

Spin dynamics in the antiferromagnetic spin-1 Heisenberg trimer

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We present exact analytical results for the spin dynamics of a spin-1 antiferromagnetic Heisenberg isosceles trimer (two bonds J_1 and one bond J_2) in the presence of an external magnetic field h_z . By tuning the two control parameters J_2/J_1 and h_z , the system realizes six distinct ground states, including a fully polarized separable state, two globally entangled asymmetric Dicke states, two biseparable states, and a highly symmetric Aharonov state with robust global entanglement. Using pair spin correlation functions, we systematically disentangle the roles of local magnetization and quantum correlations in shaping the strength and the ferro- or antiferromagnetic character of spin fluctuations along different bonds. We uncover pronounced bond anisotropy as well as a strong spin-space anisotropy between longitudinal (C_{ij}^z) and transverse ($C_{ij}^{x(y)}$) correlations. The time-dependent correlation functions exhibit qualitatively distinct dynamical regimes, including single-frequency, multi-frequency (quasiperiodic), and time-independent behavior across the full parameter space. We demonstrate that the external magnetic field primarily controls the transverse spin dynamics in the selected ground state, where it tunes the relevant excitation gaps and, consequently, the oscillation frequencies, while the longitudinal correlations remain field-independent at zero temperature due to symmetry constraints.

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