

Valley-controlled many-body exciton interactions in monolayer WSe₂ phototransistors

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Many-body exciton interactions govern the optoelectronic response of atomically thin transition metal dichalcogenides, where strong Coulomb interactions produce tightly bound electron-hole pairs (excitons), which dominate their linear and nonlinear optical responses [1]. These materials host two inequivalent valleys at the K and K' points, with excitonic transitions selectively addressable by using circularly polarised light. Here, we employ high fluence helicity-resolved photocurrent spectroscopy [2] to probe excitonic nonlinearities in a monolayer WSe₂ phototransistor. We observe a pronounced helicity-dependent sublinear photocurrent, revealing valley-dependent many-body exciton interactions. Our results are well explained by a model incorporating intervalley scattering [3] and exciton-exciton annihilation [4]. This valley-dependent control provides a powerful all-optical experimental knob for enhancing and tuning many-body excitonic effects, offering novel pathways for excitonic and valleytronic device engineering and for exploring strong correlated exciton phases.

References

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 [3] M. Selig et al. Physical Review Research, 2 (2020), 023322
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Figure

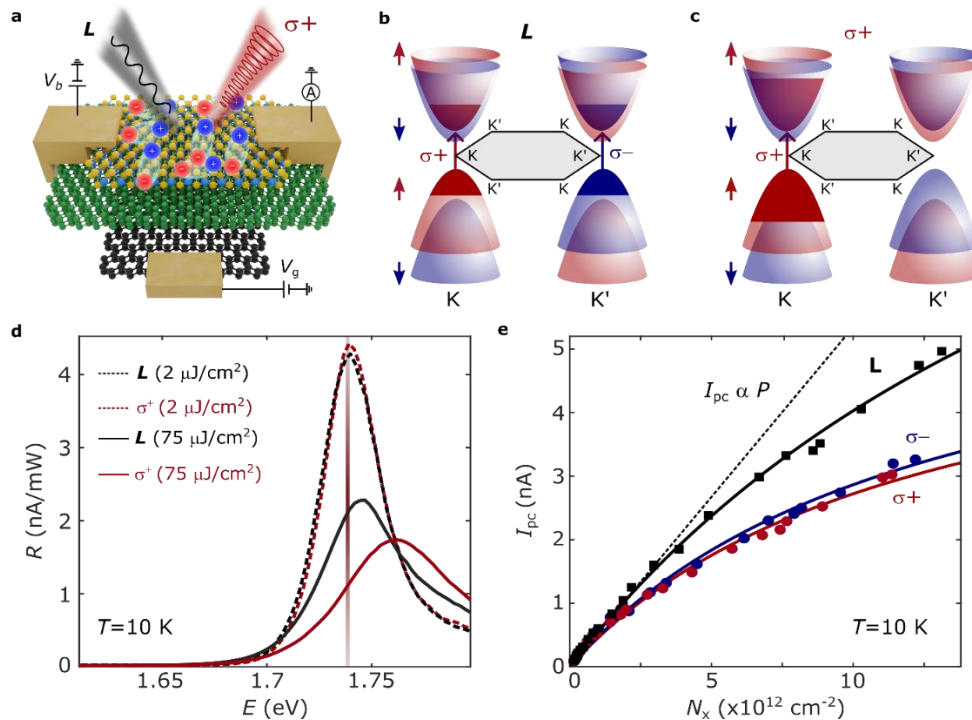


Figure 1: Valley-controlled many-body excitonic effects in 1L-WSe₂. a) Schematic of photoexcited excitons in a graphite/hBN/1L-WSe₂ device. Valley exciton populations under b) linear (L) and c) circular (σ^+) excitation. d) Responsivity spectra under linear (black) and right-handed circular (red) excitation at low (dashed) and high (solid) fluence. e) Helicity-dependent sublinear photocurrent as a function of exciton density.