Tnano 2020

International Workshop on Nanotechnology (Tnano20)
October 5 – 8, 2020, in Tbilisi, Georgia

CRYSTAL PHASES OF CHARGED INTERLAYER EXCITONS IN VAN DER WAALS HETEROSTRUCTURES

Igor BONDAREV

Math & Physics Department, North Carolina Central University, Durham, NC 27707, USA,
ibondarev@nccu.edu

We study the properties of charged interlayer excitons (CIE) in highly excited vdW heterostructures [1] — a compound fermion system with the permanent dipole moment observed recently in Transition-Metal-Dichalcogenide bilayer heterostructures [2]. We predict the existence of new strongly correlated collective CIE states, the long-range ordered phases of the excited heterostructure — the crystal phase and the Wigner crystal phase. We evaluate the critical temperatures and density for the formation of such many-particle cooperative compound fermion states. We demonstrate that they can be selectively realized with bilayers of properly chosen electron-hole effective mass ratio by just varying their interlayer separation distance. Compound fermion systems featuring permanent electric dipole moments are of both fundamental and practical importance due to their inherently unique many-body correlation effects between electric-dipole and spin degrees of freedom. The spin in such systems could potentially be used for quantum information processing and its correlation with the dipole moment provides an opportunity for spin manipulation through optical means. Fundamental cooperative crystallization phenomena we predict will greatly increase the potential capabilities of such systems to open up new avenues for experimental exploration and novel device technologies with van der Waals heterostructures.

References

[1] I.V. Bondarev, O.L. Berman, R.Ya. Kezerashvili, and Yu.E. Lozovik, *Crystal Phases of Charged Interlayer Excitons in van der Waals Heterostructures*, arxiv:2002.09988

[2] L.A.Jauregui, A.Y.Joe, K.Pistunova, D.S.Wild, A.A.High, Y.Zhou, G.Scuri, K.De Greve, A.Sushko, C.-H.Yu, T.Taniguchi, K.Watanabe, D.J.Needleman, M.D.Lukin, H.Park, and P.Kim, *Electrical Control of Interlayer Exciton Dynamics in Atomically Thin Heterostructures*, Science **366**, 870 (2019)