

« Coherent microwave nano-oscillator arrays integrable on a monolithic circuit »

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PRIMARY OBJECTIVE:

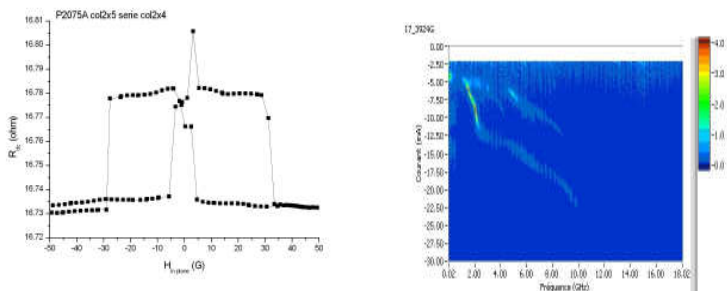
The main objective of the **NanoMASER** proposal is a fundamental study on stimulated amplification of the magnetization precession by spin momentum transfer from a spin polarized current. The effect bears some strong similarities with the light amplification found in LASER: a continuous current is converted into microwave radiation through stimulated emission of spin-wave. Our project specifically addresses the bottleneck issue of power conversion efficiency. The microwave output power of a single device is too weak (~pico Watt) at the moment to be of any practical use. We propose to take advantage of phase-locking between non-linear coupled oscillators to significantly increase the device performance.

Achieving phase-locking between neighboring oscillators also requires substantial progress in our understanding of the **fundamental** mechanisms that are involved in the transfer of spin angular momentum from spin-polarized current to the precessing moment of the magnetic layer. Our research objectives are:

- Identification (spatio-temporal profile and relaxation times) of the fundamental spin-wave eigen-modes excited by a dc current in nano-structured magnetic heterojunctions.
- Study of the **phase-locking** phenomena between the eigen-modes of elementary nano-pillars.
- **Optimization** of the emitted microwave power

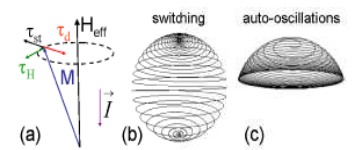
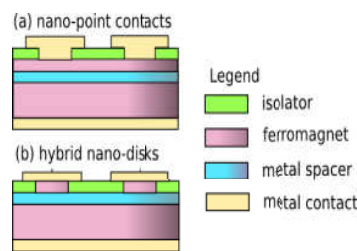
The pivotal idea is to progress beyond the present state of the art with respect to the type of experiments performed in this system. We plan to use an original and sensitive detection method to study, in an **individual** nano-device, the spin-wave spectrum excited **both** by a **microwave field** and by a **continuous current**. The aim is to perform a thorough characterization of the dynamics induced by spin-momentum transfer, to identify the selection rules, to measure the damping parameter and the behavior in the non-linear regime. Optimization attempts of the synchronization between oscillators will be done by playing on the nature of the confinement, the geometry of the assembly and the nature of the materials or interface. On the theoretical side, we shall make efforts to progress in the understanding of the physics underlying the microwave power generation associated to spin-momentum transfer effects as well as the basic mechanisms responsible for the phase-locking phenomena between non-linear coupled oscillators.

CPP-GMR characteristics:

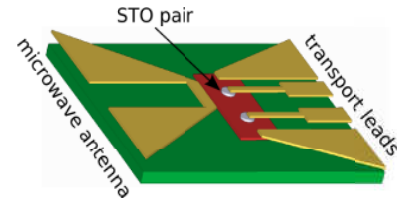
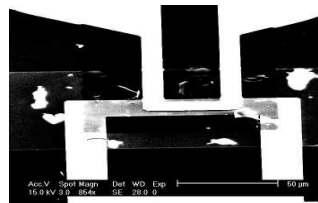


Power spectrum of the auto-oscillation dynamics for a 300nm diameter hybrid STO, perpendicularly magnetized by a 3.924 kOe perpendicular bias field.

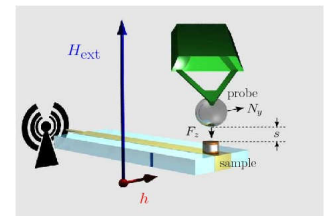
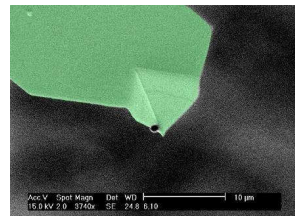
The samples categories:



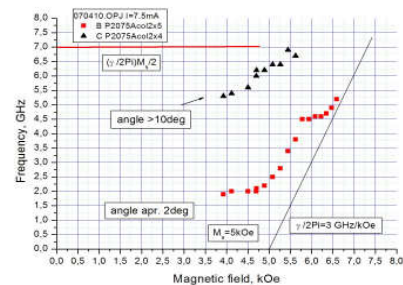
Schematic representation of torques acting on the magnetization **M** of a nanomagnet. For large enough current densities, the spin-torque overcomes the dissipation and the magnetization moves away from **H_{eff}**. (b) Magnetization trajectory for a field below the critical field – the magnetization switches between energy minima. (c) Trajectory in a field above the critical field – the average magnetization vector reaches a limit cycle and persistently auto-oscillates under the action of the direct spin-polarized current.



- The three instruments:
- (1) Magneto-Transport measurements.
 - (2) Cavity-FMR.
 - (3) Mechanical-FMR:



SEM image of a 700nm diameter Fe sphere glued at the tip of an AFM cantilever. (b): Schematic of the mechanical-FMR setup.



Dispersion curve of two separate STOs, showing the statistical distribution of nano-oscillators characteristics between samples.