CEA - Saclay 91191 Gif-sur-yvette Cedex
Service de Physique de l'Etat Condensé

SÉMINAIRE

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Mercredi 16 Janvier 11h15

Orme des Merisiers SPEC Salle Itzykson, Bât.774

Novel two-dimensional electron gases at the surface of transition-metal oxides

Andrés Felipe Santander Syro

CSNSM, Université Paris Sud

Electronic states at surfaces or interfaces can lead to groundbreaking phenomena and applications. Paradigmatic examples are the field-effect semiconductor transistors, the quantum Hall effect, the topological insulators, and the two-dimensional electron gases (2DEGs) at interfaces between $SrTiO_3$ (STO) and other insulating transition-metal oxides [1]. These interfaces display stunning properties, such as superconductivity or magnetoresistance. However, they are difficult to produce, and their electric properties depend strongly on the fabrication details. This has hampered the understanding of the physical origin of such 2DEGs and their generalization to other multifunctional oxides.

In this talk, I will first present our recent discovery that a 2DEG can be simply realized at the vacuum-cleaved surface of $SrTiO_3$ [2]. We probed this state using light-polarized angle-resolved photoemission spectroscopy, a technique that gives the band structure and symmetries at the surface of materials. We observe multiple subbands of heavy and light electrons, confined within a region of ~5 unit cells beneath the surface, and ordered by their bulk orbital symmetries. This discovery provides a model system for the study of the electronic structure of 2DEGs in STO-based devices, and a novel route to generate 2DEGs at surfaces of other functional oxides.

I will then show that a 2DEG can indeed be also created at the surface of $KTaO_3$, a wide-gap insulator with a spin-orbit coupling more than one order of magnitude larger than in STO. As it turns out, the Fermi energy and subband splittings of the 2DEG in KTO are comparable to the strong spin-orbit coupling, resulting in a new physical system with respect to the bulk: the orbital symmetries of the 2DEG's subbands are entirely reconstructed and their masses are renormalized [3]. These results demonstrate that in transition-metal oxides 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); C. Cen et al., Nature Mater. 7, 298-302 (2008) ; N. Reyren et al., Science 317, 1196-1199 (2006); K. Ueno et al., Nature Mater. 7, 855-858 (2008); 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).

A coffee break will be served at 11h00. The seminar will be given in English.

Contact : marcelo.goffman@cea.fr/sebastien.aumaitre@cea.fr - Tel : +33 1 69 08 55 29 / 74 37
http://iramis.cea.fr/spec/