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Electrical control of truly two-dimensional neutral and charged excitons in monolayer $MoSe_2$[1] JASON ROSS, SANFENG WU, University of Washington, HONGYI YU, University of Hong Kong, NIRMAL GHIMIRE, University of Tennessee, AARON JONES, GRANT AIVAZIAN, University of Washington, JIAQIANG YAN, Oak Ridge National Lab, DAVID MANDRUS, University of Tennessee, DI XIAO, Carnegie Mellon University, DI XIAO, University of Hong Kong, XIAODONG XU, University of Washington — Monolayer transition metal dichalcogenides (TMDs) have emerged as ideal 2D semiconductors with valley and spin polarized excitations expected to enable true valley-tronics. Here we investigate $MoSe_2$, a TMD which has yet to be characterized in the monolayer limit. Specifically, we examine excitons and trions (their singly charged counterparts) in the ultimate 2D limit. Utilizing high quality exfoliated $MoSe_2$ monolayers, we report the observation and electrostatic tunability of positively charged (X+), neutral (Xo), and negatively charged (X-) excitons via photoluminescence in FETs. The trion charging energy is large (30 meV), enhanced by strong confinement and heavy effective masses, while the linewidth is narrow (5 meV) at temperatures below 55 K. This is greater spectral contrast than in any known quasi-2D system. Further, the charging energies for X+ and X- to are nearly identical implying the same effective mass for electrons and holes, which supports their recent description as massive Dirac fermions. This work demonstrates that monolayer $MoSe_2$ is an ultimate 2D semiconductor opening the door for the investigation of truly 2D exciton physics while laying the ground work necessary to begin valley-spin polarization studies.

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