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Even-denominator fractional quantum Hall physics in ZnO

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The study of even denominator fractional quantum Hall physics has for a long time been the exclusive privilege of the III-V semiconductor community. Its discovery at filling 5/2 and 7/2 in GaAs unleashed a flood of theoretical as well as experimental work, because these states are in essence thought to be p-wave superconducting ground states possessing non-abelian excitations. Recently however even-denominator fractional quantum Hall physics has been observed outside of the realm of III-V heterostructures in the emergent ZnO 2D electron system. ZnO not only exhibits a robust quantum Hall state at filling 7/2, but also at unconventional fillings. There is an incipient 9/2 state in perpendicular field and a fully resolved 3/2-state emerges when tilting. The latter is believed to be, just like the 7/2 state, a genuine single component state analogous to the 5/2 and 7/2 states in GaAs. Alternatively, it could be a two component spin state, a variant two-component state that has not previously been reported. The use of ZnO for investigating this even denominator FQH-physics offers a powerful additional degree of freedom. Because the Zeeman splitting and the cyclotron energy are comparable, it is possible to alter the orbital character of the partially filled level at fixed filling by tilting the sample. Our studies show unequivocally that the orbital nature of the partially filled level is crucial for the appearance of even-denominator fractional quantum Hall physics. While a basic understanding has been developed, key features remain to be understood with the spin degree of freedom likely playing a prominent role. This work has been performed together with J. Falson (University of Tokyo), D. Maryenko (RIKEN), B. Friess (MPI-FKF), D. Zhang (MPI-FKF), Y. Kozuka (University of Tokyo), A. Tsukazaki (Tohuku University and JST), M. Kawasaki (University of Tokyo and RIKEN).