Collective dynamic state of a Josephson junction array

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We derive current-voltage characteristics for one- and two-dimensional Josephson junction arrays in the insulating state and find an Arrhenius-like thermally activated behavior at moderate temperatures and the double-exponential temperature dependence at very low temperatures, reflecting transition into a zero-conducting state. In this state the conductivity exhibits sharp voltage threshold behavior : it abruptly switches from zero to a finite value as the bias achieves the threshold. In a one-dimensional chain, both the activation energy and voltage threshold scale linearly with the length of the array. In a 2D array, the activation energy scales as logarithm of its size while the threshold voltage retains the linear dependence. We obtain the magnetic field dependences for the activation energy and voltage threshold. The comparison with the experimental findings on Josephson junction chains and the disordered superconducting films near the superconductor-insulator transition shows an excellent agreement.