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 4$d$ or 5$d$ 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 $\lambda$. 