Internship proposal

Novel electronic states and exotic phase transitions in correlated electron systems

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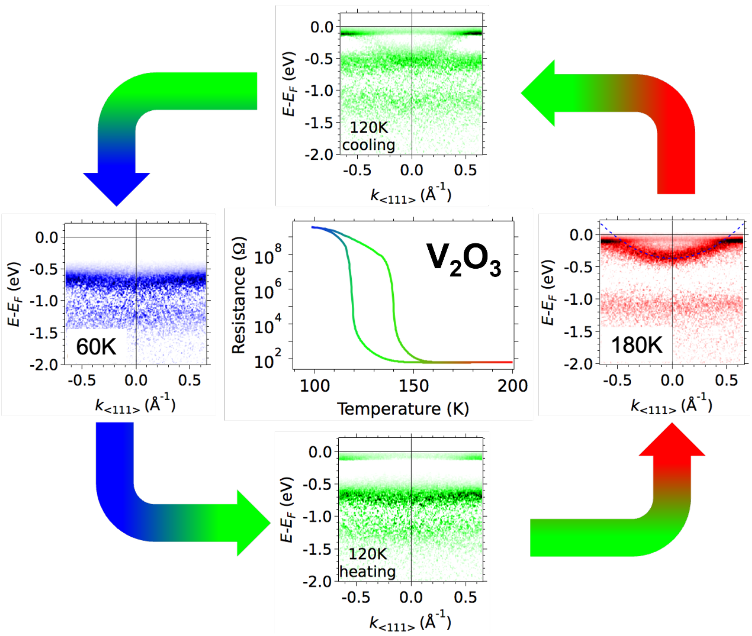
The physics of strongly interacting fermions is the common pillar of several challenging open problems at all scales. One finds it in the description of quarks and gluons in compact nuclear and sub-nuclear matter, in neutron stars, or in the behavior of electrons in a large class of solids in which strong electron interactions are present. For instance, in transition-metal oxides electron correlations are so strong that the slightest perturbation can radically change their ground state. These materials display thus numerous classical and quantum phase transitions and exotic states of matter showing remarkable properties, such as high-temperature superconductivity, large magneto-resistance, or a metal-to-insulator transition. The resulting broken symmetries and electronic collective phenomena are among the most puzzling challenges of modern physics. Take for instance the MIT, observed in several oxides. According to the Bloch theory, metal or insulator are mutually exclusive states of matter. The very existence of a metal-to-insulator transition shakes the foundations of such a well-tested theory, considered the "Standard Model" for the quantum description of solids!

Using angle-resolved photoemission spectroscopy (ARPES), a technique that directly images the electronic energies of a solid, we recently measured how the electronic structure of V_2O_3 changes across the temperature-induced metal-insulator transition [M. Thees et al, Science Advances **7**, eabj1164 (2021)]. This opens the door to in-depth fundamental studies of this archetypal open problem of correlated-electron physics.

During this internship you will use ARPES to explore how strain and doping, which both affect electron interactions, change the electronic structure and induce broken symmetries across the metal-insulator transition in V_2O_3. The experiments will be performed at several synchrotrons around Europe (France, Germany, Spain, Sweden, among others), and possibly Japan and China. You will also participate to the assembly and operation of a laboratory-based high-resolution ARPES system.

The internship can be continued, upon mutual agreement, with a PhD thesis.



Changes of the electronic structure of V_2O_3 near the Fermi level when cooling and warming across its metal-to-insulator transition. The inset shows the corresponding change in resistivity. Adapted from M. Thees et al, Science Advances **7**, eabj1164 (2021).