Magnetic Field Tuned Quantum Phase Transition in the Insulating Regime of Ultrathin Amorphous Bi Films

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A surprisingly strong variation of resistance with perpendicular magnetic field, and a giant peak in $R(B)$ has been found in insulating films of a sequence of homogeneous, quench-condensed films of amorphous Bi undergoing a thickness-tuned superconductor-insulator transition. Isotherms of magnetoresistance, rather than $R(B)$ were found to cross at a well-defined magnetic field higher than the field corresponding to the peak in $R(B)$. For all values of B, $R(T)$ was found to obey an Arrhenius form. At the crossover magnetic field the prefactor became equal to the quantum resistance of electron pairs, $h/4e^2$, and the activation energy returned to its zero field value. Magnetoresistance data near the crossover magnetic field are consistent with finite size scaling. The critical exponent product found in the scaling analysis, is consistent with the universality class of the $(2+1)D$ XY Model assuming that the dynamical exponent z, which is not measured, is unity. We suggest that these observations are evidence of a quantum phase transition between two distinct insulating phases, which might be identified as Bose and Fermi insulators.
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