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Bosonic Insulator Phase beyond the Superconductor-Insulator Transition in Granular In/InO_x Thin Films

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Abstract

From extensive measurements of the resistance and the dynamic resistance as functions of magnetic field and temperature, we find that the transport in the insulating state beyond the superconductor-insulator (S-I) transition is dominated by bosons (Cooper pairs and/or vortices) and cannot be described by the theory of the fermionic insulating phase. The maximum of the magnetoresistance at $B = B_m$ and the following negative slope in $R(B)$ with increasing field can be explained by the crossover from the "Bose-glass" to the "Fermi-glass" phase as suggested by Paalanen, Hebard, and Ruel. The zero bias peak in dV/dI for biases below the characteristic voltage V_c (or current I_c), gives a clue for the assumption of the "dirty boson" model which states that the insulating state above the critical magnetic field is the phase where Cooper pairs are localized due to the Coulomb blockade with a nonvanishing order parameter. The shift to a lower value of the critical magnetic field by overlaying thin Au layer, which is known as a strong spin-orbit scatterer, also supports the bosonic nature of the S-I transition.