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Order in quantum compass and orbital e_g models

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Exchange interactions in orbital models are frustrated even on a square lattice, where two $T=1/2$ pseudospin components $T_i^{\gamma}(\theta)$ parameterized by angle $\theta\in(0,\pi/2]$ interact by terms $JT_i^{\gamma}(\theta)T_j^{\gamma}(\theta)$. Maximal frustration in the quantum compass model with $T_i^{\gamma}(\pi/2)\equiv\frac{1}{2}\sigma_i^{\gamma}$, where σ_i^{γ} is the Pauli matrix, is reduced to moderate frustration for the e_g orbital model at $\theta=\pi/3$ [1].
We investigate thermodynamic phase transitions at temperature T_c on an infinite square lattice by variational tensor network renormalization (VTNR) in imaginary time. From the linear susceptibility (order parameter) in the symmetric (symmetry-broken) phase the onset of nematic order in the quantum compass model is estimated at $T_c/J=0.0606(4)$ [2], in good agreement with Quantum Monte Carlo (QMC). For the 2D e_g orbital model one finds: (i) a very accurate VTNR estimate of $T_c/J=0.3566\pm0.0001$ while QMC fails due to the sign problem, and (ii) that the critical exponents are within the Ising universality class. Remarkably large difference in frustration and entanglement results in so distinct T_c.

[1] L. Cincio, J. Dziarmaga, and A. M. Oleś, Phys. Rev. B **82**, 104416 (2010).

[2] P. Czarnik, J. Dziarmaga, and A. M. Oleś, Phys. Rev. B **93**, 184410 (2016).

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