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Sub-lattice displacement in multiferroic Rashba semiconductor (Ge,Mn)Te (IS648)

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Multiferroic Rashba semiconductors (MUFERS) are novel functional materials based on the coupling between ferromagnetism, ferroelectricity and Rashba-Zeeman effects [1]. $Ge_{1-x}Mn_xTe$, the model MUFERS, inherits the robust ferroelectricity and giant Rashba splitting of α-GeTe, undergoing a ferroelectric phase transition at T_C^{FE}. Below the transition temperature, the cubic rocksalt symmetry is broken and a rhombohedral phase is formed by elongation along the <111> direction. This distortion induces a displacement Δr between the cation (Ge or Mn) and the anion (Te) sub-lattices, which is responsible for the spontaneous ferroelectric dipole. Ferromagnetism in (Ge,Mn)Te, stemming from exchange interaction between Mn^{2+} moments mediated by free carriers (holes), induces a Zeeman splitting in the electronic structure. Thanks to the high Mn solubility in GeTe, Curie temperatures T_C^{FM} as high as 180 K have been achieved, among the highest of all ferromagnetic semiconductors. Varying Mn concentration has not only a direct effect on the magnetization of (Ge,Mn)Te, but also influences the ferroelectric distortion. The direction and magnitude of Δr define the direction and magnitude of the FE polarization, which together with the magnetization determine the Rashba and Zeeman effects on the electronic structure.
In this experiment (IS648), we are developing a novel approach to measuring the direction and magnitude of the sub-lattice displacement Δr in (Ge,Mn)Te, based on the emission channeling technique. By implanting ^{56}Mn radioactive probes into $Ge_{1-x}Mn_xTe$ films, emission channeling can be used to directly measure Δr, with sub-Angstrom precision. Experiments both below and above the ferroelectric transition were performed in 2018 for a range of Mn concentrations up to 21%. In this talk, we will present and discuss the observed dependence of Δr on Mn concentration. These results set the basis for future experiments in which we will study how switching the magnetization direction (with a magnetic field applied in-situ) affects the direction of the FE polarization (Δr) through magnetoelectric coupling.

[1] Krempaský, J., et al. "Operando imaging of all-electric spin texture manipulation in ferroelectric and multiferroic Rashba semiconductors." Physical Review X 8.2 (2018): 021067.

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