Modelling of thermal processes for spintronics

12 months - postdoctoral researcher

Offer Description. Positioned at the crossroad of science and technology, SPINTEC (SPINtronique et TEchnologie des Composants) is one of the leading spintronics research laboratories worldwide. SPINTEC objective is to bridge fundamental research and innovative devices technology in the fast-growing field of spin electronics (spintronics). Ideally located on the MINATEC campus in France, SPINTEC unique positioning brings together top-level scientists and applicative engineers that work in close collaboration in order to ensure that new spintronics paradigms can be swiftly translated into technology proof of concepts and functional devices. As such, the outcome of the laboratory is not only scientific publications and communications in international conferences, but also a coherent patents portfolioand implementation of relevant functional demonstrators. The laboratory houses 105 persons of which 42 permanent staff and about 63 Ph.D. students, post-docs and international visitors. SPINTEC is jointly operated by CEA, CNRS, UGA, G-INP and located in Grenoble, France.

Scientific context. Spintronics, or spin electronics, is the new field to which the global electronics industry is now turning. The SpinTronicFactory (STF) is one of the majorEuropean networks, that promotes European research and innovation in spintronics and involves academic and industrial players from all over Europe. Today STF has 87 partners from 17 different countries. In France PEPR SPIN is a multi-year plan that aims to raise the TRL of several spintronic components, while building up an appropriate experimental and theoretical base. PEPR SPIN also aims to promote academic and industrial networking in France. However, in addition to the imperatives of supporting the national microelectronics industry, there are many scientific and technical issues that are poorly addressed by these networks. In particular, the modeling tools needed by industry must be able to be integrated into professional software packages for simulating electronic circuit architecture. These software packages need the macroscopic laws of magnetic devices specific to spintronics, which are obtained by models describing the behavior of magnetic materials at lower scales. In principle, micromagnetic theory describes this behavior, but faces several limitations thatrestricts itselfto describeferromagnetic materials, whereas the nature of the magnetic materials envisaged for frugal, agile and sustainable spintronics also includes ferrimagnetic and anti-ferromagnetic materials. On the other hand, and more profoundly, the very natureof its magnetization dynamics is not correctly described when magnetic moments are coupled to athermal bath. Integrating temperature via a fluctuating field in the Landau-Lifshitz-Gilbert (LLG) equation is common practice, but far from rigorous and reliable. This calls for a radical change of simulation paradigm. We propose a new approach based on a more flexible non-equilibrium form of Landau-Lifshitz-Bloch (LLB) formalism, capable of accounting for the impact of thermal reservoirs on the behavior of magnetic materials properties.

Scientific objectives. The design and development of innovative, high-performance spintronic devices requires adequate predictive modeling combining a multitude of interactions (e.g. exchange, anisotropy, spin transfer torque, etc.). In particular, the coupling of magnetic moments to a thermal (caloritronic) reservoir is proving to be a fundamental ingredient in qualifying the efficiency of a device. The aim of THERMOSPIN project is to include thermal processes based on original non-equilibrium dynamic equations [1]. The project is divided into three stages. i) Complete these equations with spin transfer torques to model a magnetic tunnel junction (MTJ) [2] at a given temperature. ii) Vary the thermal connection during magnetization dynamics by interacting either with a two-temperature model [3,4] to simulate laser pulse heating, or with resistive heating due to the passage of an electric current. iii) Process the magnetostatic interaction to analyze the dynamics of coupled nanostructures (e.g. spintronic nanoscillator array) [5]. THERMOSPIN will contribute to the development of an open-access code with multiple functionalities, capable of addressing the modeling of numerous spintronic devices (memories, nano-oscillators, bio-inspired devices, etc.) that are composed on any kind of magnetic materials.

[1] J. Tranchida, P. Thibaudeau and S. Nicolis, Phys. Rev. E 98, 042101 (2018)
[2] A. A. Timopheev, R. C. Sousa, M. Chshiev, L. D. Buda-Prejbeanu, B. Dieny, Phys. Rev. B 92, 104430 (2015)
[3] F. Jakobs and U. Atxitia, Phys. Rev. B 106, 134414 (2022)
[4] L. Avilés-Félix, L. Farcis, Z. Jin, L. Alvaro-Gomez, G. Li, A. Kirilyuk, A. V. Kimel, Th. Rasing, B. Dieny, R. C. Sousa, I. L. Prejbeanu, and L. D. Buda-Prejbeanu, Sci Rep 11 (1) (2021)
[5] M. A. Castro, D. Mancilla-Almonacid, A. Litvinenko, M. Ibarra Gomez, B. Dieny, S. Allende, L. D. Buda-Prejbeanu, and U. Ebels Sci. Rep. 12, 12030 (2022)

Scientific environment. The fundamental research is mostly operated through collaborative (financed) national and international projectsin many areas such as 2D spintronics, AFMs spintronics, AI, health & biology, magnetic sensors, microwave devices, MRAM, spin insulatronics, spin orbitronics, spin textures, topological spintronics, spintronic IC design and theory/simulation. Moreoverthe applied research is very often carried out in partnership with private actors, as large as major companies (Applied Materials, ST Microelectronics, Thales, Samsung, Seagate, Western Digital Corp,…), SME's (SNR, Singulus, TowerJazz, Toplink Innovation, Headway Technologies, CAPRES,…) or start-ups (Crocus, Menta, Spin Transfer Technologies,…). Spintec has spun-off several start-up companies such as Crocus Technology and more recently HProbe.

Skills/Qualifications

- Applicants must have a recent Ph.D. in Physics, Applied mathematics, Chemistry, or Materials science.
- Expertise in spin dynamics, with track record of implementation/development of numerical methods in large scale simulation codes such as Feelgood, Vampire and/or Lammps. As this position involves a significant amount of numerical code development, the candidate will have prior scientific programming experience.
- Applicants should have excellent writing and communication skills necessary to author technical and scientific reports, publications, and deliver scientific presentations, seminars, meetings and/or teaching lectures.
- Experience of effective collaborations with a team of scientists of diverse backgrounds.

Job Information
Organisation/Company : SPINTEC
Research Field : Physics » Spintronics and Computing : Programming
Researcher Profile : First Stage Researcher (R1), Recognised Researcher (R2), Established Researcher (R3) or Leading Researcher (R4)
Country : France
Application Deadline : 30/09/2023
Type of Contract : Temporary
Offer Starting Date : 1/12/2023
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