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The Response of an Uniaxial Ferromagnetic Nanoparticle to a Spin-polarized Current

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The actuality of the considered problem is originated from the practically reasons firstly. Since bistable states of ferromagnetic particle magnetic moment can be associated with the binary bit, such particles are widely used in modern media-devices. In this regard one should underline the patterned media HDD and MRAM devices. The writing process here physically needs the remagnetization of a particle, which can be performed in a few ways. The simplest of them imply the application of the external field. But actually the remagnetization can be assisted by heating or spin-polarized current.

The deep understanding of the magnetic moment forced dynamics is a key to fast and reliable writing process. In this study we use the Landau-Lifshitz-Gilbert equation to explore the stable motion of the nanoparticle magnetic moment. The action of spin-polarized current is interpreted on the effective field term in the Slonczewski-Berge form $\mathbf{h}_c = \beta \mathbf{s} \times \mathbf{m}$, where β is a coefficient, which is proportional to the current, **s** is the vector of spin polarization, **m** is the nanoparticle magnetic moment. It is implied that a circularly polarized field, rotated in the plane, perpendicular to the easy axis, can be also applied.

The analytical results have been obtained for the following cases. **1.** The permanent spin-polarized current flow in the way, when spin polarization **s** is *parallel* to the easy axis. In addition, the circularly polarized field is applied as well. **2.** The alternating spin-polarized current flow in the way, when spin polarization **s** is parallel to the easy axis. Here small anisotropy limit is considered. **3.** The alternating spin-polarized current flow in the way, when spin polarization **s** is *perpendicular* to the easy axis. In addition, the circularly polarized field is applied as well.

The derived exact expressions allow us to establish the relationship between the parameters of the external action and the **m** trajectory characterizations. In turn, now we can analyze the conditions of the optimal control of the magnetic moment dynamics. In particular, together with the common amplitude-frequency characteristics of the field the current density is discussed. This especially interesting because of the current can produce the particle heating, which assist the writing process as well.