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SEMINAR

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Light control of electronic interactions in organic molecular solids

Organic molecular solids are appealing systems for next-generation optoelectronics, light harvesting and biophysical applications. They are particularly apt to exploring many-body electronic behavior due to their extreme structural tunability (with pressure or chemical substitution), their narrow electronic bands, and their local molecular degrees of freedom. In this talk I will present recent experimental work on ultrafast light control of organic molecular crystals, These experiments are especially aimed to investigate of the intrinsic nature of electronic phase transitions by manipulating interactions (e.g. Coulomb interactions, electron-phonon coupling, etc.) on their intrinsic timescales and achieve dynamical control of transient electronic phases by means of mode-selective excitations. In the first part of the talk, I will introduce experiments focused on the many-body dynamics of strongly correlated electrons in reduced dimensionality. The organic compound of choice, ET-F2TCNQ, is a quasi-1D Mott insulator characterized by a weak electron-lattice interaction and therefore almost ideal for the investigation of purely electronic excitations in presence of strong correlations. I will show first that the photoinduced insulator-to-metal transition in this material strongly depends on the degree of correlation of the ground state [1]. Secondly I will discuss how ultrafast resonant vibrational excitation of intramolecular modes can lead to a dynamical modulation of the onsite Coulomb repulsion [2,3]. In the second part of the talk I will present instead nonequilibrium optical experiments in which the concept of resonant phonon excitation is applied to a BCS-like superconductor, K3C60 (Tc=20 K) [4]. Superconductivity is here mediated by high-energy (100-200 meV) intramolecular vibrations with Jahn-Teller character that favor the creation of Cooper pairs and the appearance of a superconducting state with s-wave symmetry [5,6]. We excited local molecular vibrations of the C60 molecule and, by measuring the transient optical response at THz frequencies, we identified a non-equilibrium state with the optical properties of a superconductor emerging from the normal phase of this organic compound for base temperatures far in excess of the equilibrium Tc = 20 K, up to about T' = 200 K [4]. These results are strongly suggestive of a new type of superconductivity that is directly stimulated by the laser field and likely associated to light-induced changes in the electron-phonon coupling and in the onsite Coulomb repulsion.

[1] M. Mitrano et al., Phys. Rev. Lett. 112, 117801 (2014)
[2] S. Kaiser et al., Sci. Rep. 4, (2014)
[3] R. Singla et al., Phys. Rev. Lett., in press (2015)
[4] M. Mitrano et al., arXiv preprint arXiv:1505.04529 (2015)
[5] O. Gunnarsson, Rev. Mod. Phys. 69, 575–606 (1997)
[6] M. Capone et al., Rev. Mod. Phys. 81, 943 (2009)

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