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Supervisor Expression of Interest
MSCA-IF Marie Sklodowska Curie Action-Individual Fellowship

Supervisor name:	Marco Finazzi
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Department Name: Research topic: (https://www.polimi.it/en/scientific-research/research-structures/departments/)	Physics Departments Spin transport in metals and semiconductors
MSCA-IF Research Area Panels	☐ CHE_Chemistry ☐ ECO_Economic Sciences ☐ ENG_Information Science and Engineering ☐ ENV_Environmental and Geosciences ☐ LIF_Life Sciences ☐ MAT_Mathematics **X PHY_Physics** ☐ SOC_Social Sciences and Humanities
Politecnico di Milano Areas:	☐ Cultural Heritage ☐ Smart Cities ☐ Territorial Fragilities ☐ Health **X Industry 4.0**
Brief description of the Department and Research Group:	The Physics Department (www.fisi.polimi.it) comprises five main research lines that together represent a very collaborative and stimulating environment covering all aspects of photonics and nanoscience: (i) Ultrashort light pulse generation and applications to the study of ultrafast phenomena in the matter; (ii) Solid state lasers and photonic devices; (iii) Photonics for health, food and cultural heritage; (iv) Epitaxial growth and nanostructure fabrication; (v) Electronic, optical and magnetic properties of low-dimensional systems. The SemiSpin laboratory, where the activities of the project will be carried on, accommodates microscopy and magneto-optics facilities dedicated to the generation of spin in semiconductors via optical orientation and to the study of spin diffusion and spin-charge interconversion effects in solid-state materials.

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Brief project description:	The manipulation of spin currents for information and communication technologies is the goal of spintronics (spin-transport electronics or spin-based electronics), as much as controlling charge currents is the key ingredient of electronics. Spintronics has already demonstrated a huge potential in consumer electronics and has stirred a technological revolution in the field of mass storage media [1,2]. Spin-based devices that have already made their way to the market are either magnetic field sensors or memory devices. The analogy between electronics and spintronics, however, cannot be pushed very far, since spin, at variance with charge, is not conserved in solids. The aim of the project is to address the fundamental laws of spin transport in solid state materials. The study of spin transport, dynamics and relaxation will thus be of paramount importance within the project. Another fundamental issue will consist in the investigation of spin-dependent diffusion mechanisms leading to spin-charge interconversion, which is the ground for the realization of assets where charge and spin functionalities might be exploited in the same device. Materials of choice will be those endowed by a high spin-orbit interaction, with particular attention to 2D materials where spin-to-moment locking occurs and spin-charge interconversion is very effective [3]. In general, very detrimental for exploiting the spin degree of freedom in applications is the fact that amplification, which is ubiquitous in electronics, still has no counterpart in spintronics. For this reason, the project also aims to finding mitigation strategies to compensate for the lack of spin amplification. One of these is suggested by the active role that collective excitations known as paramagnons play in spin transport across a paramagnetic material [4]. The spin-polarized electrons flowing in a non-magnetic (paramagnetic) material can in fact polarize the local magnetic moments at each lattice site. This phenomenon can be viewed as if the electrons were effectively “dressed” in paramagnons, resulting in a net enhancement of the total spin carried by each electron [4]. The final goal will be to investigate and exploit the role of paramagnons in enhancing spin-to-charge interconversion effects. [1] I. Žutić *et al.*, Rev. Mod. Phys. **76**, 323 (2004). [2] S. A. Wolf *et al.*, Science **294**, 1488 (2001). [3] C. Zucchetti, M. Finazzi *et al.*, Phys Rev B **98**, 184418 (2018). [4] M. Finazzi *et al.*, Sci. Rep. **8**, 17108 (2018).