The influence of global and local magnetic fields on the optical properties of two-dimensional semiconductors

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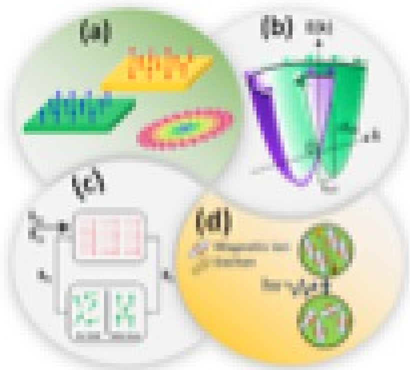
Resumen:

Magnetism is a topic of a wide interest since the discoveries of motors/generators, through magneto-resistance and up to modern times, where low dimensional materials offer a support for new magnetic phenomena. The talk will focus on the influence of magnetic moments and magnetism on the optical magneto-properties of semiconductors in an ultimate two-dimensional limit found in van der Waals transition metal tri-chalcogenides and perovskite nanoplatelets. A few types of magnetic properties will be discussed as summarized in Scheme: The long-range magnetic order, ferromagnetism, anti-ferromagnetism or special spin textures (a); An interfacial developed Rashba spin-orbit effect (b); Nuclear spin Overhauser effect (c); Magnetic polaron (d), all gaining special stabilization by the size confinement and a shape anisotropy. The mentioned intrinsic fields lead to a lift of energy or momentum degeneracy at band-edge states with selective spin orientation in the ground or/and excited state, being of a special interest in emerging technologies of spin-electronics and quantum computation. The lecture will include the following topics:



Long-range magnetic order and valley effects in single layer of metal phosphor tri-chalcogenide compounds: Metal phosphor tri-chalcogenides with the general chemical formula MPX_3 (M=metal, X=chalcogenide) closely resembling the metal di-chalcogenides, but the metal being paramagnetic elements, while one-third of them are replaced by phosphor pairs. The metal ions within a single layer produce a ferromagnetic or anti-ferromagnetic arrangement, endowing those materials with unique magnetic and magneto-optical properties. Most recent magneto-optical measurements will be reported, exposing the existence of valley degree of freedom in a few MPX_3 (e.g., $FePS_3$), that reveals a protection of the spin helicity of each valley however, the coupling to an anti-ferromagnetism lifts the valleys' energy degeneracy. The phenomenon was also examined in magnetically doped diamagnetic MPX_3 layers. The results indicated the occurrence of coupling between photo-generated carriers and magnetic impurities and the formation of magnetic polaron.

Rashba and Overhauser effects in perovskite materials: Perovskite materials are composed of organic-inorganic or all inorganic constituents. They mostly contain octahedral units of metal-halides or metal-oxides, generating an inorganic network with voids that are filled by organic or inorganic counter ions. The studies to be reported are related to compounds with chemical formula $APbX_3$ (A = methylammonium or Cs; X= I, Br) grown in 2D and 3D forms. The magneto-optical properties of such compounds revealed selective exciton' circular polarization components following a non-linear energy split upon an increase of an applied external magnetic field, which was associated with the involvement of a Rashba effect. A Rashba effect is related to a creation of a spin-orbit effective magnetic field, splitting a band-edge in momentum space into two valleys symmetrically spaced around k=0 of a Brillouin zone. Each valley accommodates one spin orientation of a carrier, hence dictating a helical recombination emission. Furthermore, degree of circular polarization dependence on the applied magnetic field, exposed a trend related to the Overhauser effect, including a strong dependence of the observation direction with respect to a crystallographic symmetry axis (e.g., the [001] direction). Simulation of the data, including a hyperfine interaction of nuclear spins (isotopes of Pb, Br, and H) with the photo-generated spins, as well as dependence on an anisotropic g-factor of the carriers, corroborated the involvement of the Overhauser field. The study also revealed an electron spin relaxation and coherence time, due to the influence of the Rashba and Overhauser effects.

Overall, the observation designated a strong influence of intrinsic magnetic effect on spin and optical properties in two-dimensional semiconductors, with a large impact on their implementation in modern spin-electronics and spin-optical devices.