Metal-insulator transition in a weakly interacting many-electron system with localized single-particle states.

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Electrons in a periodic potential are described by freely propagating Bloch waves. Disorder tends to localize electron states. In a three-dimensional system, introduction of a disorder leads to the existence of a mobility edge. If the Fermi level lies below the mobility edge, then the conductivity in the model of non-interacting electrons is described by a simple activation law.

In lower dimensions, a generic model with disorder yields localization of all single-particle states. In this case, a system of non-interacting electrons has zero conductivity at any temperature (Anderson insulator). Conductivity then may be finite only in the presence of interactions.
The "strength" of the single-particle localization is characterized by the ratio of the localization length to the electronic Fermi wavelength. This ratio is large in the regime of "weak localization". At a sufficiently high temperature, finite conductivity in this regime is associated with the electronic phase relaxation occurring due to the electron-electron interactions. Such phase relaxation acts against the effect of localization and renders conductivity finite. The well-established theory deals only with the limit of sufficiently short phase relaxation length, which is the case at high temperatures. (In a two-dimensional system, conductivity in this limit exceeds significantly the quantum e^2/h.) In the opposite limit of low temperatures, conductivity is conventionally associated with a variety of phonon-assisted hopping mechanisms, allowed in the presence of electron-phonon interaction. Phonons facilitating the hopping of electrons are considered to be de-localized. (In the regime of "strong localization", phonon-assisted hopping is the dominant mechanism at any temperature). Phonon-assisted hopping mechanisms yield finite albeit exponentially small low-temperature conductivity.

One may ask a question about the conductivity of an Anderson insulator at low temperatures in the presence of electron-electron interaction only, assuming that electrons do not interact with phonons. This is the question formulated and answered in the work of Basko *et al*. The authors come to the striking conclusion that the system exhibits a finite-temperature phase transition. Conductivity turns out to be strictly zero below certain temperature T_c, and is finite above that temperature. The conclusion about zero conductivity is reached by a method involving a generalization of the original Anderson locator expansion to the case of electron many-body states. The value of T_c, see Eq. (2.42) in the preprint cited above, depends on the specific model considered. However, the conclusions regarding the existence of the metal-insulator transition at a finite temperature and regarding the zero value of the conductivity in the insulating phase apparently are universal. Sufficiently far above T_c, the temperature dependence of conductivity crosses over to the conventional one, defined by the mentioned above phase relaxation mechanism.