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Quadrupolar Excitons in $MoSe_2$ Bilayers

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Abstract

We investigate the evolution of the excitonic energy landscape under external electric field in double-gated devices based on an inherently robust and scalable system of natural $MoSe_2$ homobilayeres. For the investigation, we employ the combination of electro-optical measurements and many-body microscopic model. Most notably, for the first time in a bilayer TMD system we observe the emergence of quadrupolar exciton states. These arise as a result of the superposition of anti-aligned inter-layer dipolar excitons enabled by a coupling mechanism attributed to to the dipolar exchange interaction. Moreover, we show a broad tunability of the quadrupolar, inter-layer and intra-layer states via external field. Overall, our results highlight the natural bilayers as a very promising field-tunable platform for investigation of nanoscale many-body physics.