The superconductor MgB_2 and the charge density wave $NbSe_3$ system: an optical perspective of their broken symmetry ground states

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Broken symmetry ground states, like superconductivity or charge density wave (CDW), are collective states in condensed matter and attracted a lot of interest over several years.

First of all, we address superconductivity in MgB_2. We present magneto-optical reflectivity results in the basal-plane from the ultraviolet down to the far infrared (IR) as a function of temperature and magnetic field oriented along the c-axis. In the far IR there is a clear signature of the superconducting gap with a gap-ratio $2\Delta/k_BT_c \sim 1.2$. The gap is suppressed in an external magnetic field, which is a function of temperature. We extract the temperature dependent upper critical field H_{c2} along the c-axis, compatible with the Helfand-Werthamer behavior.

Secondly, we present data on the CDW material $NbSe_3$. This system exhibits two CDW phase transitions at 145 and 59 K, where the resistivity shows sharp anomalies upon decreasing temperature. In the mid to the far IR region we find a depletion of the optical conductivity with decreasing temperature. This leads to a redistribution of spectral weight from low to high energies due to partial gapping of the Fermi surface as consequence of the CDW transitions. We establish also how much of the Fermi surface is gapped by the transitions. Finally, we deduce the bulk magnitudes of the CDW gaps and discuss the scattering of the ungapped free charge carriers and the role of fluctuation effects.

A better understanding of both MgB_2 and $NbSe_3$ may take great advantage from future investigations with infrared synchrotron radiation (IRSR). The high brightness of IRSR can help to overcome difficulties in measuring the electrodynamic response of such materials under extreme experimental conditions (low temperature, high magnetic field, and high pressure). The possibility to extend measurements at frequencies normally not accessible to conventional IR thermal sources may shed more light on the behavior of the collective phenomena characterizing broken symmetry ground state systems.