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Simple Screened Hydrogen Model of Excitons in Two-Dimensional Materials THOMAS OLSEN, SIMONE LATINI, FILIP RASMUSSEN, KRISTIAN THYGESEN, Tech Univ of Denmark — We present a generalized hydrogen model for the binding energies (E_B) of excitons in two-dimensional (2D) materials that sheds light on the fundamental differences between excitons in two and three dimensions. In contrast to the well-known hydrogen model of three-dimensional (3D) excitons, the description of 2D excitons is complicated by the fact that the screening cannot be assumed to be local. We show that one can consistently define an effective 2D dielectric constant by averaging the screening over the extend of the exciton. For an ideal 2D semiconductor this leads to a simple expression for E_B that only depends on the excitonic mass and the 2D polarizability α. The model is shown to produce accurate results for 51 transition metal dichalcogenides. Remarkably, over a wide range of polarizabilities the expression becomes independent of the mass and we obtain $E_B^{2D} \approx 3/(4\pi\alpha)$, which explains the recently observed linear scaling of exciton binding energies with band gap. It is also shown that the model accurately reproduces the non-hydrogenic Rydberg series in WS_2 and can account for screening from the environment.

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