TUTORIAL

Theoretical Models for the Understanding of High T_c Superconductivity in MgB_2: A Tutorial

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In this tutorial lecture, several key issues in the theoretical models for the understanding of the high T_c superconductivity in MgB_2 will be discussed based on the basic electronic structure and phonons for the description of the conventional BCS mechanism of superconductivity. Since the superconducting transition temperature of 40K is well above the once predicted upper limit of phonon-mediated superconductivity from the BCS theory and the more refined Eliashberg theory as well, the discovery of high Tc superconductivity in MgB_2 has again raised questions on the origin of such high T_c superconductivity. Despite such high superconducting transition temperature, MgB_2 shares many common features with conventional superconductors, as observed in the study of electronic structure, phonons, and other various bulk measurements, thereby indicating that this brand-new high Tc superconductor is rather close to the conventional superconductors. On the other hand, however, there are several anomalies reported from the specific heat measurements, tunneling spectra, and other optical measurements. One of the crucial points is that the $2\Delta/k_BT_c$ of MgB_2 is unusually small compared to the conventional superconductors, which led to a speculation on the two-gap order parameters, a signature of unconventional superconductivity. In addition, the specific heat data also report anomalous dependence of $\gamma(T,H)$ on temperature- and applied magnetic-field. Comparing the hallmarks of the conventional superconductors with the observed physical properties of MgB_2 superconductors, we will try to cover various issues in understanding the physical properties of MgB_2.

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