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Letter

Investigation of the impact of a strain-induced pseudo-magnetic field on the magneto-optical absorption spectra of monolayer 8–*Pmmn* borophene

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ABSTRACT

The 8–*Pmmn* borophene monolayer exhibits tilted and anisotropic Dirac energy dispersion cones. In this study, we theoretically investigate the magneto-optical absorption in the presence of a perpendicular static magnetic field and mechanical strain, which is treated as a pseudo-magnetic field under certain conditions. Using perturbation theory for a degenerate electron gas at low temperatures, we derive the magneto-optical absorption coefficient. Our results show that, in the absence of strain, Landau levels and absorption spectra in the K and K' valleys are identical, with no valley polarization. Valley polarization emerges only under strain and depends on the strain strength, external magnetic field, and tilt parameter. Notably, strain induces opposite shifts in the absorption spectra for the two valleys—redshift in the K valley and blueshift in the K' valley—while the absorption peak intensity changes accordingly. These findings suggest potential applications in valleytronics and strain-engineered optoelectronics.

1. Introduction

The growing interest in two-dimensional (2D) materials stems from their unique physical properties [1–11]. Among these materials, borophene stands out as a promising candidate due to its distinctive characteristics that are not found in graphene. Although borophene is a monolayer material as well, its key distinction lies in its electronic structure, which arises from the presence of four available orbitals and three valence electrons in each boron atom. This distinct configuration enables the formation of both covalent and ionic bonds, enhancing borophene's exceptional characteristics [12–16]. Depending on the arrangement of boron atoms in crystal lattices, there are many different allotropes of 2D borophene, possessing diverse electronic properties such as metallic, semiconducting, or topological insulating phases, leading to different interesting physical properties [17–19]. Remarkably, a special polymorph of borophene, called 8–*Pmmn* borophene, was first proposed in Ref. [20] with exciting electronic properties being explored in detail [21,22]. 8–*Pmmn* borophene possesses two Dirac cones/valleys in its electronic band structure within the first Brillouin zone. These two cones are anisotropic and tilted in opposite directions, resulting in valley-dependent electronic and transport properties. This opens up possibilities for using this material in valleytronic applications.

Strain has been demonstrated as one of the effective tools in adjusting the electronic properties, and thus the physical properties, of materials [23–31]. Even the field called straintronics has been formed and developed recently [32–41]. When materials are subjected to strain, their electronic and transport properties undergo significant changes, creating opportunities for innovative applications in electronics, photonics, and other fields. Studies have demonstrated that strain can act similarly to a pseudo-magnetic field. [23,42–44], opening up the possibility of controlling the magnetic properties of materials through strain. The problem of strain-induced valley polarization has been studied widely in Dirac materials including graphene [42,45–50], silicene [51–54], and other structures [55–58]. The strain-induced quantum valley Hall effect has been studied in 8–*Pmmn* borophene [44]. A tight-binding Hamiltonian for Dirac fermions was developed. The strain applied to the system was shown to generate a pseudo-magnetic field vector potential and a scalar potential. The vector potential has opposite directions in two valleys. The dependence of these potentials on the strain tensor was considered in detail. In the work by S. K. F. Islam [59], the effect of strain on the longitudinal conductivity and Hall conductivity in

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