NÉEL INSTITUTE Grenoble

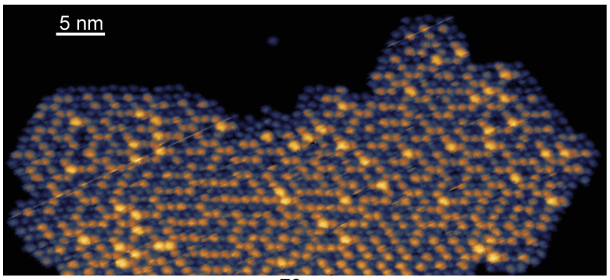
Master 2 research internship – Academic year 2023-2024

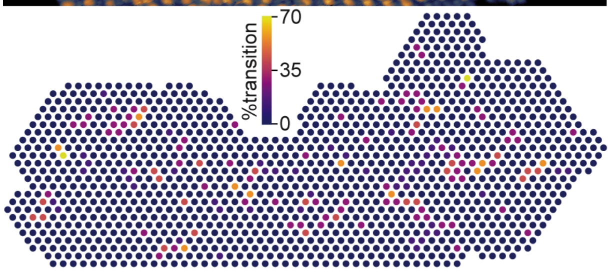
Spatiotemporal dynamics of 2D frustrated lattices

General Scope: Since 1935 and Pauling's seminal work on the 0 K residual entropy in solid water (at odds with Planck's formulation of the 3rd law of thermodynamics!), condensed matter physicists have continuously explored frustration phenomena appearing when a crystal lattice hosts a structural or magnetic correlated disorder. Such correlated disorder, distinct from trivial random disorder, can be found in a wide range of systems, either found in nature or made artificially. In our group, we address the physics of various systems at different lengthscales and with different kinds of degree of freedom (μm-scale pseudo-spins, structural configuration of *nm*-scale molecules or of *mm*-scale magnets), all arranged within two-dimensional (2D) lattices. Our approach is to directly resolve the configuration at each lattice site, using *ad hoc* imaging techniques, and thereby to understand the correlated disorder phenomena at play. Using statistical physics tools it is even possible to derive thermodynamic quantities from real space 2D images and to figure out whether model spin Hamiltonians are relevant to account for the observed physics. In the past years we accordingly managed to observe a long-sought-for spin liquid phase, explored the role of extended topological defects, and investigated intriguing coexistences of liquid/solid phases.

A few relevant articles from our group: https://arxiv.org/abs/2302.01652 (under review); Phys. Rev. Lett. 129, 027202 (2022); Nature 540, 410 (2016).

Research topic and facilities available: The focus of the internship is to go beyond the usual static 2D imaging of correlated disorder in frustrated systems, and to analyse, on top of the x,y dimensions, the *time* dimension. The goal is to understand the dynamics of defects, to figure out how disorder evolves, possibly in a spatially and temporally correlated way between different sites of the lattices. This is crucial to understand the creation/ annihilation of defects, cascade events involving numerous lattice sites, and to which extent these bring the system closer to thermodynamic equilibrium. How the lattices will respond to local excitations will be also studied. The methods that will be used include dynamical imaging by optical microscopy (for lattices of *mm*-sized magnets) or scanning tunneling microscopies (for lattices of fullerene molecules, see top image) and image post-processing (see bottom image of the probability of change of molecular state). To interpret the data, numerical Monte Carlo simulations will be used.





Possible collaboration and networking: Work will be done in collaboration between the intern and three senior researchers and two engineers; international collaborations are also foreseen.

Funding for a PhD thesis in the continuity of the internship is secured.

Required skills: Strong background in solid state physics and statistical physics.

Starting date: Spring 2024.

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More information : http://neel.cnrs.fr