydrides

Date/Time **10:00-11:00 , April 30 (Fri.), 2021**

Venue **Online (ZOOM)**

Speaker **Russell Hemley**(University of Illinois at Chicago)

Abstract

Realizing superconductivity in the vicinity of room temperature in hydrogen-rich materials under pressure is a topic of great current interest. Specifically, high-pressure experiments motivated by density-functional theory and conventional electron-phonon coupling models have uncovered new classes of hydrogen-rich metal hydrides, or superhydrides, with superconducting critical temperatures (T_c) in the vicinity of room-temperature at megabar pressures (i.e., >100 GPa). Original calculations for the rare-earth hydrides predicted that LaH_{10} and YH_{10} would form dense hydride clathrate structures exhibiting T_c's in the vicinity of room temperature at pressures of 200-300 GPa. X- ray diffraction experiments on the La-H system confirmed the formation and stability of the LaH_{10} structure near the predicted pressures, and subsequent electrical conductivity and critical current measurements confirmed the very high-temperature superconductivity of the phase. Experiments that used ammonia borane as the hydrogen source indicated T_c's beginning at 260 K, including conductivity onsets as high as 290 K that have been confirmed in more recent work. It was proposed that the high and variable T_c arises from incorporation of N and/or B in the structure from the ammonia borane starting material. Using methods developed previously and applied to H_3S, B and N doping of the La-based superhydride increases the T_c of the material to room temperature. These techniques were also used to examine the doping of C on the superconductivity of H_3S. As found for the La-based superconductor, low-level substitution of C for S can fine-tune the Fermi energy to match the peak in the electronic density-of-states peak, thereby maximizing the electron-phonon coupling and boosting the critical temperature from the original 203 K to 289 K at 260 GPa for 4% doping of C for S in H_3S. The results provide an explanation for the recent experimental observation of room-temperature superconductivity in a highly compressed C-S-H mixture. We also have new constraints on the structure and equation of state from x-ray diffraction measurements. The above findings open new avenues for creating 'hot' hydrogen-rich superconductors with T_c's above room temperature.

Webinar (ZOOM)

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