Novel 2D electron gases at the surface of transition-metal oxides

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Transition-metal oxides (TMOs) are correlated-electron systems presenting remarkable properties, such as high-temperature superconductivity or multi-ferroic behaviour. The realization of two-dimensional electron gases (2DEGs) at surfaces or interfaces of TMOs, a field of current active research [1], is crucial for harnessing the functionalities of these materials in view of future applications. From a fundamental point of view, these 2DEGs offer the possibility to explore new physics emerging from the combined effects of electron correlations and low-dimensional confinement.

In this talk, I will present our recent discovery that a 2DEG can be simply realized at the vacuum-cleaved surface of a *transparent, insulating* TMO: $SrTiO_3$ [2]. Using angle-resolved photoemission spectroscopy, we directly observed multiple subbands of heavy and light electrons confined within ~5 unit cells beneath the surface, and ordered by their orbital character. I will then show that such a procedure can be extended to obtain 2DEGs in other TMOs, opening a wide realm of possibilities for the study of correlations in low dimensions. I will discuss the specific case of $KTaO_3$, a wide-gap insulator with a spin-orbit coupling about 30 times larger than in STO. I will show that quasi-2D confinement in this system leads to a reconstruction of the *orbital symmetries* [3], and that the electronic structure of the surface 2DEG dramatically changes with the surface termination. These results demonstrate that in TMOs the strong couplings between the active electronic degrees of freedom, combined with the electron confinement, can lead to novel electronic states at the surface that are not simple extensions of the bulk bands.

[1] A. Ohtomo and H. Y. Hwang, *Nature* **427**, 423 (2004); C. H. Ahn, J.-M. Triscone and J. Mannhart, .*Nature* **424**, 1015 (2003); N. Reyren *et al., Science* **317**, 1196-1199 (2006); A. Brinkman *et al., Nature Mater*. **6**, 493-496 (2007).
[2] A. F. Santander-Syro *et al*., *Nature* **469**, 189 (2011).
[3] A. F. Santander-Syro *et al*., Phys. Rev. B **86**, 121107(R) (2012).