Dynamics of Bloch points in regularized micromagnetic S3-model

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Magnetic singularities known as Bloch points (BPs) present a fundamental challenge for micromagnetic theory, which is based on the assumption of a fixed magnetization vector length. Due to the divergence of the effective field at a BP, classical micromagnetics fails to adequately describe BP dynamics. To address this issue, we propose a regularized micromagnetic model in which the magnetization vector can vary in length but not exceed a threshold value. More specifically, the magnetization is treated as an order parameter constrained to a S3-sphere. This constraint respects fundamental properties of local spin expectation values in quantum systems. We derive the corresponding regularized Landau–Lifshitz–Gilbert equation and the analogue of the Thiele equation describing the steady motion of spin textures under various external stimuli. We demonstrate the applicability of our theory by modeling the dynamics of several magnetic textures containing BPs, including domain walls in nanowires, chiral bobbers, and magnetic dipolar strings [2]. The presented results extend micromagnetic theory by incorporating a regularized description of BP dynamics.

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