Università Ca'Foscari Venezia

PROJECT ACRONYM AND TITLE: **Understanding and controlling magnetic inertia: towards terahertz spin-based technologies**

FUNDING PROGRAMME: **PRIN 2020**

HOST DEPARTMENT: **Department of Molecular Sciences and Nanosystems**

SCIENTIFIC RESPONSIBLE: **Stefano Bonetti**

FINANCIAL DATA:

Project total costs	Overall funding assigned to UNIVE
€ 505.357,00	€ 188.025,00

ABSTRACT:
The energy consumption of digital information is the fastest increasing item in the global energy balance, directly correlated with the ever-increasing data transfer from large-scale data centers, which rely magnetic technology for storing and writing information. The understanding of how spins, the building blocks of magnetism, move and can be manipulated at their fundamental ultrafast (pico- and femtosecond) timescales has implications for energy-efficient data-processing and storage applications in the data centers worldwide. However, the possibility of realizing novel commercial technologies based on such ultrafast spin dynamics has been hampered by our limited knowledge of the physics behind processes at these timescales. Recently, we detected for the first time the experimental evidence of intrinsic inertial effects in thin ferromagnetic films, in the form of a nutation of the magnetization at a frequency of ~0.5 THz, i.e. with a period of a few picoseconds. Right after our experiment, a first attempt of encoding information with picosecond electrical pulses has been made, which makes the understanding of magnetic inertia a fundamental and timely requirement for advancing this area of technology.
This proposal suggests a cohesive approach to achieve an encompassing view of inertial spin dynamics in metallic ferromagnets, via three work packages. The first one aims at measuring inertial dynamics (i.e. spin nutation) driven by strong THz radiation in several magnetic materials using table-top femtosecond lasers and free electron laser radiation; the second is dedicated to the growth and synthesis of different magnetic systems, epitaxial thin films and nanoparticle assemblies, in order to explore how microscopic (intrinsic) and, respectively, mesoscopic (extrinsic) properties affect the spin nutation. The last work package's goal is to develop an analytical and numerical theory for inertial spin dynamics able to describe the experimental evidence in a fully consistent way. Preliminary experiments on different epitaxial thin cobalt films show that different structural order and magnetic anisotropy affect the nutation frequency in a tangible way, laying the foundation for the research plan in this proposal. The proposed investigations are challenging and explore unchartered territories: we anticipate that they will advance the fundamental understanding of inertial spin dynamics and of ultrafast control of magnetization, with potential implications for future spin-based technologies.

PARTNERSHIP:

1 Università Ca' Foscari di Venezia	**Venezia (IT)**	**Coordinator**
2 Consiglio Nazionale delle Ricerche	**Roma (IT)**	**Partner**
3 Università degli Studi di Napoli Federico II	**Napoli (IT)**	**Partner**