Order in Quantum Compass and Orbital e_g Models

Piotr Czarnik,[1,2] Jacek Dziarmaga,[1] and Andrzej M. Oleś[1,3]

[1] *Institute of Physics, Jagiellonian University, Kraków, Poland*

[2] *Institute of Physics, Universiteit van Amsterdam, The Netherlands*

[3] *Max Planck Institute for Solid State Research, Stuttgart, Germany*

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 e_g orbital model one finds: (*i*) a very accurate VTNR estimate of $T_c/J = 0.3566 \pm 0.0001$ 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.

References:

[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).