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(G*) Wigner negativity in spin-j systems

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The nonclassicality of simple spin systems as measured by Wigner negativity is studied on a spherical phase space. Several SU(2)-covariant states with common qubit representations are addressed: spin coherent, spin cat (GHZ/N00N), and Dicke (W). We derive an upper bound on the Wigner negativity of spin cat states that rapidly approaches the true value as spin increases beyond $j \approx 5$. We find that spin cat states are not significantly Wigner-negative relative to their Dicke state counterparts of equal dimension. We also find, in contrast to several entanglement measures, that the most nonclassical Dicke basis element is spin-dependent, and is not in general the equatorial state $|j, 0\rangle$ (or $|j, \pm 1/2\rangle$ for half-integer spin). These results underscore the influence that dynamical symmetry has on nonclassicality, and suggest a guiding perspective for finding novel quantum computational applications.

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