Analysis of spin-torque driven magnetization dynamics in saturated disks

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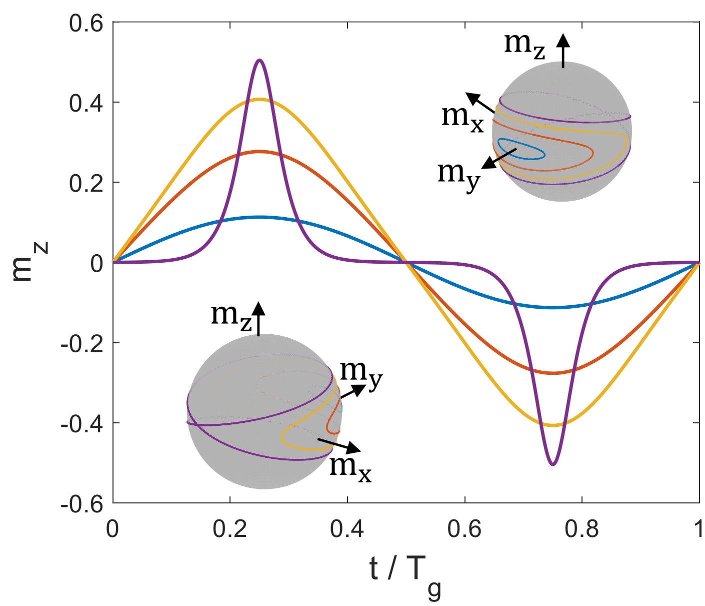
The functioning of magnetic nanotechnology is based on the complex features of nonlinear magnetization dynamics [1]. For example, in spintronic devices, magnetic fields or spin-polarized currents of appropriate strength are able to switch the magnetization in bistable magnetic particles or excite magnetization self-oscillations. These basic operations are building blocks to realize future nanotechnologies for microwave signals generation and detection, neuromorphic computation, and energy harvesting [2]. In the case of spin-torque nano-oscillators, the spin-polarized current is able to sustain continuous magnetization precession suppressing the dissipative effects. Such complex interplay is studied via the Landau-Lifshitz equation augmented with the Slonczewskii spin-transfer-torque (LLS). The LLS equation, in its dimensionless form, shows that the damping torque and the spin-transfer torque are small compared to the precession torque. This relative order of magnitude produces self-oscillation trajectories that are very close to the conservative ones, namely those that conserve magnetic energy. Therefore, closed-form expressions for magnetization trajectories are instrumental for perturbative analysis on magnetization self-oscillations [1]. In this work, a soft-magnetic disk saturated in the plane is considered. The analytical expressions of the conservative magnetization trajectories are obtained in terms of Jacobi elliptic functions consistently with previous studies. Starting from this result, spin-torque-driven magnetization self-oscillations are studied with a perturbative approach that makes use of the Melnikov function [1]. Eventually, the microwave power emitted by the device is computed as a function of the spin-polarized current value and the in-plane magnetic field.
In the figure, the z-component of 4 conservative trajectories as a function of time, which correspond to 4 different values of energy, are displayed. The insets are the same trajectories shown on the unit sphere of the (m_x, m_y, m_z) space. For each trajectory, time is normalized to the oscillation period of the same trajectory.



References

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