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Electric Control of the Giant Rashba effect in bulk GeTe

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Relativistic effects are increasingly seen as key ingredients in the burgeoning field of spintronics. Among them, the Rashba effect, in which the spin degeneracy is removed as a consequence of spin-orbit interaction in noncentrosymmetric structures, plays a leading role. While the Rashba effect is commonly associated to two dimensional systems and interfaces, recent reports suggest that a sizeable Rashba splitting might also occur in bulk materials, such as BiTeI. In our work we establish, for the first time, a link between Rashba physics and the field of ferroelectricity in single-phase materials, by predicting from first-principles a giant Rashba effect in bulk GeTe, a narrow gap ferroelectric semiconductor.

We focus on the dependence of the spin splitting amplitude on the ferroelectric polarization, which makes the spin polarization of the current fl owing in GeTe to be controllable and switchable by an electric field. In particular, we demonstrate that a full reversal of the spin polarization, i.e., of the Rashba parameter, can be achieved upon reversal of the ferroelectric polarization. Noteworthy, the hysteretic nature of ferroelectricity provides a unique way to exploit the Rashba effect in novel spintronics devices with non volatile logic functions associated with the remanent ferroelectric states. As an example, the design of a spin FET employing a bulk GeTe channel is also discussed.

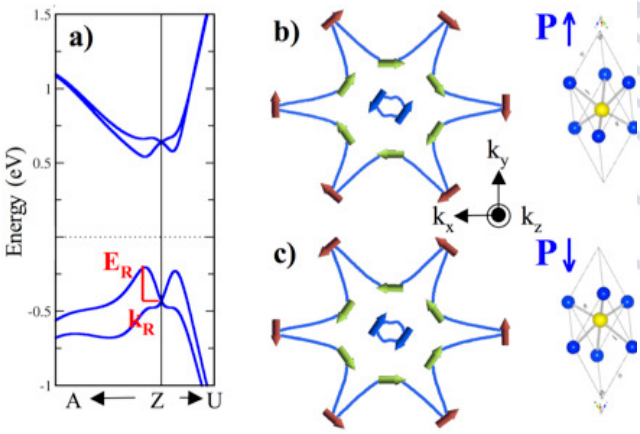

Fig.: a) Zoom of the density-functional band structure in the Brillouin Zone plane A-Z-U perpendicular to polarization P for bands close to the Fermi level. The Rashba parameters E_R and k_R are highlighted. b) Isoenergy cuts at an energy of -0.47 eV around Z in the A-Z-U plane. The spin-expectation values for holes are shown by arrows for polarization direction parallel to [111] (see sketch on the right for GeTe atomic arrangement); c) same as panel b) but for opposite polarization direction: the spin texture is reversed.