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Transition between critical antiferromagnetic phases in the J_1-J_2 spin chain

The J_1-J_2 spin chain is one of the canonical models of quantum magnetism, and has long been known to host a critical antiferromagnetic phase with power-law decay of spin correlations.

Using the matrix product state path integral to capture the effects of entanglement near the saddle points, we argue here that there are, in fact, two distinct critical phases: the 'Affleck-Haldane' phase, where the dimer field that parametrises local singlet order is part of a joint O(4) N\'eel-singlet order parameter; and the 'Zirnbauer' phase, where the dimer field is gapped out and the critical theory involves only an O(3) N\'eel order parameter. We describe a similar critical-to-critical transition in a model of three coupled spin chains.

The phases are so-named because each realises one of the competing pictures for how the O(3) non-linear sigma model with a topological theta term renormalises to the $\hat{\mathfrak{su}}(2)_1$ Wess-Zumino-Witten model.

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