Valley and pseudospin polarization in two-dimensional hexagonal lattice

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Abstract

In two-dimensional (2D) materials with the hexagonal lattice, such as graphene, transition metal dichalcogenides (TMD), there are two independent freedoms for an electron to occupy at (1) either the K or K' valley in the Brillouin zone, and (2) either the A or B atom in the unit cell, which are called freedoms of valley and pseudospin, respectively. Further, in the presence of spin-orbit interaction, the energy bands near the Fermi energy are exchanged each other and the topological edge states appear.

In this talk, we will discuss that the valley and pseudospin polarization occurs at the same time when the inversion symmetry between A and B atoms is broken. The effects of valley and pseudospin polarization appear in optical properties of the 2D materials [1]. In particular, for the 2D materials with a buckled structure such as silicene, the valley and pseudospin polarization can be controlled by applying the electric field in the direction perpendicular to the 2D plane which makes the on-site energies of the A and B atoms different from each other. Although the valley polarization at the K or K' point does not change with increasing the electric field, the k-dependent degree of valley polarization changes as a function of the electric field as shown in Fig. 1 [2].

Next we will discuss Raman spectra of the TMDs in which we use the circularly polarized light. Chou et al. show that the scattered light changes the helicity of the circularly polarized light for so-called the IMC phonon modes while the helicity of the scattered light does not change for the OC modes [3]. In order to explain the helicity exchange of the light in the Raman process we will calculate the resonant Raman spectra by the first principles calculation as a function of laser excitation energy [4]. In particular, we will discuss the conservation law of the angular momentum of the circularly polarized light in the 2D materials.

In the most of the 2D materials, the valley and pseudospin polarization occurs simultaneously. However, we will show a simple theoretical model that the two polarization does not occur simultaneously [5]. This work is supported by MEXT Kakenhi Grant No. JP25107005.

References

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Figure

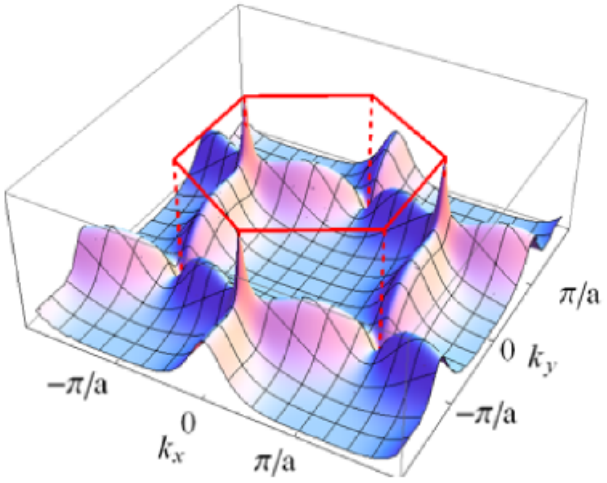

Figure 1: Optical absorption probability for circular polarized light in which the valley polarization (sharp peaks at the K point) occurs.