Looking for a realization of the excitonic insulator phase in low dimensional crystals

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It has been proposed in 1961 by Mott that a semimetal may be unstable towards an insulating ground state, when electrons and holes bind together through the Coulomb interaction and form excitons [1]. On this basis, it was elaborated a few years later that both a semimetal and a semiconductor can undergo this phase transition [2]. The phase transition occurs at low temperature, when the excitons condense in a macroscopic state, giving rise to the so-called *excitonic insulator phase*. Experimental observation of this phase has proven to be very challenging since its theoretical prediction and not much is known about the time-domain dynamics of this exotic phase.

In this talk, I will present **time-resolved angle-resolved photoemission spectroscopy data** taken on two different materials, which have been recently proposed as an experimental realization of an excitonic insulator phase. The semimetal $TiSe_2$ has an indirect negative gap (band overlap) and displays a peculiar charge density wave phase transition at 200 K [3]. The semiconductor Ta_2NiSe_5 has a direct (positive) gap and displays a semiconductor-semiconductor phase transition at about 330 K [4].

I will present and discuss data supporting a mixed scenario for which excitonic correlations cooperate with the electron-phonon coupling in triggering the charge density wave phase transition in $TiSe_2$. For Ta_2NiSe_5, I will show how its correlation gap can be *increased* on the femtosecond timescale in a pump-probe experiment. I will argue that this observation is a direct consequence of the exciton condensate being trapped in a non-thermodynamical state where it is transiently strengthened.

References:

[1] N. Mott, Phil. Mag. 6, 287 (1961).
[2] D. Jérome et al, Phys. Rev. 158, 462 (1967).
[3] H. Cercellier et al., Phys. Rev. Lett. 99, 146403 (2007).
[4] Y. Wakisaka et al., Phys. Rev. Lett. 103, 026402 (2009).