The Ioffe-Regel criterion and saturation of electrical resistivity in metals

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The electrical resistivity of metals normally saturates if it reaches values of the order of 0.1 mΩcm. This happens when the apparent mean free path l becomes comparable to the separation d of two atoms, the Ioffe-Regel criterion. Several striking exceptions have, however, been observed, in particular some high-T_c cuprates and doped fullerenes. We present a model of transition metal compounds, in which noninteracting electrons are scattered by phonons. This model leads to resistivity saturation. Using the f-sum rule, we show that saturation happens when $l \sim d$ [1]. We next consider models of high T_c cuprates, focusing on the strong correlation between the electrons. From the f-sum rule, we conclude that one should expect saturation also for these systems. Due to the strong correlation, however, the saturation resistivity can be very large, and the Ioffe-Regel criterion may be strongly violated. The experimental data are consistent with such a scenario [2]. Finally, we present a model of doped fullerenes, in which noninteracting electrons couple to intramolecular phonons. This model shows no saturation. The key features of this model is that the phonons couple to the electronic level energies and that the band width is small [3].

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[3] O. Gunnarsson and J.E. Han, Nature **405**, 1027 (2000).