

## Unusual electron-phonon superconductivity in MgB<sub>2</sub>.

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Most of the early theoretical works (e.g, [2]) lean towards conventional, intermediate-coupling Eliashberg-type superconductivity. Indeed, state-of-the-art linear-response calculations produce a reasonably large electron-phonon coupling constant  $\lambda$  of the order of 0.8 (e.g., [3]). Together with the high-frequency boron phonons, this is just a little lower than what the MacMillan equation requires for  $T_c=39$  K. While this conventional picture seems to be basically right, there are indication that the real life may not be as simple: (1) specific heat suggests  $\lambda$  even smaller than the calculated one (b) various experiments disagree about the size of the gap; there is evidence of a gap smaller than  $3.5 T_c$ , and of more than one gap (c) Many low-temperature experiment disagree with the simple BCS temperature behaviour of the order parameter. There are also theoretical arguments that the superconductivity in MgB<sub>2</sub> is in several aspects different from the Eliashberg picture: (1) most of the calculated coupling comes from interaction of the two phonons ( $E_{2g}$  symmetry at the zone center) with two (out of four) bands. (2) The phonons in question are strongly anharmonic (3) Very unusually, nonlinear coupling of these phonons with electrons is stronger than the linear coupling, which signify substantial contribution to the Cooper pairing from the two-phonon exchange. A consequence of this is that the theory predicts two considerably different order parameters for the two sets of bands[3]. The main argument against this multigap scenario so far was the lack of any correlation between the residual resistivity and  $T_c$ , predicted for a multiband superconductivity[1]. Fortunately, optical absorption gives as a clue[4]: it appears that the two band systems have totally different relaxation rate, and while the DC current is carried mostly by the first pair of bands, superconductivity appears because of the other pair. It can be shown[1] that intraband defect scattering, while affecting greatly the DC conductivity, does not have the pairbreaking effect of the interband scattering, thus reconciling the multigap scenarion with the experiment. The current situation with MgB<sub>2</sub> can be characterized as follows: The underlying mechanism is likely to be the electron-phonon coupling, as in conventional materials. However, the specific realization of this mechanism in MgB<sub>2</sub> seems to be rather nontrivial and requires going beyond the standard Eliashberg theory in substantial ways, primarily in the direction of multigap superconductivity.

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