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(G*) IDMRG study of the J-Gamma Ladder: Shy of a Bakers Dozen

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Quantum spin liquids (QSLs) may roughly be defined as states possessing sufficiently high quantum fluctuations that they impede long range magnetic order. Various electron interactions are currently being studied in order to physically realize such states in condensed matter systems since they can host fractionalized excitations. The purpose of our study is to examine two interactions established as important in the literature while not having been paired together. We consider a bond-dependant J-Γ ladder, comprised of an alternating symmetric exchange of spin components, mediated by Γ, along with a Heisenberg interaction controlled by J. By parameterizing these couplings by an angle ϕ, we produce a phase diagram of the system using the Infinite Density Matrix Renormalization Group (IDMRG) numerical technique. In order to classify the phases, we search for discontinuities in the entanglement spectrum for bonds along one of the legs and the rungs of the ladder while also looking at divergences in the susceptibility of the energy. These criteria reveal 11 phases hosted by the system, with 9 of them showing some form of magnetic ordering seen directly from the spin correlations and by applying magnetic fields in appropriate directions. Moreover, known points in the phase diagram can be adiabatically connected to other points within the same phase by tuning J or Γ. The remaining two phases however show no obvious long-range magnetic order while also having large contributions to the entanglement spectrum. Such phases, showing interesting initial signs, are discussed further in our study.

Author: AVAKIAN, Sebastien (McMaster University)

Co-author: Prof. SORENSEN, Erik (McMaster University)

Presenter: AVAKIAN, Sebastien (McMaster University)

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