Novel 2D electron gases at the surface of transition-metal oxides: role of topology and spin-orbit coupling

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Transition-metal oxides (TMOs) are correlated-electron systems with remarkable properties, such as high-temperature superconductivity or large magnetoresistance. The realization of two-dimensional electron gases (2DEGs) at surfaces or interfaces of TMOs, a field of current active research, is crucial for harnessing the functionalities of these materials for future applications. Additionally, these 2DEGs offer the possibility to explore new physics emerging from the combined effects of electron correlations and low-dimensional confinement.

Recently, we discovered that a 2DEG is simply realized at the vacuum-cleaved surface of $SrTiO_3$, a transparent, insulating TMO with a gap of 3.5 eV. We directly imaged its multiple heavy and light subbands using angle-resolved photoemission spectroscopy [1]. In this talk, I will show that one can also create and tailor 2DEGs in other TMO surfaces, opening vast possibilities for the study of correlations in low dimensions in materials showing diverse functionalities. I will first discuss the specific case of $KTaO_3$, a wide-gap insulator with a spin-orbit coupling 30 times larger than in $SrTiO_3$. I will show that quasi-2D confinement in this system results in comparable scales for the Fermi energy, the subband splitting, and the spin-orbit coupling, leading to a complete reconstruction of the orbital symmetries and band masses [2]. Then, I will show that by choosing various surface terminations of different symmetries one can modify the electronic structure of the 2DEGs at the surface of TMOs [3, 4]. Additionally, I will discuss the experimentally observed effects of spin-orbit coupling in the 2DEG at the surface of $SrTiO_3$. All these results demonstrate that, in TMOs, the strong correlations, together with the electron confinement and the surface-lattice symmetry, can lead to novel states at the surface that are not simple extensions of the bulk bands.

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[2] A. F. Santander-Syro *et al*., Phys. Rev. B **86**, 121107(R) (2012).
[3] C. Bareille *et al*., Sci. Rep. **4**, 3586 (2014).
[4] T. Rödel *et al*., submitted (2014)