SEMINAR DEC. 12, 2019 • 11:00 am • Lecture Hall • MPI B.1.11

SPEAKER Mikhail Eremets • MPI for Chemistry, Mainz

Problems of room temperature superconductivity and metallic hydrogen

ABSTRACT • Metallic hydrogen and room-temperature superconductivity are one of the most challenging and very long standing problems in solid-state physics. In both, there is a significant progress over the recent years. Nearly room temperature conventional superconductivity was discovered in hydrides[1]: recently the critical temperature Tc ~250 K at high pressure of ~150 GPa was found in superhydride LaH10 [2,3] following the predictions[4,5].

We will discuss prospects for further increase of Tc to room temperature, in particular in yttrium hydride YH10 with predicted Tc ~300 K at 400 GPa and Li2MgH16 with Tc of ~473K at 250 GPa. We will consider various directions to explore high temperature conventional superconductivity at low and ambient pressures. Metallic hydrogen was predicted by Wigner and Huntington[6] in 1935, and N. Ashcroft in 1968 suggested that it should be a high temperature superconductor[7], room temperature superconductivity follows from the recent calcultions[7,8]. However achieving and measuring of metallic hydrogen is very challanging task, in particular, very high pressures are required[9]: only at ~370-500 GPa solid molecular hydrogen would dissociate and form atomic solid at pressures.

In another scenario, the metallization first occurs in the 250-500 GPa pressure range in molecular hydrogen through overlapping of electronic bands[10]. The calculations are not accurate enough to predict which option is realized. Our experiments[11] indicate the metallization in molecular hydrogen through closing of energy gap. We observed that at a pressure of ~360 GPa and temperatures <200 K (phase III) the hydrogen starts to conduct, and that temperature dependence of the electrical conductivity is typical of a semimetal.

Raman spectra, measured up to 480 GPa, indicate that hydrogen remains a molecular solid at pressures up to 440 GPa, while at higher pressures the Raman signal vanishes, likely indicating further transformation to a good molecular metal or to an atomic state.

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