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Mott insulators as promising candidates for straintronics

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Mott insulators are a class of strongly correlated materials with emergent properties important for modern electronics applications[1]. The key property for potential application is the Mott insulator to metal transition (IMT). This IMT appears at equilibrium by submitting Mott insulators to various perturbations such as strain or electronic doping. However, the breakthrough concerning applications comes from recent discoveries showing the possibility of inducing out-of-equilibrium Mott IMTs thanks to light or electrical pulses which generate highly excited electronic states. On the theoretical side, the full description of Mott IMTs is a long-standing problem. At equilibrium, the evolution of most of the electronic properties at the Mott IMT can be well captured by the Hubbard Hamiltonian, a purely electronic model ignoring the response of the lattice.[2,3]. Conversely the description of out-of-equilibrium Mott IMTs is still a major theoretical challenge because of complex many-body effects and constitutes a very active field of research at present [4].

The paradigmatic example of Mott insulator is the $(V_{1-x}Cr_x)_2O_3$ system. In this compound, an IMT can be induced at equilibrium by physical or chemical pressure and out-of-equilibrium by strong electronic excitation [5,6]. We have recently demonstrated that a local compressive lattice strain accompanies the out-of-equilibrium Mott IMT caused by an electric field [7], which is reminiscent of $\approx$ 1% volume drop observed at the Mott IMT observed at equilibrium under pressure [6].

During the talk, we will present Raman studies on $(V_{1-x}Cr_x)_2O_3$, showing that, despite the lattice compressive strain, the Mott IMT is associated to a softening of elastic constants, both at equilibrium (chemical or physical strain-induced IMT) and out-of-equilibrium (E-field-induced IMT). These results show that the minimal model to fully describe the Mott IMT in solids is a Hubbard model on a compressible lattice. In addition this work shows the pivotal role of lattice strain at the Mott IMT. Most importantly, it illustrates how the degree of the electronic delocalization can control the lattice stiffness in strongly correlated systems, [7,8] both at and out-of thermodynamic equilibrium.

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