Highlights

Oxides - 2015

Coupling Ferroelectricity with Spin-Valley Physics in Oxide-Based Heterostructures

K. Yamauchi[1], P. Barone[2], T. Shishidou[3], T. Oguchi[1] and S. Picozzi[2]

[1] ISIR-SANKEN, Osaka Univ., 8-1 Mihogaoka, Ibaraki, Osaka 567-0047, Japan
[2] Consiglio Nazionale delle Ricerche (CNR-SPIN), 67100 L'Aquila, Italy
[3] Dep. of Quantum Matter, Hiroshima Univ., Higashihiroshima 739-8530, Japan

PHYSICAL REVIEW LETTERS 115, 037602 (2015)

The coupling of spin and valley physics is nowadays regarded as a promising route toward next-generation spintronic and valleytronic devices. Valley-contrasting physical quantities may emerge whenever inversion symmetry is broken; when realized in ferroelectrics, the valley phenomenology could be controlled by acting on the ferroelectric polarization. We focus on the quest for ferroelectric spin-valley physics in the perovskite oxide heterostructure shown in Fig a), where a (111) bilayer of $BiIrO_3$ is embedded in the robust ferroelectric $BiAlO_3$. The interplay of spin-orbit coupling and trigonal crystal-field effect in the (111) oxide bilayer leads to graphene-like low-energy electronic properties, hence to the appearance of coupled spin-valley physics. Specifically, a large valley spin polarization is induced and modulated by the ferroelectric polarization, as shown in Figs. b) and c). Our theoretical analysis suggests that the realization of spin-valley physics in oxide heterostructures is possible, allowing, in principle, for larger effects (due to the large spin-orbit coupling of *4d* or *5d* transition-metal ions), increased tunability (brought in by oxygens, both determining the trigonal crystal-field splittings and mediating the hopping interactions), and the integration of additional functionalities, such as ferroelectricity, which could be exploited in advanced next-generation electronic devices aiming at a full-electric control of spin polarization.

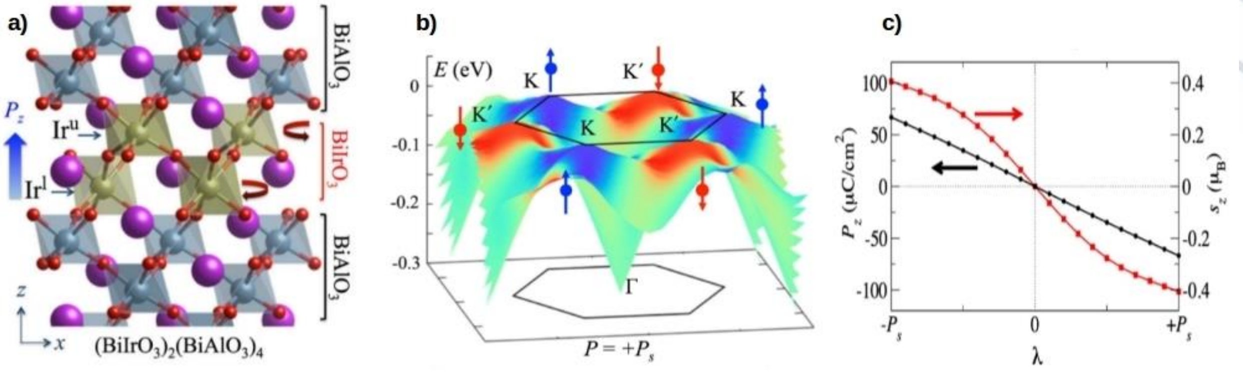

Figure: a) Multilayer structure of $(BiIrO_3)_2(BiAlO_3)_4$ heterostructure; the direction of the ferroelectric polarization is shown by the blue arrow. b) Energy dispersion of the top valence band, with projected valley-dependent spin polarization s_z, showing opposite directions at different valleys. c) Ferroelectric polarization P_z and spin polarization s_z of the top valence band at the valley K as a function of the polar structural distortion parametrized by λ.