Spin physics in lead halide perovskites

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Great actual interest to the lead halide perovskite materials $APbX_3$, where A = Cs, FA or MA anion and X = I, Br or Cl halogen ions, is provided by their remarkable photovoltaic properties. Also their light emission efficiency is very high making them very promising for opto-electronic devices. Spin-dependent properties of these materials remain weakly investigated, while even the first studies demonstrate that they are very bright and can be well addressed by various magneto-optical and time-resolved techniques used in semiconductor physics.

In this lecture I will overview recent experimental studies of spin-dependent phenomena in perovskite crystals, based on hybrid organic-inorganic ($FA_{0.9}Cs_{0.1}PbI_{2.8}Br_{0.2}$ and $MAPbI_3$) and inorganic cesium ($CsPbBr_3$) lead halide perovskites, as well as $CsPbBr_3$ nanocrystals. Experiments were performed at low temperatures of 1.6-40 K and in strong magnetic fields up to 10 T. Several experimental techniques were used, which allow us to measure exciton, electron and hole g-factors, spin relaxation and spin coherence times and to evaluate hyperfine interaction of charge carriers with nuclear spins. Among the techniques are: (i) polarized photoluminescence, (ii) pump-probe Kerr rotation with picosecond time resolution, and (iii) spin-flip Raman scattering. These experiments show that (rather unexpectedly) the lead halide perovskites are very well suited for these optical techniques, providing strong signals and having long spin relaxations times. For example, longitudinal relaxation times (T_1) of about 50 ns and spin dephasing times (T_2*) up to 5 ns are measured. Due to their "inverted" band structure in respect to most of common semiconductors, e.g. GaAs, the perovskites are very promising model system for spintronics research.

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