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Entanglement Suppression, Quantum Statistics and Symmetries in Spin-3/2 Baryon Scatterings

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We explore the interplay among entanglement suppression, quantum statistics and enhanced symmetries in the non-relativistic S-wave scattering involving the lowest-lying spin-3/2 baryons, which can be considered as four-dimensional qudits. These baryons form a ten-dimensional representation (decuplet) under the $SU(3)$ light-flavor symmetry and, in this limit, are considered indistinguishable under strong interactions. Treating the S-matrix in the spin-3/2 baryon-baryon scattering as a quantum logic gate in the spin space, we study the consequence of entanglement suppression and compute the entanglement power of the S-matrix. When the entanglement power vanishes, the S-matrix is either an Identity or a SWAP gate and spin-flavor symmetries and/or non-relativistic conformal invariance emerge, as previously observed in spin-1/2 baryons. In the case of scattering identical particles, the entanglement power never vanishes due to constraints from spin statistics, which we interpret as projection-valued measurements onto symmetric or antisymmetric Hilbert space and define the entanglement power accordingly. When the entanglement power is non-vanishing but sits at a global or local minimum, enhanced symmetries still emerge and the S-matrix can be interpreted as an Identity or a SWAP gate acting on the restricted Hilbert space allowed by quantum statistics. In general, when scattering identical spin-s particles, we identify an enhanced $SU(2s+1)$ spin symmetry for the Identity gate.

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