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The physics of doped Quantum Dimer Models

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Magnetic frustration commonly leads, in two-dimensional (2D) quantum spin systems, to the (dynamical) formation of spin singlets (or dimers). Generically, systems of quantum fluctuating dimers may order into Valence Bond Crystals (VBC) or remain in some unconventional quantum dimer liquid similar to Anderson's original RVB state (see e.g. Fig. 1(A)). The two-dimensional Quantum Dimer Model [1] (QDM) plays an increasing role in the understanding of frustrated quantum antiferromagnets and quantum-disordered spin systems and offers completely new routes of investigations.

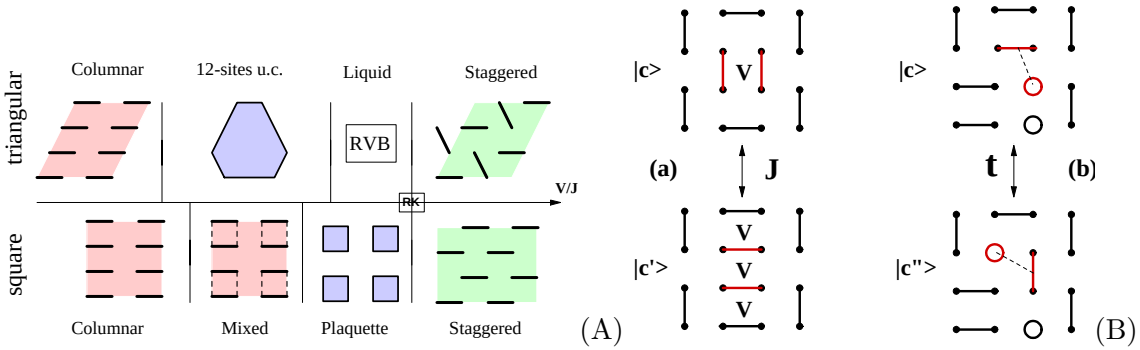

Figure 1: (A) Schematic phase diagrams of the (undoped) QDM on triangular and square [2] lattices. Only the triangular lattice exhibits a liquid (RVB) phase [3]. A novel mixed phase on the square lattice has been reported in [4]. (B) Schematic plots of the dimer flip (a) and holon hopping (b) in the doped QDM on the square lattice.

Yet, little is known theoretically on itinerant frustrated systems and the investigation of doped quantum dimer models (see Fig. 1(B)) is a promising route towards a better understanding of e.g. doped frustrated antiferromagnets or the pseudogap phase of the high-T_c cuprates. I will review recent progress on the bosonic doped QDM [5] and the "non-Frobenius" doped QDM [6] retaining the original Fermi statistics of the electrons. These models show rich phase diagrams including, in the latter case, a d-wave hole-pair unconventional superconductor at small enough doping and a bosonic superfluid at large doping. The hole kinetic energy is shown to favor binding of topological defects to the bare fermionic holons turning them into bosons, in agreement with arguments based on RVB wave-functions [7]. Under an applied Aharonov-Bohm flux, the superfluid exhibits quantization in terms of half-flux quanta, consistent with $Q = 2e$ elementary charge quanta [5].

[1] D.S. Rokhsar and S.A. Kivelson, Phys. Rev. Lett.**61**, 2376 (1988).
[2] O.F. Syljuasen, Phys. Rev. B **71**, 020401(R) (2005).
[3] R. Moessner and S. L. Sondhi, Phys. Rev. B **63**, 224401 (2001).
[4] A. Ralko, D. Poilblanc and R. Moessner, Phys. Rev. Lett. **100**, 037201 (2008).
[5] A. Ralko, F. Mila and D. Poilblanc, Phys. Rev. Lett. **99** 127202 (2007).
[6] D. Poilblanc, arXiv:0711.2229.
[7] N. Read and B. Chakraborty, Phys. Rev. B **40**, 7133 (1989).