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Exciton-induced Superconductivity in Doped Atomically Thin Semiconductor Heterostructures

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Abstract

We explore a novel mechanism to induce superconductivity in transition metal dichalcogenides at high temperatures that exploits excitons as the mediator of attractive interactions. To this end we develop a strong-coupling model that is reproduces well-established limits of Bose and Fermi polarons as observed in TMD-based experiments. Based on this new model, we find that —due to the presence of trions— the effective exciton-electron interaction develops strong retardation and non-local characteristics. This results in a significant influence on the formation of Cooper pairs whose effective mass remains small even at strong coupling. Key to our idea is to consider a TMD heterostructure where dipolar excitons are spatially separated from the electrons in an adjacent layer. We find that as the doping level is decreased, the system develops an emerging BCS-BEC crossover from a BCS superconductor to a bipolaron superfluid. Our results indicate that superconducting temperatures of up to 10% of the Fermi temperature are possible, highlighting exciting perspectives for experiments and future applications.