

Spin-1/2 one- and two- particle systems in physical space without eigen-algebra or tensor product

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Abstract

A novel representation of spin 1/2 combines in a single geometric object the standard Pauli spin operator and spin state. Under the spin-position decoupling approximation it consists of the sum of three orthogonal vectors comprising a gauge phase. In the one-spin case the representation: (1) is Hermitian; (2) endowed with handedness; (3) yields all standard results, including the total spin angular momentum $S = (\hbar/2)\sqrt{3}$; (4) relates basis spins by proper rotations, thus preserving handedness; (5) allows formalizing irreversibility in spin measurement. In the bipartite case: (1) entangled spins have precisely related gauge phases and opposite handedness; (2) maximally entangled spins relate by one of the four improper rotations in 3D: plane-reflections (triplets) and inversion (singlet); (3) the full spin expressions yield the standard total two-spin angular momentum; (4) all standard expected values for bipartite observations follow. Depending on whether spin operations act one – or two – sided, the formalism appears in two complementary forms, the ‘spinor’ or the ‘vector’ form, respectively. The proposed scheme provides a clear geometric picture of spin transformations and correlations in the 3D physical orientation space.

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