Synthetic approaches to new 2D magnets

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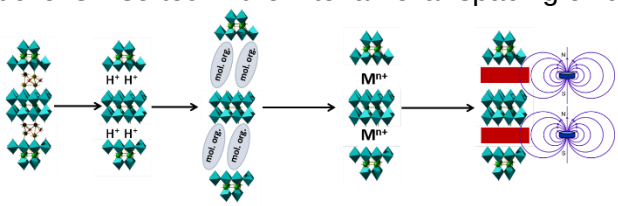
Since the discovery of the outstanding properties of graphene,[1] research on all kinds of nanosheets have increased considerably. Applications of such nanosheets can be found in catalysis, magnetism, dielectrics, or batteries and capacitors.[2] Yet although there have been efforts to induce magnetism in graphene and transition metal dichalcogenides, 2D materials with intrinsic magnetism had been missing until quite recently.[3] The discovery of monolayer magnetic materials is generating considerable excitement within both the magnetism/spintronics and 2D communities because it enables fundamental studies of magnetism in the true 2D limit and applications based on the integration of 2D magnetic layers into device structures. Yet, this field is up to now limited to a relatively small amount of systems (MPS_3, CrI_3, $Cr_2Ge_2Te_6$, VSe_2 and $MnSe_2$) and would require innovative solutions and materials.

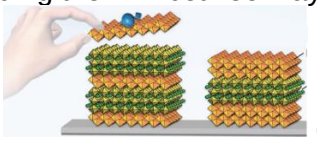
We have been interested for several years in the synthesis and characterization of lamellar hybrid materials (oxides or hydroxides), essentially for their magnetic, optical or electrochemical properties.[4,5] We have developed new synthetic strategies for functionalizing such layered materials, using micro-wave activation[6,7] or *in situ* syntheses.[8,9] Moreover, we are currently developing innovative methods to obtain easily and rapidly functionalized nanosheets resulting from the controlled exfoliation layered precursors.

The proposed Ph-D project will consist in taking advantage of this experience to develop new approaches to 2D magnets. Two strategies will be followed:

-the controlled growth in a 2D confined environment of magnetic coordination networks by connecting paramagnetic ions inserted in the interlamellar spacing of layered oxides



-the exfoliation of magnetic layered materials (MPS_3 or LDH for instance) and their stabilization as nanosheets by embedding them in between layers of exfoliated oxides.

 (adapted from [10])

The advantages of these approaches will be will be i) the intrinsic protection of the magnetic 2D nanosheets, ii) the possibility to couple the magnetic properties of the 2D nanosheets with other properties brought by the oxide layers (luminescence, ferroelectricity, semi-conductivity…)

Besides synthetic aspects this PhD will involve deep structural characterizations (XRD, TEM) and magnetic investigations (Squid, EPR).

[1] K. S. Novoselov, A. K. Geim, S. V. Morozov, D. Jiang, Y. Zhang, S. V. Dubonos, I. V. Grigorieva, A. A. Firsov, *Science* **2004**, *306*, 666–669.
[2] C. Tan, X. Cao, X.-J. Wu, Q. He, J. Yang, X. Zhang, J. Chen, W. Zhao, S. Han, G.-H. Nam, et al., *Chem. Rev.* **2017**, *117*, 6225–6331.
[3] C. Gong, L. Li, Z. Li, H. Ji, A. Stern, Y. Xia, T. Cao, W. Bao, C. Wang, Y. Wang, et al., *Nature* **2017**, *546*, 265–269.
[4] G. Rogez, C. Massobrio, P. Rabu, M. Drillon, *Chem. Soc. Rev.* **2011**, *40*, 1031–1058.
[5] R. Bourzami, S. Eyele-Mezui, E. Delahaye, M. Drillon, P. Rabu, N. Parizel, S. Choua, P. Turek, G. Rogez, *Inorg. Chem.* **2014**, *53*, 1184–1194.
[6] Y. Wang, E. Delahaye, C. Leuvrey, F. Leroux, P. Rabu, G. Rogez, *Inorg. Chem.* **2016**, *55*, 4039–4046.
[7] Y. Wang, M. Nikolopoulou, E. Delahaye, C. Leuvrey, F. Leroux, P. Rabu, G. Rogez, *Chem. Sci.* **2018**, *9*, 7104–7114.
[8] O. Palamarciuc, E. Delahaye, P. Rabu, G. Rogez, *New J. Chem.* **2014**, *38*, 2016–2023.
[9] Y. Wang, E. Delahaye, C. Leuvrey, F. Leroux, P. Rabu, G. Rogez, *Inorg. Chem.* **2016**, *55*, 9790–9797.
[10] M. Osada, T. Sasaki, *Dalton Trans.* **2018**, *47*, 2841–2851.