Quantum Skyrmion Qudit in a Triangular-lattice magnet

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Quantum Skyrmions have highly unusual properties as compared to the classical Skyrmions and, due to their quantumness, cannot be described by continuous magnetic textures akin to the classical Skyrmions. Competing nearest-neighbor and next-nearest-neighbor ferromagnetic and antiferromagnetic interactions in triangular spin-frustrated magnets lead to the formation of quantum Skyrmion states. In frustrated magnets, Skyrmions are characterized by the helical degree of freedom, which can store quantum information. In the limit of a weak electric field, the system can be described as a two-level system, i.e., a Skyrmion qubit. Here, we propose a general formulation of the problem and obtain general analytic solution. Our solution is valid not only for small barrier but for the arbitrary electric field. In the case of a significant barrier, we prove that the system's state is not a Skyrmion qubit as it was thought before, but a Skyrmion qudit. We constructed the density matrix of the Skyrmion qudit and studied its evolution in time. The obtained results suggest that the proposed model can be exploited further to meet the needs of quantum information theory and quantum skyrmionics. We showed that the l_1 norm of coherence of the Skyrmion qudit is a thousand times larger than the coherence of the Skyrmion qubit. The obtained result opens new perspectives for quantum skyrmion-based resource theory.