Quantum technologies with oxide 2DEGs

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In the last few years, new phases of matter emerged from the interplay between SOC and low dimensionality, such as spin-polarized surface and interface states, topological phases of matter and topological superconductivity. SOC splits degenerate bands with finite angular momentum, modifying the electronic band structure, and it is dramatically enhanced in 2D-electron gases (2DEGs) due to the inversion symmetry breaking. In these systems the atomic SO-interaction combines with the Rashba-type SOC giving rise to an electric field effect tunable electron spin–momentum locking, where the motion of electrons is tied to their spins. This provide ways to control spins electrically and indeed it is driving tremendous advancements in the field of spin-orbitronics and topological quantum physics.

A promising material platform in this endeavor is represented by 2DEGs formed at the interface between oxide band insulators, like $SrTiO_3$ (STO) and $KTaO_3$, and large band-gap transition metal oxides (TMO) like $LaAlO_3$ (LAO), EuO and $EuTiO_3$, as in the case of the LAO/STO and LAO/KTO systems[1]. These oxide 2DEGs are characterized by a unique combination of large Rashba-like SOC (up to 0.4 eV in KTO-2DEGs)], and superconductivity (SC) (200 mK in LAO/STO and 2.2K in LAO/KTO)[2-4]. The electronic properties of oxide 2DEGs are very sensitive to the electronic filling and are widely tunable by electric field effect. In particular, the Rashba-SOC can be switched -on and -off by moderate gate voltages, a characteristic hardly achievable with semiconducting platforms. Moreover, oxide 2DEGs can be reconfigured by atomic interface engineering using advanced epitaxial growth methods to include specific functional properties, like interfacial 2D-ferromagnetism (FM)[5], ferroelectricity (FE)[6], and their coupling[7].

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