Dynamics of Entangled Spins under Correlated Classical Random Magnetic Fields with Sustainable Entanglement via Spin Energy Interaction

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Entanglement in quantum mechanics is useful in quantum communication protocols like quantum teleportation and superdense coding enabling the communicating parties sharing maximally entangled pair of qubits to communicate secured information (C. Bennett et al., 1993). Entanglement survival is to be understood by the behaviour of entangled states (herein, the spin-$\frac{1}{2}$ quantum states subjected to stochastic magnetic field fluctuations) in the presence of disturbances. The dynamics of a single spin-$\frac{1}{2}$ particle in its pure state evolving into a random pure state, in the presence of a random magnetic field (T. R. Field and A. D. Bain, 2013) forms a foundation for the case of a pair of maximally entangled spin-$\frac{1}{2}$ particles that are spatially separated, influenced generically by correlated random fields (V. S. S. P. Pydimarri and T. R. Field, Jan 2023). The dynamics of a general case of the joint state of pair of entangled spins (which need not necessarily be maximally entangled initially) under correlated random magnetic fields via the random Hamiltonian (without the spin interaction) give rise to a quantum spin-exchange energy interaction. These dynamics under which the random pure entangled state evolves can be parameterized by a stochastic exchange operator process which is mean reverting, indicating an emergent steady state characteristics. This parametric process in particular characterizes the dynamics in the special case of an initial state that is one of the maximally entangled (Bell) states (V. S. S. P. Pydimarri and T. R. Field, Jan 2023). Accordingly we are led to understand how a partially entangled state can be controlled via a parametric operator process when the constituent spins are subject to random fields. The steady state indicates the partial entanglement that persists within the system of entangled spin-pairs under these circumstances.