Mini-rencontre du GDR Meeticc

Vendredi 07 mai 2021
De 13h30 à 15h30

Programme

*Animatrice : Nathalie **VIART**, IPCMS

	Exposé (30 min + 10 min)
13:30 – 14:10	**Kitaev interactions in cobalt honeycomb-lattice oxides** Manila SONGVILAY Institut Néel
14:10 – 14:50	***Pause / discussion libre***
	Exposés (15 min + 5 min)
14:30 – 14:50	**Classical Hall effect: do not forget the surface currents!** Jean-Eric WEGROWE Laboratoire des solides Iradiés (LSI)
14:50 – 15:10	**Resistive switching under pressure in the Mott insulator GaV4S8** Julia MOKDAD Laboratoire PHotonique ELectronique et Ingénierie QuantiqueS (PHELIQS)
15:10 – 15:30	**Evidence of Charge Density Wave transverse pinning by x-ray micro-diffraction** Ewen BELLEC ESRF

First NAME : Manila	last NAME : Songvilay
Affiliation : Institut Néel	

Presentation type : *Long (30 min)*	Talk given in : *English* (please prepare the of the presentation in english)
I authorize the GDR to record a video of my presentation : *YES*	

Kitaev interactions in cobalt honeycomb-lattice oxides

The recent Kitaev model (2006) provides an exact model to achieve a quantum spin liquid ground state in a 2D honeycomb lattice system through Ising-like bond-dependent interactions [1]. While first considered as a toy model, a theoretical work from Jackeli and Khaliullin has paved the way toward the realization of Kitaev physics in bulk materials. They first showed that bond-dependent interactions can be achieved through the interplay between crystal field, spin-orbit coupling and bond geometry using 4d and 5d transition metal ions, that exhibit a strong spin-orbit coupling [2]. Since then, a significant amount of experimental works have focused on iridate and ruthenate compounds to find a suitable candidate material [3].

Co^{2+} ions in an octahedral crystal field stabilize a j_{eff} = 1/2 ground state with an orbital degree of freedom and have been more recently put forward for realizing Kitaev interactions [4], a prediction we have tested by investigating spin dynamics in two cobalt honeycomb lattice compounds, $Na_2Co_2TeO_6$ and $Na_3Co_2SbO_6$, using inelastic neutron scattering. We used linear spin wave theory to show that the magnetic spectra can be reproduced with a spin Hamiltonian including a dominant Kitaev nearest-neighbor interaction, weaker Heisenberg interactions up to the third neighbor, and bond-dependent off-diagonal exchange interactions [5]. Beyond the Kitaev interaction that alone would induce a quantum spin liquid state, the presence of these additional couplings is responsible for the zigzag-type long-range magnetic ordering observed at low temperature in both compounds. These results provide evidence for the realization of Kitaev-type couplings in cobalt-based materials, despite hosting a weaker spin-orbit coupling than their 4*d* and 5*d* counterparts.

Références :

[1] A. Kitaev, Annals of Physics 321, 2-111 (2006)

[2] G. Jackeli and G. Khaliullin, Physical Review Letters 102, 017205 (2009)

[3] S. M. Winter et al., J. Phys. : Condens. Matter 29, 493002 (2017)

[4] H. Liu and G. Khaliullin, Physical Review B 97, 014407 (2018); R. Sano et al., Physical Review B 97, 014408 (2018); H. Liu et al., Physical Review Letters 125, 047201 (2020)

[5] M. Songvilay et al., Physical Review B 102, 224429 (2020)

First NAME : Jean-Eric	**last NAME : WEGROWE**
Affiliation : LSI, Ecole Polytechnique, CEA/DRF/Iramis, CNRS, IPP	

Presentation type : *Long (30 min)*	Talk given in : Choisissez un élément. (please prepare the presentation in english)
I authorize the GDR to record a video of my presentation : *yes*	

Classical Hall effect: do not forget the surface currents!

The non-equilibrium stationary state of an ideal Hall device is investigated. The Hall device is reduced to its fundamental symmetries, that are the longitudinal translational invariance (oriented along the direction of the current injected), the symmetry of the two lateral edges, and the Onsager reciprocity relation due to the applied magnetic field (« time-invariance symmetry »).

The stationary state of this ideal Hall bar is defined by the minimum power dissipation principle (i.e. a variational approach). It is easy to show that the minimum is reached for zero transverse current J_y=0, a charge accumulation at the interface over the Debye-Fermi length $\Box_D$, and the presence of a inhomogeneous longitudinal surface current $J_x(y)$. As far as we know, this last fundamental characteristic has not been reported so far in the litterature.

In a second step, we add a load circuit contacted to the lateral edges of the ideal Hall bar described above. By re- applaying the variational appraoch to this system, we show that a lateral current is injected into the lead circuit, and a lateral current appears (J_y≠0). Analytical expressions for the longitudinal and the transverse currents are derived. The efficiency of the power injected into the lateral circuit follows the « maximum transfer theorem ». However, for usual values of the Hall angle, the lateral current is negligible and the main contribution of the power injected into the lateral circuit provides from the longitudinal current flowing along the edges. This picture is somewhat conter-intuitive.

Références :

[1] M. Creff, F. Faisan, J.-E. Wegrowe, *Surface currents in Hall devices*, J. Appl. Phys **128**, 054501 (2021).

[2] F. Faisan, M. Creff, J.-E. Wegrowe, *The physical properties of the Hall current*, J. Appl. Phys **129**, 144501 (2021)

[3] P.-M. Déjardin and J.-E. Wegrowe, *Stochastic desription of the stationary Hall effect,* J. Appl. Phys. **128**, 184505 (2020).

[4] R. Benda, J. M. Rubì, E. Olive, and J.-E. Wegrowe, Toward Joule heating optimization in Hall devices, Phys. Rev. B **98**, 085417 (2018).

First NAME : JULIA	last NAME : MOKDAD
Affiliation : Laboratoire PHotonique ELectronique et Ingénierie QuantiqueS (PHELIQS)	

Presentation type : *Short (15 min)*	Talk given in : *English* (please prepare the of the presentation in english)
I authorize the GDR to record a video of my presentation : *YES*	

Resistive switching under pressure in the Mott insulator GaV_4S_8

Mott insulators are systems that according to band theory should be conductors, but in reality are found to be insulators because of the strong electronic correlations. However, the metallic state can be induced by the application of pressure or an electric field.

In some of these systems, a relatively weak electric field pulse has been shown to control the insulator to metal transition: this is called resistive switching. The possibility of switching in Mott insulators is of great interest to realize a new type of resistive memories (RRAM), called Mott memories. Switching in Mott insulators is probably due to an electronic avalanche breakdown phenomenon, but the mechanism of filament formation is not yet understood. By analogy with the metallic state induced under pressure, one possible hypothesis is a local compressive effect of the material.

In this work we studied the GaV_4S_8 compound under pressure. GaV_4S_8 is a narrow gap Mott insulator of the AM_4X_8 lacunar spinel family in which the switching phenomenon has already been demonstrated. We present several instrumental developments where we have adapted existing pressure measurement techniques to the study of insulators. We have performed measurements of AC calorimetry, capacitance or dielectric constant, loss, resistivity and AC magnetic susceptibility in a diamond anvil cell with an in-situ pressure tuning system that can be used over a wide temperature range. This enables us to present a complete study of the temperature - pressure phase diagram in GaV_4S_8, highlighting the transition to the metallic state at around 14 GPa and the evolution of the Mott gap with pressure. This compound also presents a very rich phase diagram with temperature and magnetic field with a ferroelectric Jahn-Teller structural transition at 43 K then a magnetic transition at 12.7 K towards a cycloidal phase then a ferromagnetic phase at lower temperature and towards a skyrmionic phase of the type Néel under magnetic field. Our study under pressure allowed us to follow these different transitions and the evolution of the different phases with pressure.

Then, we present an original study of the switching phenomenon by combining the two parameters that induce the metallic state: pressure and electric field. We show that the threshold electric field necessary to induce a volatile transition changes little with the pressure while the Mott gap decreases sharply. We discuss the implications of these results to better understand the formation of the metallic state in this system.

First NAME : Ewen	last NAME : BELLEC
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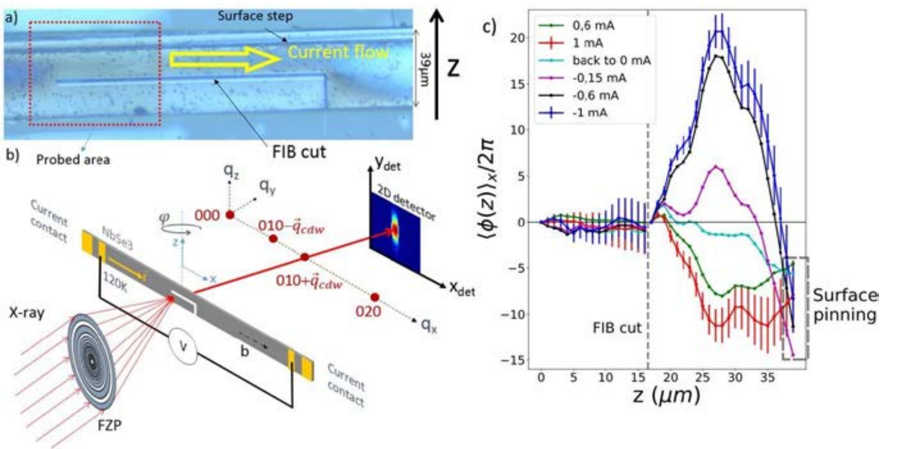
Presentation type : *Short (15 min)*	Talk given in : Choisissez un élément. (please prepare the presentation in english)
I authorize the GDR to record a video of my presentation : *yes*	

Evidence of Charge Density Wave transverse pinning by x-ray micro-diffraction

At low temperature, some metals have an incommensurate Charge Density Wave (CDW) transition where a periodic lattice distortion appears and opens a gap at the Fermi energy. When applying a large electrical current to a CDW material, a non-linear collective current is measured and is interpreted as the periodic creation of charged topological solitons at the electrical contacts [1,2]. We studied the CDW deformation under current in NbSe3 using the micro-diffraction setup at ID01 beamline of the ESRF synchrotron [3]. The sample was prepared with a Focused Ion Beam (FIB) cut in a « L » shape as shown in Figure 1a. Therefore, the current could only flow in the upper region and we could compare on the same sample a CDW region with current with one without current. As shown in Figure 1b, aFresnel Zone Plate focused the beam on a 200nmx300nm area allowing us to scan the CDW satellite peak (0 1 0)+qcdw over the red region of Figure 1a with steps of 1µm. At each beam position on the sample, we measure the diffracted peak on a 2D detector and perform a rockingcurve. Each map has a size of 0.6 TeraBytes and takes 45 minutes to measure due to the CDW satellite low diffracted intensity. From these map averaged along the horizontal axis, we could reconstruct the CDW phase Φ shown in Figure 1c. Below the FIB cut, where there is no current, Φ is constant at every current while in the upper region (where current is flowing) an unexpected shear deformation was measured. This transverse evolution has been interpreted asa surface pinning effect since Φ comes to the same value ((-10±5)*2π) at the sample upper border (z=37) for every current. This transverse pinning can explain the dependence of the threshold current on the sample cross-section [4].



<u>Figure 1</u>: a) NbSe3 sample prepared with a FIB cut. The current can only flow in the upper region. b) A FresnelZone Plate focused the X-ray beam on the sample, allowing to scan the CDW deformation as a function of position. c) Reconstructed CDW phase shear deformation along z. A surface pinning effect is observed at the sample upper border.

[1] E. Bellec, Study of charge density wave materials under current by X-ray diffraction, Thesis (2019)
[2] - A. Rojo-Bravo et al. , Phys. Rev. B **94**, 201120 (2016)
[3] - E. Bellec et al., Phys. Rev. B 101, 125122 (2020)
[4] Bellec, et al. The essential role of surface pinning in the dynamics of chargedensity waves submitted to external dc fields. Eur. Phys. J. B 93, 165 (2020)