ESONN' 2020 European School On Nanosciences and Nanotechnologies

Virtual practicals & on-line tutorials

N°16: Spintronics Based Radiofrequency Nano-Oscillator: From Spin Polarized Current Induced Excitations towards Applications

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Spintronics associates spin polarized transport properties with magnetic properties in magnetic/non-magnetic thin film heterostructures. This provides novel functionalities to spintronic devices that are of interest for the information and communication technologies (e.g. read head and magnetic random access memory). Since the response of the magnetization to external perturbations is a precession of the magnetization around its equilibrium (similar to a spinning top), spintronic devices can also act as nanoscale microwave signal generators and detectors. This is achieved through one of the most important properties which is the spin momentum transfer from a spin polarized current to the local magnetization. The torque generated from the spin momentum transfer, counteracts the intrinsic damping torque of the precession and generates a multitude of different functionalities (see Fig. below). For instance spin transfer torque can drive the magnetization into large angle auto-oscillations that are converted into an electronic signal via the magneto-resistance. This effect allows one to study the intrinsic non-linear dynamic properties of nanoscale magnetic devices.

In this on-line practical the students will be introduced to: (i) the basics of spintronics devices (magnetic tunnel junctions); (ii) the non-linear magnetization dynamics under spin momentum transfer; (iii) the applications and (iv) the microwave measurement techniques using a spectrum analyzer, oscilloscope and/or signal generator to perform experiments on the characterization of the signal generation, modulation and synchronization.

After introduction of the basic concepts, we will go step by step through the experimental set-up to explain the different components and measurement procedures. From pre-registered data we will explain the treatment and analysis of the data, that the students can do in part by themselves. The demonstrations will be interactive with a set of questions that the students will have to answer to better understand the demonstration.

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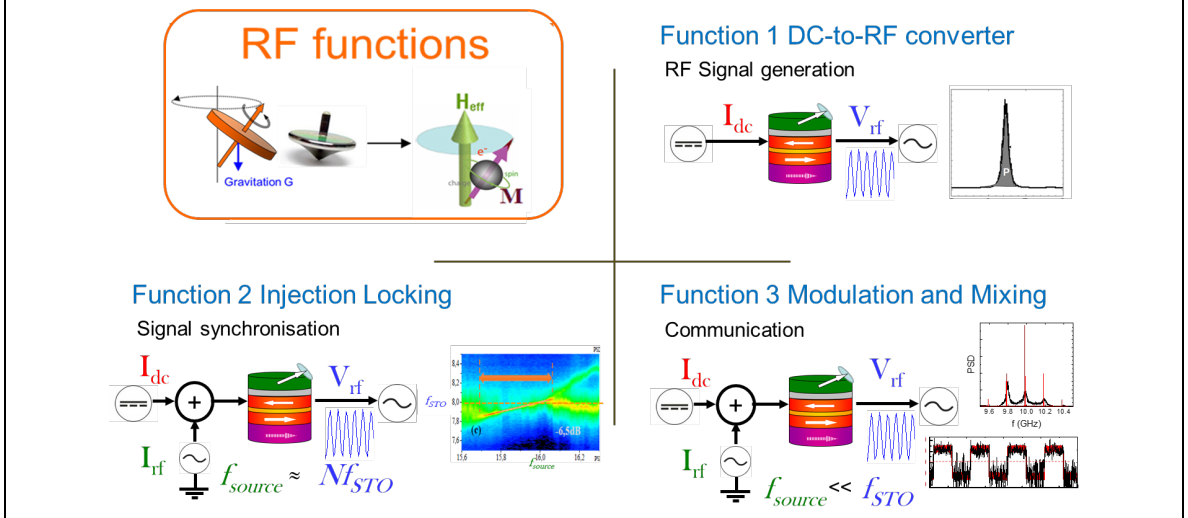

Figure 1: Top left: Equivalence of a spinning top and the magnetization dynamics; Top right: RF-DC conversion: injection of a DC spin polarized current results in an rf voltage signal due to steady state excitations. Bottom: By adding an additional RF current one can (left) injection lock the device ($f_{source} \approx f_{STO}$) or (right) frequency modulate the output signal ($f_{source} << f_{STO}$).