Double occupancy as a universal probe for antiferromagnetic correlations and entropy in cold fermions on optical lattices

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We demonstrate that the signatures of antiferromagnetic (AF) correlations in the double occupancy D persist in all dimensions down to $d = 1$, therefore establishing D as a local probe of AF correlations. As a function of entropy $s = S/(Nk_{\mathrm{B}})$, D is nearly universal with respect to dimension; the minimum in $D(s)$ approaches $s \approx \log(2)$ at strong coupling, also marking the applicability limit of spin models. Long-range order appears hardly relevant for the current search of AF signatures in cold fermions. Thus, experimentalists need not achieve $s < \log(2)/2$ and should consider lower dimensions, for which the AF effects are larger. [D measurable! unique AF signature almost within current s reach, new: weak coupling, cubic T_N nonuniversal (sc vs. bcc)]

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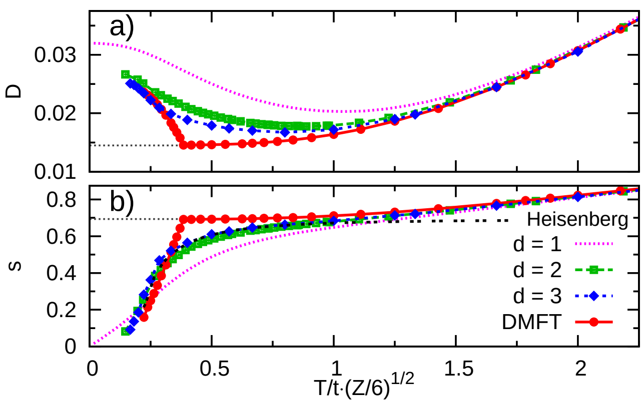

FIG. 1. (Color online) Hypercubic lattice ($1 \leq d \leq 3$) at strong coupling: a) $D(T)$ as estimated from DMFT ($d = 3$, circles), QMC ($d = 2$, 3, squares/diamonds), and BA ($d = 1$, dash-dotted line). b) Corresponding estimates of entropy per particle $s = S/N$. All interactions correspond approximately to the ground state Mott transition at $U/(\sqrt{Z}t) \approx 6$.

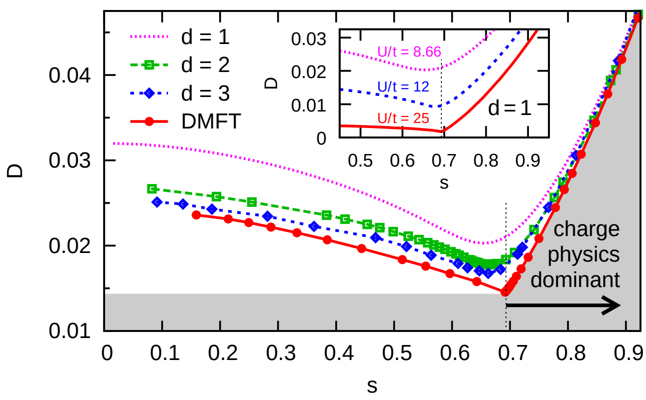

FIG. 2. (Color online) Hypercubic lattice ($1 \leq d \leq 3$) at strong coupling: Double occupancy as a function of entropy per particle. In all cases, the minimum of the double occupancy corresponds to $s \approx \log(2)$ (dotted line). The shaded area indicates the nonmagnetic contribution to D. Inset: the effect of interaction strength on the double occupancy for $d = 1$.

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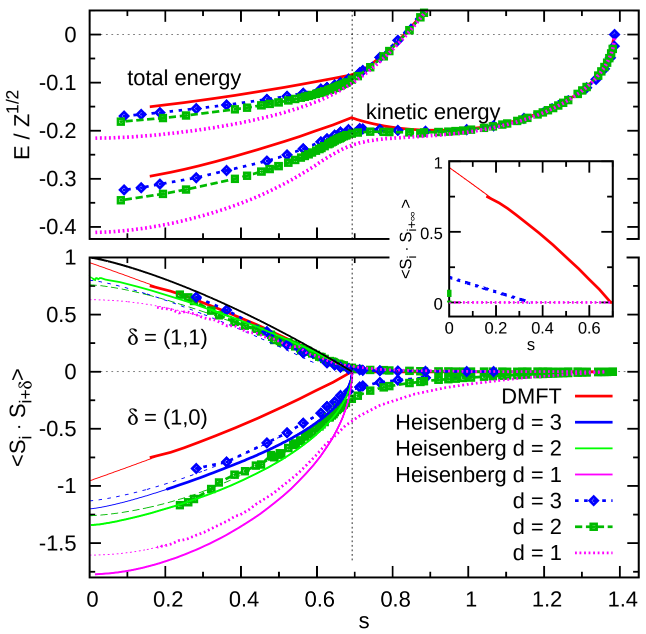

FIG. 3. (Color online) Hypercubic lattice ($1 \leq d \leq 3$) at strong coupling: further observables as a function of entropy per particle. a) Rescaled total and kinetic energies as a function of entropy per particle. b) Spin-spin correlations $\langle S_i \cdot S_{i+\delta}\rangle$ for the nearest neighbours ($\delta_{d=1} = 1$, $\delta_{d=2} = (1,0)$, $\delta_{d=3} = (1,0,0)$) and for the next-nearest neighbours ($\delta_{d=1} = 2$, $\delta_{d=2} = (1,1)$, $\delta_{d=3} = (1,1,0)$). Inset: long range order spin correlations.

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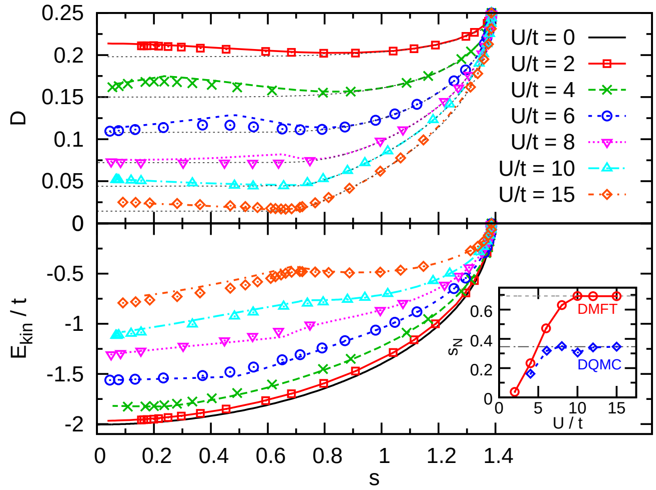

FIG. 4. (Color online) Cubic lattice ($d = 3$): Comparison of DMFT (circles) and direct QMC (diamonds) results for the entropy dependence of the a) double occupancy $D(s)$, and b) kinetic energy E_{kin}. Inset: The Néel entropy per particle $s_N(U)$, estimated from DMFT (circles) and QMC (diamonds). This lines show critical entropies for the Heisenberg model ($s_N^{\text{Heisenberg}} = \frac{1}{2}\log 2$) and Weiss mean-field theory ($s_N^{\text{Weiss}} = \log 2$).

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