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.

The aim of the practical is to introduce the students to (i) microwave measurement techniques using a spectrum analyzer, oscilloscope and/or signal generator and (ii) to the basics of spintronics devices (magnetic tunnel junctions) and the associated non-linear magnetization dynamics under spin momentum transfer.

The students will first establish the electrical measurement circuit by connecting the device via a high frequency probe, bias T and amplifier to a spectrum analyzer and oscilloscope. Then they will study the excitations from low current (damped oscillations – linear modes) to high current (steady state excitations) to observe the non-linear frequency shift, linewidth reduction and power and will learn how to manipulate the excitation mode with the spin polarized current. These studies will be followed by either injection locking the devices to an external rf signal or by modulating the frequency via an external rf signal, to reduce the linewidth of the devices or to generate modulation sidebands.

The practical work will be based at the Institute of Interdisciplinary Research (IRIG) at CEA Grenoble. (http://www.spintec.fr)

Level requested: Master of Science in Physics, Material's Science or Nanotechnology.

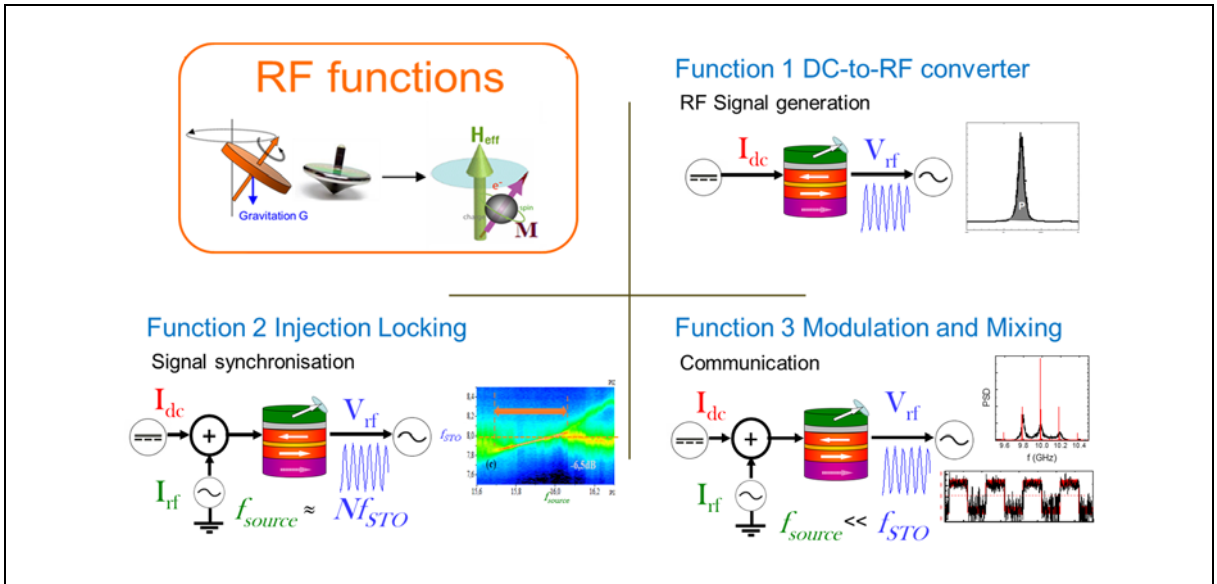

Figure 1: Top left: Equivalence of a spinning top and the magnetization dynamics; Top right: RF-DC conversion: injection of a DC spin polarized current results in an rf voltage signal due to steady state excitations. Bottom: By adding an additional RF current one can (left) injection lock the device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