FACOLTÀ DI SCIENZE MATEMATICHE, FISICHE E NATURALI
DIPARTIMENTO DI MATEMATICA E FISICA "NICCOLÒ TARTAGLIA"

Ultrafast time-resolved investigation of novel complex materials

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Abstract:

Topological Insulators (TIs) are a phase of matter characterized by in-plane spin- polarized surface states (TSSs) arising within the bulk insulating energy gap [1]. The protection against spin-flip events [1] and the capability to control the spin polarization using ultrashort light pulses [2] open new scenarios in the use of this class of materials for future opto-spintronic devices.

Using a novel Yb:laser based TR-ARPES setup[3], we studied the response of spin- polarized electrons to ultrashort circularly-polarized pulses in the Bi_2Se_3 prototypical TI. We reported the first experimental evidence of a direct coupling between circular light and the empty topological surface state (ESS) located within a bulk-gap of the unoccupied states. We reported also the ultrafast building-up of a spin-polarized electron population in the ESS i.e. an ultrafast photon-induced spin-current [4].

Low-dimensional condensed matter systems that exhibit a metal-to-insulator transition attracted a lot of attentions in the material science community suggesting the unique possibility to drive and control the opening and closing of the band gap by an external parameter. The opening of the gap below a critical temperature is due to the formation of a modulating low energy excitation known as charge density wave (CDW) that is closely related to a periodic lattice distortion (PLD) [5]. Although this transition is well-known since the '70s, the underlying mechanism is not well-established and understood.

We investigated the photo-induced melting of CDW in 1T-$TiSe_2$ single crystals by TR- ARPES and TR-Reflectivity. Our measurements reveal that after photo-excitation different dynamics arise in the closing of the band-gap and in the melting of the charge order suggesting an excitonic-lattice cooperative model [6].

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Seminario

Giovedì 14 giugno 2018
Aula 8, ore 14.30
Via dei Musei 41 - Brescia

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