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Multi-orbital subband structure of transition-metal oxide 2DEGs PHIL D.C. KING, University of St Andrews, W. MEEVASANA, Suranaree University of Technology, H.Y. HWANG, Z.-X. SHEN, Stanford University, F. BAUMBERGER, University of St Andrews — We demonstrate the creation and control of two-dimensional electron gases (2DEGs) in the 3d and 5d transition metal oxides $SrTiO_3$ and $KTaO_3$. These 2DEGs, of the form usually generated by interface engineering, are created here at the bare oxide surfaces. This permits their detailed spectroscopic investigation using angle-resolved photoemission (ARPES), and we employ this to directly image the d-orbital subband structure of the 2DEGs. We find that quantum confinement lifts the degeneracy of the bulk band structure, driving orbital ordering of the 2DEG. We measure the resulting ladder of light d_{xy} subbands, which co-exist at lower binding energies with heavy $d_{xz/yz}$-derived states. The electronic structure revealed by ARPES is in quantitative agreement with our model tight-binding calculations. While the strong spin-orbit coupling of $KTaO_3$ promotes substantial orbital mixing, our calculations predict only a small Rashba splitting of the 2DEG states, consistent with our experimental measurements where any spin splitting is too small to be resolved. The polar nature of the $KTaO_3(100)$ surface plays a striking role in mediating formation of the 2DEG as compared to non-polar $SrTiO_3(100)$, reminiscent of the polar catastrophe at $LaAlO_3/SrTiO_3$ interfaces.

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