Bistability and bifurcations in the dynamics of coupled identical spin-torque vortex oscillators

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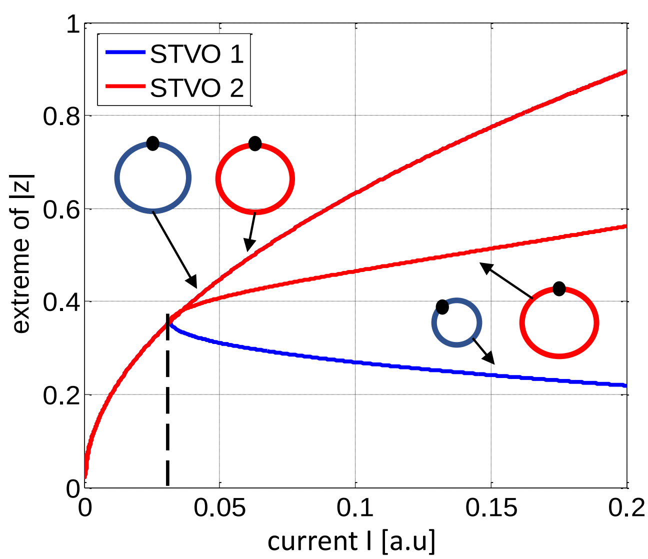
Spin-torque vortex oscillators (STVOs) are promising candidates for microwave power generation and detection, neuromorphic computations, and energy harvesting [1]. In this area, the problem of the coupled STVOs dynamics is of crucial importance for its impact on the performances of systems based on STVOs.
In this work, we investigate the nonlinear dynamics of a system of two coupled identical STVOs. We model the system by two linearly coupled Stuart-Landau equations (SLEs) that govern the dynamics of the in-plane vortex core displacements of the two STVOs. These displacements are represented by the complex variable z_1 and z_2, respectively. The system has the exchange symmetry property [2]. This means, that for a given trajectory $(z_1(t), z_2(t))$, there exists another trajectory obtained by the transformation $(z_1, z_2) \to (z_2, z_1)$. In this context, we study bifurcations in the four-dimensional space (z_1, z_2) by changing the spin-polarized current and the coupling strength. When the current is changed, we show that stable self-oscillations with both $z_1(t) = z_2(t)$ and $z_1(t) \neq z_2(t)$ are observable. The transition between these two different dynamical regimes occurs via a pitchfork bifurcation of limit cycles. Bifurcations occurring when the coupling strength is changed are also investigated. In this respect, it is shown that the transition between stable self-oscillations occurs in correspondence of homoclinic connection bifurcations. We finally discuss how this type of bifurcation leads to bistability. In the figure, the extremes of the trajectory for each STVO are shown as a function of the normalized spin-torque current. The vertical black dotted line indicates the threshold current for the pitchfork bifurcation, after which, two exchange-symmetric trajectories with $z_1(t) \neq z_2(t)$ are stabilized and that one with $z_1(t) = z_2(t)$ becomes unstable.



References

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