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Phase diagram of quantum square ice LOUIS-PAUL HENRY, PETER HOLDSWORTH, Ecole Normale Supérieure de Lyon, France, FREDERIC MILA, Ecole Polytechnique Fédérale de Lausanne, Switzerland, TOMMASO ROSCILDE, Ecole Normale Supérieure de Lyon, France — We have investigated the ground-state and finite-temperature phase diagram of quantum square ice - realized by the transverse-field Ising model on a checkerboard lattice - using both linear spin-wave (LSW) theory and quantum Monte Carlo (QMC). We generalize the model with different couplings between nearest (J_1) and next-to-nearest (J_2) neighbors on the checkerboard lattice. Our QMC approach generalizes the loop algorithm - very efficient in the study of constrained classical systems - to a "brane algorithm" for quantum systems. At the LSW level the vast degeneracy of the ground-state for $J_1 = J_2$ and $J_2 > J_1$ remains intact; moreover LSW theory breaks down in extended regions of the phase diagram, pointing at non-classical states [1]. Our QMC study goes beyond perturbative schemes and addresses directly the nature of the low-temperature phases. We have critically examined the possibility of a resonating-plaquette state for $J_1 = J_2$, suggested by degenerate perturbation theory on the ice-rule manifold for weak fields. Our QMC results for finite fields confirm the absence of Néel or collinear order, but they do not confirm the presence of resonating-plaquette order, pointing at a possibly more complex non-classical state.

[1] L.-P. Henry et al., PRB 85, 134427 (2012).

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