Spin squeezing in symmetric multiqubit states with two non-orthogonal spinors

K. S. Akhilesh[1], B. G. Divyamani[2], Sudha[3,4], A. R. Usha Devi[4,5] and K. S. Mallesh[1]
[1]Department of Studies in Physics, University of Mysore, Manasagangotri, Mysuru-570006, Karantaka, India
[2]Department of Physics, Tunga Mahavidyalaya, Thirthahalli, Karnataka-577432, India
[3]Department of Physics, Kuvempu University, Shankaraghatta, Shimoga-577 451, Karnataka,India
[4]Inspire Institute Inc., Alexandria, Virginia, 22303, USA.
[5] Department of Physics, Bangalore University Bangalore-560056, India

Abstract

Squeezed spin states are a class of permutation symmetric N particle entangled states, which exhibit reduced quantum fluctuation in their collective spin angular momentum in a certain direction, and they are useful for quantum enhanced metrology. In this work, the celebrated Majorana representation is exploited to investigate spin squeezing in different classes of pure symmetric states of N qubits with two distinct spinors, namely the Dicke-class of states $\{D_{N-k,k}\}$. It is shown that the states in the Dicke-class, characterized by two-distinct non-orthogonal spinors, exhibit spin squeezing. On obtaining a general expression for spin squeezing parameter, the variation of squeezing for different configurations is studied in detail.

Keywords Spin squeezing, Majorana goemetric representation, Symmetric multiqubit states

Enhanced precision measurements using entangled many particle states are crucial for their technological applications in quantum information science. Permutation symmetric states attract attention as they offer test grounds for the description of entanglement in multiqubit systems, which is crucial for processing complex quantum information tasks. Entanglement in multiqubit systems is a useful resource in quantum metrology. Witnessing entanglement in multiqubit systems containing large amount of atoms, that can be addressed collectively, is a difficult task. Collective measurements of the mean value and variance of total spin of the system aid experimental detection of entanglement in permutation symmetric multiqubit systems. An established experimental friendly criterion of entanglement in permutation symmetric N qubit system is spin squeezing, which manifests in the form of reduced variance of collective spin of the system in a specific direction below the value set by uncorrelated spin coherent state. To study spin squeezing in multiqubit systems, we employ an elegant geometrical representation proposed by Majorana [1] in 1932. The Majorana geoemtric representation enables one to visualise multiqubit pure symmetric symmetric states composed of N distinct qubits as constellation of N distinct points on the Bloch sphere. As an initial step, we consider only N-qubit symmetric states characterized by two non-orthogonal distinct qubits. While pure symmetric states characterized by two orthogonal qubits are shown to be entangled, but are not spin squeezed [2]. We prove that N-qubit symmetric states consisting of two distinct non-orthogonal spinors do exhibit spin squeezing. We explore spin-squeezing behaviour in different classes of N-qubit symmetric states [3] consisting of all permutations of two distinct spinors, thus expanding the avenues of their applicability in quantum enhanced sensing tasks.

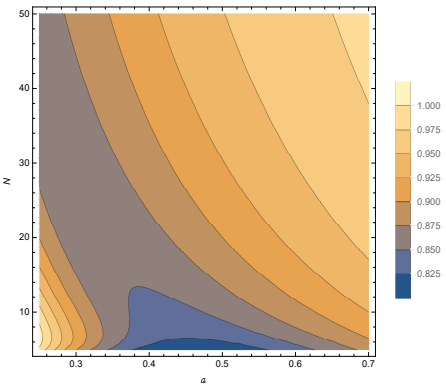

Figure 1: Spin squeezing in the class of states $\{D_{N-1,1}\}$

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