Coulomb Effects and Hopping Transport in Granular Metals

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We study the effects of Coulomb interaction in granular metals in the regime of low and intermediate coupling between the grains. We consider the model of a periodic granular array as well as an irregular model that includes a random on-site electrostatic potential. For the former case we find the dependence of the Mott gap on the intergranular coupling and study the Mott transition between the insulating and metallic states. For the later case we concentrate on the limit of low coupling and study the hopping conductivity. The conductivity of a periodic array has an activation form governed by the Mott gap that is a function of the intergranular coupling. In the case of irregular arrays the electrostatic disorder gives rise to the finite density of states on the Fermi level and as a result the conductivity is determined the variable range hopping mechanism. Depending on the temperature regime and the strength of the applied electric field the conductivity is determined by either elastic or inelastic cotunneling mechanisms. The results are obtained within the effective description where the processes of quantum tunnelling of real electrons are represented as trajectories (world lines) of charged classical particles in $d + 1$ dimensions. The Mott gap is related to the dielectric susceptibility of the Coulomb gas. We show that elastic cotunneling processes are very important for the description of the metal to insulator transition in periodic granular arrays. \textsuperscript{1}

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