Analytical description of quasi-random magnetization relaxation to equilibrium

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Magnetization relaxation processes appear in many situations of fundamental and technological interest, such as the operation of spin valve elements, precessional switching of the magnetization or switching induced by spin polarized currents.

Due to the fact that the damping constant in the Landau-Lifshitz (LL) equation is a small quantity, two widely different time scales are present in the relaxation process: a fast one, over which precessional (conservative) motion of the magnetization occurs, and a slow one, over which the free energy of the system relaxes to its final equilibrium value.

By carrying out averaging of the LL equation with respect to the fast time scale, the differential equation which governs the slow decay of the system free energy is derived. The derivation is based on the knowledge of the trajectories of the ‘unperturbed’ (undamped) conservative motion which can be analytically determined.

It turns out that the above averaging technique (and the mentioned separation of time scales) breaks up when relaxation leads magnetization to cross the separatrices (trajectories ending or starting at saddle equilibria) of the unperturbed conservative motion.

In this work, we discuss how it is possible to extend the averaging technique in presence of this separatrix crossing [1]. Interestingly, due to the small damping constant, this phenomenon gives rise to a quasi-random behaviour in magnetization relaxations [2].

This means that, in presence of multiple stable equilibria, very small perturbations of the initial condition may induce magnetization to relax to one or another stable equilibrium.

In this case, it is clear that small perturbations in the initial conditions may lead to different magnetization relaxations, which in the limit of small damping can be described in probabilistic terms.

REFERENCES
