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Symmetry Controlled Optical Properties in TMD Nanostructures

MoS_2 and related semiconducting transition metal dichalcogenide (TMD) family is regarded as a gapped graphene systems, the properties of which are controlled by the structural symmetry. The direct band gap at K and –K points that appears in monolayer MoS_2 is regarded as a mass gap opened by the in-plane broken inversion symmetry as compared with the Dirac cone in monolayer graphene. Effects of structural symmetry on TMDs can be investigated not only by thinning TMDs from bilayer to monolayer, but also by wrapping up the 2D sheets to tubular structures. In this presentation, we would like to report a couple of subjects related to the Berry curvature in 2D and 1D TMD nanostructures.

As a first topic, we report the exciton Hall effect [1]. Hall effect is a well known phenomena to determine the carrier density in semiconductors, in which carriers are subjected to the transverse motion due to the Lorentz force by the externally applied magnetic field. We found that exciton in monolayer MoS_2 shows a similar Hall effect without external magnetic fields. This transverse motion of excitons are driven by the Berry curvature of the K and K' bands, which works as an internal magnetic field in the momentum space. From the real space imaging of the exciton diffusion trajectories, we found that the valley diffusion length reached 2 μm at 50 K.

The second subject is related to TMD nanotubes. TMD nanotube was first synthesized a quarter century ago [2], however, the investigation of electronic properties have been started only several years ago [3]. Very recently, our group have discovered superconductivity in individual WS_2 multiwalled nanotubes through ionic gating [4], and photovoltaic properties of p-n junctions formed on the WS_2 nanotubes [5]. In particular we focus on the unique photovoltaic properties of WS_2 multiwalled nanotubes, which clearly reflects its structural symmetry.

References

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