The effect of an uniaxial single-ion anisotropy on the quantum and thermal entanglement of a mixed spin-(1/2,S) Heisenberg dimer

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An exact analytical diagonalization method is used to study the quantum and thermal entanglement of the antiferromagnetic spin-(1/2,S) Heisenberg dimer with the help of a concept the negativity. Under the assumption of non-zero uniaxial single-ion anisotropy affecting the higher spin-S ($S > 1/2$) entities only, the ground-state degeneracy $2S$ is partially lift and the ground-state is two-fold degenerate with the total magnetization per dimer $S-1/2$ ($1/2-(2S \mod 2)/2$) for the easy-axis (easy-plane) anisotropic single-ion anisotropy. It is shown that the maximal quantum entanglement is reached for the antiferromagnetic ground state of a mixed spin-(1/2, S) Heisenberg dimer with an arbitrary non-integer spin-S atom, regardless of the easy-plane single-ion anisotropy. Contrary to this, the degree of a quantum entanglement in a mixed spin-(1/2,S) Heisenberg dimer with an integer spin-S atom for the easy-plane single-ion anisotropy, exhibits a decreasing tendency with an obvious spin-S driven crossing point. It is furthermore shown that the increasing spin-S magnitude is a crucial driving mechanism for an enlargement of a threshold temperature above which the thermal entanglement vanishes. As a result, the easy-plane single-ion anisotropy together with an enlargement of the spin-S magnitude, is other significant driving mechanism for an enhancement of a degree of the thermal entanglement in a mixed spin-(1/2,S) Heisenberg dimer.