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Engineering $LaAlO_3/SrTiO_3$ quantum wells by selective orbital occupancy

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The two-dimensional confinement of electrons in quantum wells (QWs) along the interface between two semiconductors such as Si or GaAs has been fundamental for technology as well for the development of new fundamental concepts. More recently, the discovery of 2D-QWs in oxides, with the flagship interface between $LaAlO_3$ and $SrTiO_3$, has been heralded as a milestone in the research of 2D electron systems. Unlike more conventional 2D-QWs based on III-V or II-VI semiconductors, carriers at $LaAlO_3/SrTiO_3$ populate narrow 3d-bands, where strong correlations underlie complex phases not present in conventional semiconductors. In $LaAlO_3/SrTiO_3$ not all the electrons reside in the same QW subband and, indeed, they behave differently depending on which orbital are they occupying. Here we demonstrate that the symmetry of the conduction band inside the QWs can be selected, disclosing unprecedented ways to tailor the electron properties. More specifically, we show that the spatial extension and anisotropy of the 2D-superconductivity and the Rashba spin-orbit field can be largely modulated by controlling the 2D-QWsubband filling. Our results indicate a route to manipulate selectively the electronic properties of QWs at the $LaAlO_3/SrTiO_3$ interface, opening new prospects to understand the link between orbital symmetry and 2D-superconductivity and to achieve enhanced properties suitable for spin-dependent transport.