Superconductor-insulator transition in Josephson-junction arrays on a honeycomb lattice and ultra-thin superconducting films with a periodic lattice of nanoholes

Enzo Granato
Instituto Nacional de Pesquisas Espaciais

The zero-temperature superconductor to insulator transition is studied in a self-charging model of Josephson-junction arrays in an external magnetic field corresponding to f flux quantum per plaquette. The model can be physically realized as two-dimensional arrays of weakly coupled superconducting grains and ultra-thin superconducting films with a triangular pattern of nanoholes [1,2]. When charging effects due to the small capacitance of the grains or junctions dominate, strong quantum fluctuations of the phase of the superconducting order parameter drive the system into an insulating phase at zero temperature leading to a superconductor to insulator transition as a function of charging energy. In presence of an external magnetic field, frustration effects lead to distinct universality classes which depend on the geometry of the array. For a Josephson-junction array on square lattice, the universality class of these transitions have already been investigated in detail numerically [3]. However, for a Josephson-junction array on a honeycomb lattice there are very few results. Path integral Monte Carlo simulations of the equivalent (2+1)-dimensional classical model are used to study the phase transition and critical behavior. For $f = 0$ and $f = 1/2$, the transition is second order and the corresponding correlation length critical exponents are estimated from finite-size scaling.

[1] M. D. Stewart Jr., Aijun Yin, J. M. Xu, James M. Valles Jr., Science **318**, 1273 (2007).
[2] E. Granato, Phys. Rev. B **87**, 094517 (2013).
[3] M-C Cha and M.S. Girvin, Phys. Rev. B **49**, 9794 (1994).