Examining an Exactly Solvable First-Order Transition in a Modified Hubbard Model

PAWEL PISARSKI, R.J. GOODING, Dept. of Physics, Queens U., Kingston ON — A previous study (PRB 63, 035014 (2000)) of the success of the different diagrammatic theories in reproducing the physics of the Hubbard model led to the introduction of a modified Hubbard interaction, the latter of which is given by $U \sum_i (\langle \hat{n}_{i,\uparrow} \rangle - \langle \hat{n}_{i,\downarrow} \rangle) (\langle \hat{n}_{i,\downarrow} \rangle - \langle \hat{n}_{i,\uparrow} \rangle)$. We show that the Hubbard model with this modified interaction leads to an exact phase diagram corresponding to a first-order phase transition, with a thermodynamic potential of the same form as that found for the familiar van der Waals equation of state. Then we show that the fully self-consistent T-Matrix Approximation for the repulsive Hubbard interaction accurately tracks the low electron density regime, and that two self-consistent solutions are found, corresponding to both the stable and metastable phases of this model. This is in contrast to the minimally self-consistent T-Matrix theory that was shown to be successful for the attractive model (PRB 71, 155111 (2005)).