SSM
Scuola Superiore Meridionale

Course title:

Micromagnetics and Spintronics

Duration [number of hours]**: 12**

PhD Program [MERC/MPHS/SPACE]**: MPHS**

Name and Contact details of unit organizer(s):

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Course Description [max 150 words]**:**

The Course contents include:

Phenomenology of ferromagnetic media
- Magnetic materials and Maxwell's equations
- Hysteresis loop
- Exchange interaction and spontaneous magnetization
- Magnetostatic dipole-dipole interactions and magnetic domains
- Anisotropy

Micromagnetic free energy and magnetization dynamics
- Micromagnetic free energy
- Brown's equations, micromagnetic Equilibria, nucleation and stability of equilibria
- Stoner-Wohlfarth model
- Gyromagnetic precession, Landau-Lifshitz (LL) and Landau-Lifshitz-Gilbert (LLG) equations
- Qualitative properties of magnetization dynamics.

Micromagnetic dynamics in uniformly magnetized nanomagnets and spintronic devices
- Introduction to Magnetic Recording, magnetization switching
- Ferromagnetic resonance
- Introduction to Spintronics: Giant Magneto-Resistive and Spin-Transfer-Torque effects.
- Spin-Transfer-Torque driven magnetization dynamics
- Magnetization self-oscillations and current-driven switching

Micromagnetic dynamics with spatially nonuniform configurations
- Numerical methods for the solution of LLG equation.
- General formulation of magnetization small oscillations problem in ferromagnets
- Small oscillations in the macrospin approximation
- Linear spin-waves
- Computations of spin-waves spectrum in confined structures.

A glimpse on selected more advanced topics in Micromagnetics and Spintronics
- Thermally-driven magnetization dynamics
- Elements of chaotic magnetization dynamics
- Topologically non-trivial configurations: vortex, Skyrmion
- Spin-transfer-torque driven vortex oscillators

Syllabus [itemized list of course topics]**:**

- Phenomenology of ferromagnetic media
- Micromagnetic free energy and magnetization dynamics
- Micromagnetic dynamics in uniformly magnetized nanomagnets and spintronics devices
- Micromagnetic dynamics with spatially nonuniform configurations
- A glimpse on selected more advanced topics in Micromagnetics and Spintronics

Assessment [form of assessment, e.g., final written/oral exam, solutions of problems during the course, final project to be handed-in, etc.]**:**

The assessment will be based on a final project that consists in writing a report on one of the topics of the course. The report is required to include numerical or analytical computations relevant to a specific problem in Micromagnetics and Spintronics.

Suggested reading and online resources:

Lecture Notes on specific topics of the course will be provided to students during the course. Suggested books:
[1] W.F. Brown, Magnetostatic Principles in Ferromagnetism, North-Holland (1962)
[2] W.F. Brown, Micromagnetics, Robert E. Krieger, Publishing Company (1978)
[3] L.D. Landau, E.M. Lifshitz, Electrodynamics of Continuous Media, Pergamon (1984)
[4] A. Aharoni, Introduction to the Theory of Ferromagnetism, Clarendon Press (1996)
[5] G.Bertotti, I.D. Mayergoyz, C. Serpico, Nonlinear Magnetization Dynamics, Elsevier (2009)