

# Seminario Tecnico

## Spintronics: state-of-the art and future!

**Speaker:** Prof. Giovanni Finocchio (Università di Messina)

### *Abstract*

The spintronic technology takes advantage of the manipulation of the electron spin together with its charge. This technology potentially combines important characteristics such as ultralow power needs, compactness (nanoscale size) and it is CMOS-compatible. Spintronics has different success stories such as the head read for magnetic hard drive and the recent spin-transfer-torque magnetic random access memories. The latter are realized with magnetic tunnel junctions (MTJs) which are devices composed by two ferromagnets separated by a ultrathin isolating material. The resistance of this device depends on the relative orientation of the magnetization of the two ferromagnets and in particular the configuration where the magnetization are parallel or antiparallel can code the binary information. In this talk, I will present recent breakthroughs in the field and future directions. In particular, I will discuss the applications of spintronic diodes based on MTJs for energy harvesting, sensors and RF detectors and what it is expected to achieve in the next three years for integration with CMOS-technology. The second part of the talk will discuss theoretical prediction on how VCMA can be used to excite linear and parametric resonant modes in easy-axis antiferromagnetic materials AFMs with perpendicular anisotropy, thus opening the way for an efficient electrical control of the Néel vector, and for detection of high-frequency dynamics. In particular, our work leads to two key results: (i) VCMA parametric pumping experiences the so-called "exchange enhancement" of the coupling efficiency and, thus, is 1-2 orders of magnitude more efficient than microwave magnetic fields or spin-orbit-torques, and (ii) it also allows for zero-field parametric resonance, which cannot be achieved by other parametric pumping mechanisms in AFMs with out-of-plane easy axis.

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I will also discuss the key ingredients of high-performance spintronic devices, in general, focusing on their possible use in “Internet of Things” nodes (e.g. energy harvesting, physical unclonable functions, GHz and THz oscillators and detectors). Finally, I will present current exciting research directions including skyrmionics, skyrmion-caloritronics, antiferromagnetic spintronics, neuromorphic computing, and unconventional computing approaches. In the former topic, I will show how spintronic diodes can be used to perform analog multiplication and how magnetic tunnel junctions can be used for the realization of activation function of neurons. The latter will focus on probabilistic computing which is nothing than a way to implement Ising Machines, a computational paradigm using probabilistic bits (p-bits), unit in the middle between standard bit and q- bits. I will show how to map hard combinatorial optimization problems (Max-Sat, Max-Cut, etc) into Ising machine and how to implement those in spintronic technology.

**Data: 19/01/2023**

**Ore: 11:00**

**Saletta Riunioni - Edificio D, Primo Piano**

**GoogleMeet: <https://meet.google.com/gbu-ywgd-tpn>**