Spin-orbital liquid state on the square lattice with emergent Majorana fermions and $Z_2$ topological order

ASHVIN VISHWANATH, FA WANG, UC Berkeley — Magnetism from d-electrons often retains orbital degeneracy which can enhance quantum fluctuations and lead to exotic liquid-like ground states with no conventional order. Indeed, experimental systems like LiNiO$_2$, FeSc$_2$S$_4$ etc. with orbital degeneracy show a lack of order down to low temperatures. We introduce a Majorana-fermion slave particle theory to study such states in spin-1/2 models with $e_g$ orbital degeneracy. This is first applied to a square lattice model with enhanced SU (4) symmetry. A mean field treatment predicts a spin-orbital liquid state with nodal Majorana fermion excitations and $Z_2$ topological order. A variational Monte-Carlo study of the corresponding wavefunction confirms the absence of magnetic order and bond order, which makes it a candidate state for a spin orbital liquid. Comparing against the exact diagonalization studies in [Bossche et al. Eur. Phys. J. B 17, 367 (2000)], our state is found to have significant overlap with the ground state on small lattices, despite the absence of a variational parameter. More realistic models with lower symmetry and on different lattices are analyzed within our formalism, and applications to S=3/2 atoms confined in optical lattices are pointed out.