

Scientific Symposium: November 13th 2025

Amphi Becquerel Grand Hall, Ecole Polytechnique

Chair: Karyn Le Hur, CPHT Ecole Polytechnique and CNRS

14h00 – 14h30 + 5 minutes questions

- Helene Bouchiat, LPS Orsay and CNRS

Probing orbital currents in 2D materials

A singular Landau orbital magnetism of graphene, occurring just at the Dirac point was predicted in 1956 by McClure but never detected until recently. It is now understood as a fundamental signature of the characteristic Berry phase of graphene's electronic wave functions.

Using a specially developed, highly sensitive, giant magnetoresistance sensor, it was possible to detect the gate voltage-dependent orbital magnetization of a single graphene layer. These measurements have paved the way for the investigation of orbital currents in 2D materials that cannot be detected in usual transport measurements and inspired experiments on Graphene with a Moiré potential.

Beside the sharp diamagnetic peak at the Dirac point, these experiments revealed sharp paramagnetic peaks surrounding satellite diamagnetic peaks. These findings showing the existence of paramagnetic current loops in 2D systems when the Fermi energy is tuned at the saddle points of the moiré band structure motivate similar investigations of graphene bilayers which are in progress.

- J. Vallejo-Bustamante et al. Science 2021 and Physical Review letters 2023

14h35-15h05 + 5 minutes questions

- Spin transport in unconventional antiferromagnets
 - Aurélien Manchon
 - CINaM, Aix-Marseille university, Marseille France
- In traditional condensed matter textbooks, magnetic materials are classified into three main categories: ferromagnets, ferrimagnets, and antiferromagnets. Since antiferromagnets exhibit a magnetic order with no overall magnetization, one naturally expects no spin polarization in the band structure. In recent years, the discovery of spin-orbit torque in “PT-symmetry broken” antiferromagnets (e.g., CuMnAs, Mn₂Au) and anomalous Hall effect in noncollinear antiferromagnets (Mn₃Sn, MnNiN) has launched an unprecedented effort to revisit this classification, leading to the discovery of new forms of antiferromagnets with spin-polarized bands. At the moment (things move fast), two such classes gather much attention: the so-called altermagnets [1] and p-wave magnets [2]. The former presents a symmetric spin polarization in the Brillouin zone, whereas the latter presents an antisymmetric one. This presentation focuses on the transport properties of these new systems.
- In this seminar, after a general overview of the topic, I will discuss the transport properties of d-wave altermagnets, deriving the phenomenological spin diffusion equation and applying it to magnetic textures [3]. I will also consider the role of electron-magnon interactions and show that charge currents can be accompanied by

magnon current displaying the so-called “magnetic spin Hall effect” [4]. Then, I will move on to p-wave magnets. Using group symmetry analysis, model calculations, and realistic simulations on selected compounds, I will study spin-polarization in the band structure and demonstrate that current-driven torque is possible [5]. Importantly, none of the effect discussed here involve spin-orbit coupling.

- [1] Yuan et al., *Giant momentum-dependent spin splitting in centrosymmetric low-Z antiferromagnets*, Physical Review B 102, 014422 (2020); Smejkal et al., *Emerging Research Landscape of Altermagnetism*, Physical Review X 12, 040501 (2022).
- [2] Hellenes et al., *Unconventional p-wave magnets*, arXiv:2309.01607; Brekke et al., *Minimal Models and Transport Properties of Unconventional p-Wave Magnets*, Physical Review Letters 133, 236703 (2024).
- [3] Manchon, *unpublished*
- [4] Sourounis, Manchon, *Efficient generation of spin currents in altermagnets via magnon drag*, Physical Review B 111 (13), 134448
- [5] Gonzalez-Hernandez et al., *Non-relativistic torque and Edelstein effect in non-collinear magnets*, Nature Communications, 15, 7663 (2024).
- **Short Bio:** Aurélien Manchon received his Ph.D. degree in 2007 from University Joseph Fourier at SPINTEC laboratory in France. He worked as a postdoctoral fellow from 2008 to 2009 at University of Missouri-Columbia and University of Arizona-Tucson in USA. Afterwards, he became an Assistant, then Associate Professor of Materials Science and Engineering at the King Abdullah University of Science and Technology (KAUST), in Saudi Arabia (2009-2019). He is currently a Professor of Physics in the Centre Interdisciplinaire de Nanoscience de Marseille (CiNaM) at Aix-Marseille University (AMU) since 2019. His research interest spans from quantum transport and spin-orbit coupling in condensed matter to chiral magnetism, antiferromagnets, and ultrafast spin dynamics.

15h10-15h40 + 5 minutes questions

Pierre Delplace, ENS Lyon and CNRS

Exceptional robustness of edge states beyond Chern insulators in non-reciprocal scattering networks

Originally discovered in the quantum Hall effect, chiral edge states are, in fact, a remarkable manifestation of a Chern topological phase, whose experimental realizations extend beyond the realm of quantum matter. The robustness of these unidirectional modes against defects and imperfections makes them ideal candidates for the robust transport of information or energy. However, this robustness has its limits, set by the energy gap, which must remain large compared to the amplitude of perturbations. The situation is different for networks of circulators. These nonreciprocal media can develop not only a Chern topological phase but also another topological phase formally analogous to the so-called anomalous Floquet topological phases. Remarkably, these edge states persist under certain types of disorder, particularly

structural disorder, beyond the threshold at which edge modes of the Chern phase are destroyed.

15h45-16h00 Coffee Discussion

Chair: Frederic Piechon, LPS Orsay

16h00-16h30 + 5 minutes questions

Jerome Cayssol (Bordeaux) and Chunxiao Liu (LPS Orsay)

Robust flat bands in honeycomb quantum wire networks

16h35-17h05 + 5 minutes questions

Jean-Eric Wegrowe, LSI Ecole Polytechnique

Phenomenological Transport: Can We Distinguish Effective vs. Real Magnetic Fields?