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fs -laser lab of novel light-matter interaction

My group has long term goal to search exotic light-matter interaction and photoinduced intriguing phenomena in emergent materials. Through the understanding of light-matter interaction, we develop ultrafast optical techniques to study, control, and manipulate the function of condensed matters with novel properties. Our research of condensed matters covers **(i) metal-insulator transitions, (ii) phase transition, (iii) magnetism, (iv) ferroelectricity, and (v) correlated electron systems and their nanostructures**. We use optical techniques of **(I) pump and probe, (II) second harmonic generation, (III) Faraday or Kerr rotation, (IV) pulse shaping, and (V) time-domain THz**. Our main projects includes: **(a) Spin dynamics and spin control:** We design time-resolved spectroscopy including Faraday and Kerr probes. We study the photoinduced spin dynamics with the aim to control spin precession and spin flip on ultrafast timescale of fs-ps. We can use different helicities of photon to manipulate spin dynamics of various condensed matters (Fig. 1). We will also develop and shape the optical pulse (Fig. 5) to achieve the spin control. **(b) Coupling after light-matter interaction:** We also study the fundamental coupling in condensed matter physics. Using pump beams to create an optically perturbed system, we study the fundamental relaxation and coupling of electron-phonon, spin-lattice, magnetoelectric multiferroics and so on. The relaxation process can be measured through different optical probes like (1)-(3). **(c) Application of nonlinear optics:** We use nonlinear optical processes to study and analyze crystal or surface structure (Fig. 3). Polar or ferroelectric materials without an inversion center allow the generation of odd harmonics, which is a great tool of analyzing polar properties (Fig. 4). Sometimes, we use or mix nonlinear optical process to generate the light source we will use to study dynamics of materials. **(d) Generation of coherent optical phonon:** Similar to spin control, we would also like to control the lattice vibration in novel materials (Fig. 1), and we study their impact on the other properties which usually has strong correlation with lattice distortion. We are also interested in using different light polarization or pulse shaping (Fig. 5) to control and generate THz optical phonons. **(e) Photoinduced phase transition and hidden state:** In some exotic materials, we study highly nonequilibrium system and look for the existence of hidden states that cannot be reached through thermal dynamic process. Such hidden states do not exist during or after the material growth, instead, they only can be found through certain extreme environments (Fig. 6) or special electronic heterostructures, and exhibit very unusual physical properties with limited lifetime (Fig. 7).

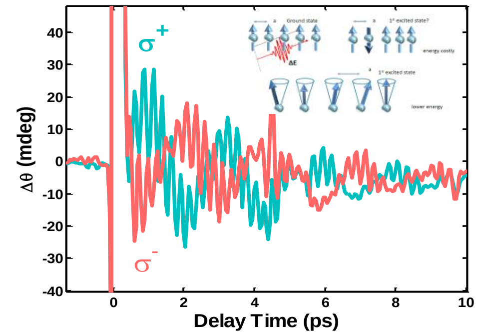

Fig. 1

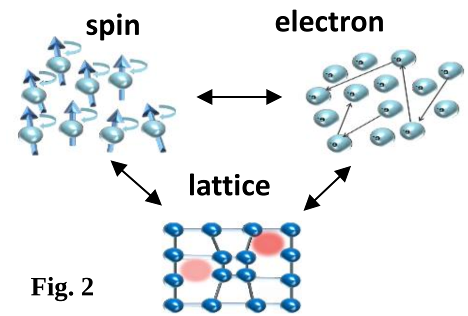

Fig. 2

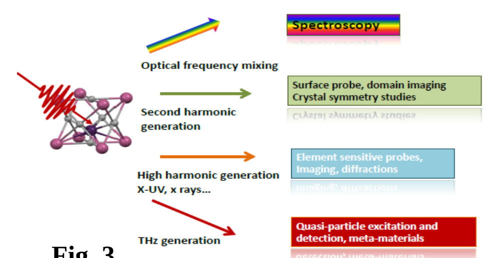

Fig. 3

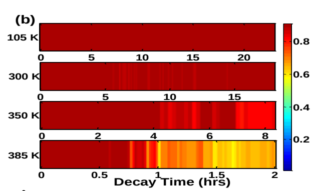

Fig. 7

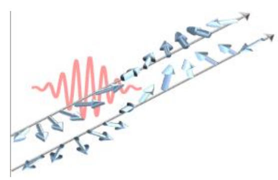

Fig. 6

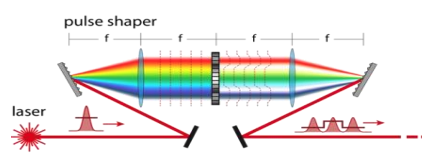

Fig. 5

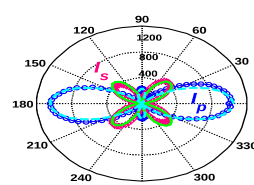

Fig. 4