Universal metal-insulator transition with Dirac electrons

S. Sorella, Y. Otsuka and S. Yunoki.

We consider electrons with massless Dirac-like dispersion in two spatial dimensions, described by the Hubbard model on two geometrically different lattices[1], and perform numerically exact calculations that, combined with a careful finite-size scaling analysis, allow us to determine the quantum critical behavior in the vicinity of the interaction-driven metal-insulator transition. Thereby, we find that the transition is continuous, and is triggered only by the vanishing of the quasiparticle weight, while we provide clear evidence that the Dirac Fermi velocity remains finite near the transition, in agreement with the underlying Gross-Neveu model. Indeed, in this work, we have confirmed that this theoretical model, widely used in particle-physics, describes perfectly the critical behavior of the metal insulator transition, that turns out to be not only quantitatively but also qualitatively different from simple mean-field or Gutzwiller-type approximate pictures. Finally I will discuss recent results [2] on the negative-U Hubbard model with π-flux in the triangular lattice, that should be relevant to understand the universal behavior of the metal-superconducting transition at zero temperature. This is a different universality class as it should be described by the Gross-Neveu model with U(1) symmetry and N=8 components.

[1] Y. Otsuka, S. Yunoki and S. Sorella PRX 6, 011029 (2016).
[2] Y. Otsuka, S.Sorella and S. Yunoki, in preparation.