PHASE LOCKING OF A SPIN TRANSFER OSCILLATOR TO AN EXTERNAL MICROWAVE CURRENT : A MILESTONE FOR THE SYNCHRONIZATION OF A LARGE ASSEMBLY OF STOS

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STOs (Spin Transfer Oscillators) are non-linear oscillators very promising for applications in next generation telecommunication devices[1,2]. However the increase of the output power is a major challenge since the emitted power by a single STO is far too weak (< 1 nW). A solution is to achieve the synchronization in frequency and phase of an array of STOs [3]. Experimentally a first proof of synchronization of two close packed STOs has been given in 2005, independently by Kaka *et al.* and Mancoff *et al* [4,5]. In both cases, the coupling needed for synchronization was mediated by interacting spin waves generated by the spin transfer torque in a common magnetic layer. However the spatial extension of the spin wave excitation, of the order of the µm, could be a strong drawback for its integration in large assemblies of STOs.

We have recently proposed an alternative scheme for the synchronization of STOs [6], that has the advantage to rely on a global coupling: each oscillator of the assembly is equally interacting with all the others. In fact, STOs are simply electrically connected to each others either in series or in parallel. The coherent emission of all STOs is governed by the coupling through the common self-generated (in each STO) microwave current that imposes a phase locking of the ensemble.

Here, we successfully demonstrate the phase locking of a single STO to an external source generated by a microwave source. Our results are in agreement with experiments made by the NIST group in Boulder on STO nanocontacts [3].

To go further, we study in detail the influence of the intrinsic characteristics of the STO such as the linewidth, the agility in current or the power amplitude on the coupling efficiency. We clearly observe the major role played by the noise on the ability of STOs to phase lock to external signals. Moreover, we analyze our results in the frame of the model of weakly forced oscillators [7,8]. From our calculations we can extract the coupling parameter ε, that determines the coupling strength between the STO and the external microwave signal. The predicted ε depends on experimentally available parameters such as linewidth, agility, dc current etc. Our experimental results are in very good quantitative agreement with our calculations. We will then show how our calculations can be extended to the case of the mutual synchonization of an assembly of electrically connected STOs.

We believe that we gain through our study a clearer understanding of the conditions for successful synchronization of a large amount of STOs via a non local coupling such as the self emitted microwave current but also via a local coupling such as spin waves or hf dipolar field.

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