

From spatially-ordered valence-bond solid to unconventional superconductivity in organic charge-transfer solids

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Unconventional superconductivity (SC) in the organic charge-transfer solids (CTS) is proximate to spatial broken symmetry states such as spin-density wave (SDW), antiferromagnetism (AFM) or charge-ordering (CO). SC is reached not by doping but by applying pressure with a constant carrier density of $n = \frac{1}{2}$ per molecule. CTS crystals typically consist of two dimensional (2D) layers of organic molecules in an anisotropic triangular lattice.

In the first part of this talk we point out that all of the above spatial broken symmetries coexist with or are close to a Bond-Charge-Density-Wave (BCDW) [1], with molecular charge occupancies $\dots 1100 \dots$, where ‘1’ and ‘0’ correspond to molecular charges $0.5 + \epsilon$ and ‘0’ to $0.5 - \epsilon$, respectively. The BCDW constitutes the valence-bond solid (VBS) that has been seen experimentally [2] in nearly isotropic lattices.

In the second half of the talk we propose a mapping of the repulsive correlated-electron Hamiltonian that describes the $n = \frac{1}{2}$ VBS [1] into an *effective* $n = 1$ attractive- U model with extended nearest neighbor Coulomb repulsion V . The effective sites of the $n = 1$ Hamiltonian are pairs of occupied (1-1) and unoccupied (0-0) molecules (Fig. 1). We have performed exact numerical calculations within the effective model on anisotropic triangular lattices that show robust frustration-induced transition from the VBS to the SC state, with the SC extending into the small effective- $|U|$ region relevant to CTS. The role of pressure in our model is simply to increase the frustration. The observed pseudogap [3], very large upper critical field [4] and other novel features are understood naturally within our theory [5].

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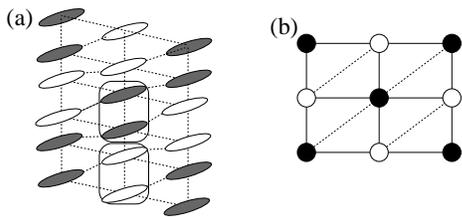


Figure 1: (a) BCDW in a 2D organic layer. Filled (un-filled) ellipses correspond to charge-rich (charge-poor) molecules. (b) Pairs of charge-rich and charge-poor molecules constitute the double occupancy (filled circle) and vacancy (empty circle) in the effective $n = 1$ lattice.

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