Superconductivity and magnetism in compressed materials: Novel phenomena

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Compression of a solid presents a natural means to tune interatomic distances and induce a variety of transitions (e. g. insulator-metal transitions, spin-crossover transitions, etc..) in a variety of materials. The most widely used technique for this purpose - diamond anvil cell (DAC) technology - has developed rapidly over the past few years. A number of techniques, which were previously limited to ambient pressure (because of the requirement of a large sample volume), may now be used at high and even ultrahigh pressures. Recent breakthrough results in transport measurements at very high pressures are discussed, as well as the progress at synchrotron facilities in phonon and electron spectroscopies. The novel techniques developed in our laboratory address fundamental properties of compressed materials, e. g. vibrational, electronic, and spin excitations. The presented techniques were made possible both by the development of multiple probes in bench-top experiments with diamond anvil cells and by the developments at the 3rd generation synchrotron x-ray sources. Brief list of topics is given below:
(1) superconductivity in multi-megabar pressure range studied by the magnetic susceptibility technique
(2) transport measurements in multi-megabar pressure range performed by four probe technique using van der Pauw method
(3) magnetic collapse and high-spin to low-spin transitions probed by the x-ray K-β emission process in transition metal compounds
(4) application of nuclear resonant x-ray technique to the measurements of magnetic transitions and the phonon density of states of iron-containing materials at megabar pressures

Few important applications of these techniques are described, with an emphasis on the superconducting properties of elements, transition metal nitrides and oxides. An overview of x-ray emission spectroscopy in iron compounds is given, as well as new results on the pressure effect on the valence band of germanium. Raman scattering from magnetic excitations under pressure is briefly reviewed.

Keywords: superconductivity; inelastic scattering;, high-spin; low-spin; x-ray emission spectroscopy; nuclear resonance; insulator-metal transition.