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Exact Field Induced Ground States of the Quantum Compass Model

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We consider the square lattice S=½ quantum compass model (QCM) parameterized by Jx, Jz, under an in-plane field. At the special field value, (hx,hz)=2S(Jx,Jz), we show that the QCM Hamiltonian may be written in a form such that two simple product states can be identified as exact ground-states, below a gap. Exact excited states can also be found. The exact product states are characterized by a staggered vector chirality, attaining a non-zero value in the surrounding phase, and can also be realized in 1D spin chains. The resulting gapped phase occupies most of the in-plane field phase diagram, but is clearly distinct from the high field polarized phase. Using iDMRG and iPEPS techniques in combination with exact diagonalizations and analytical arguments, we determine the complete in-plane field phase diagram [1]. Our findings are important for understanding the field dependent phase diagram of materials with predominantly directionally-dependent Ising interactions, and duality relations connects the QCM model to the Xu-Moore model and the toric code.

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