# Tuning Normal State and Superconducting Properties at the $LaAlO_3/SrTiO_3$ Interface

*A. Caviglia[1], N. Reyren[1], S. Gariglio[1], C. Cancellieri[1], S. Thiel[2], G. Hammerl[2], D. Jaccard[1], M. Gabay[3], T. Schneider[4], J. Mannhart[2], and J.-M. Triscone[1*]*

*[1]DPMC, University of Geneva, 24 quai E.-Ansermet, 1211 Geneva 4, Switzerland.*
*[2] Experimental Physics VI, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, D-86135 Augsburg, Germany.*
*[3] Laboratoire de Physique des Solides, Bat 510, Université d'Orsay, 91405 Orsay, Cedex, France.*
*[4]Physik Institut, University of Zurich, Winterthurerstrasse 190, 8057 Zurich, Switzerland.*

At interfaces between complex oxides, electronic systems with unusual properties can be generated [1,2]. A striking example is the interface between $LaAlO_3$ and $SrTiO_3$, two good *insulating* perovskites, which was found in 2004 to be conducting with a high mobility [3]. We discovered that the ground state of this system is a superconducting condensate, with a critical temperature of about 200 mK [4]. The characteristics observed for the superconducting transitions are consistent with a two-dimensional superconducting sheet as thin as a few nanometers [5]. Field effect experiments revealed the sensitivity of the normal and superconducting states to the carrier density. In particular, the electric field allows the tuning of the critical temperature between 200 mK and 0 K and thus the on-off switching of superconductivity, revealing a complex phase diagram and a superconductor to insulator transition [6]. Analyses of the anisotropy of the superconducting properties across the phase diagram show that the system is a 2D superconductor for all the doping levels investigated. Recent results reveal a large, interfacially generated, tunable spin-orbit coupling and a remarkable correlation between the spin-orbit coupling strength and the system phase diagram [7]. Finally, progress in the realization of mesoscopic structures in this electron gas and in the study of transport in the quantum regime will be reported.

[1] See for instance, "Enter the oxides", J. Heber, Nature **459**, 28 (2009).
[2] J. Mannhart and D. Schlom, Science **327**, 1607 (2010).
[3] A. Ohtomo, H. Y. Hwang, Nature **427**, 423 (2004).
[4] N. Reyren, S. Thiel, A. D. Caviglia, L. Fitting Kourkoutis, G. Hammerl, C. Richter, C. W. Schneider, T. Kopp, A.-S. Ruetschi, D. Jaccard, M. Gabay, D. A. Muller, J.-M. Triscone and J. Mannhart, Science **317**, 1196 (2007).
[5] N. Reyren, S. Gariglio, A. Caviglia, D. Jaccard, and J.-M. Triscone, Applied Physics Letters **94**, 112506 (2009).
[6] A. Caviglia, S. Gariglio, N. Reyren, D. Jaccard, T. Schneider, M. Gabay, S. Thiel, G. Hammerl, J. Mannhart, and J.-M. Triscone, Nature **456**, 624 (2008).
[7] A.D. Caviglia, M. Gabay, S. Gariglio, N. Reyren, C. Cancellieri, and J.-M. , Physical Review **104**, 126803 (2010).