Determination of a soft gap in the density of states of a granular carbon

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In this work we discuss the application of variable range hopping model for the electrical transport in carbon-black, a granular and disordered kind of carbon. We analyze the measured resistivity of samples with different volumetric densities, from room temperature to 1.2 K, using the Mott and Efros-Shklovskii (ES) approximations. We show that they give ambiguous results within a temperature range where they both seem to be applicable. We propose a continuous function for the density of states which implies a thermally activated correction to the Mott resistivity equation at high temperatures, and connects smoothly to the ES equation, at low temperatures. With this function we obtain good fits to the experimental data and determine a value for the gap half width around 1.4 meV for the sample with the lowest density. This gap decreases with the powder density. We argue that transport in carbon nanoparticles and agglomerates occur through localized states and that a soft gap is most probably to exist in the density of states, at the Fermi level, due to the Coulomb interactions.