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Non-stabilizerness in quantum-enhanced metrological protocols

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Non-stabilizerness, colloquially magic state resource—has emerged as the resource that separates classically simulable quantum circuits from those offering a genuine quantum-computational advantage. Although its dynamics have been mapped in digital (gate-based) architectures, almost nothing is known about how magic resources are generated in analog quantum simulators with all-to-all couplings between qubits.

Here we provide the study of magic state resources production in paradigmatic spin-squeezing protocols, i.e. one-axis twisting and two-axis counter-twisting models. We derive closed-form expressions for the Rényi stabilizer entropies for spin-squeezing dynamics. We show that magic appears simultaneously with the onset of metrologically useful spin squeezing in the short-time evolution. On the longer time scales, maxima of magic correspond to the generation of many-body Bell-correlated states, which however saturates at constant values for large system sizes.

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