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Gate-tunable phase transitions in thin flakes of 1T-TaS_2

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The competition, coexistence and cooperation of various collectively ordered electronic states in two-dimensional (2D) systems has been breeding ground for novel states of matter. Controllable manipulation of the various phases through gate-tunable charge doping may lead to new device paradigm for future material science and technology. We develop a new doping method that utilizes a gate electric field to drive lithium ions in and out of the layered 1T-TaS_2, and introduces high doping levels in each atomic layer. This is realized in a device, referred to as ionic field-effect transistor (iFET), that controls the electronic properties of a layered material (1T-TaS_2 in our case) by gate-controlled intercalation. In this talk, we explore previously inaccessible parameter space in 1T-TaS_2 based iFETs following two pathways: i) reducing the dimensionality of 1T-TaS_2 by thinning it down to a few atomic layers, and ii) doping it by gate-controlled intercalation. Our complete phase diagram reveals the importance of dimensionality and gate-controlled ionic doping in layered atomic crystals, and provides fresh insights into the relation between superconducting phase and various other charge-ordered phases.