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In their Letter [1], the authors claimed that in bilayer MoS_2, the valley-Hall effect (VHE) vanishes, while the orbital-Hall effect (OHE) has a sizable orbital-Hall conductivity. Consequently, the authors concluded that OHE in bilayer MoS_2 can be distinguished from VHE, in contrast to the monolayer case that OHE are entangled with VHE. In this Comment, we show that this is not the case. In fact, hidden VHE with nonvanishing valley-Hall conductivity in each monolayer can occur in bilayer MoS_2. Although the net valley-Hall conductivity is zero, the hidden VHE in bilayer MoS_2 can contribute to a net valley orbital angular momentum current, resulting in entangled OHE and hidden VHE.

Figure 1(a) shows the schematic of VHE of monolayer MoS_2. When an in-plane electric field (***E***) is applied, carriers in the K and $-K$ valleys flow in opposing transverse directions and accumulate on sample edges [2–4]. When the entire device in Fig. 1(a), including both sample and ***E***, is rotated by 180° around the z axis, the direction of valley currents would be switched [Fig. 1(b)]. When reversing ***E*** in Fig. 1(b) (keeping sample orientation unchanged), carriers in the K and $-K$ valleys would be transformed to accumulate on upper or lower edges [Fig. 1(c)]. Comparing Figs. 1(a) and 1(c), we can know that the 180° sample rotation does not affect the valley current.

Since interlayer hopping vanishes (e.g., conduction-band edges) or is virtually suppressed due to the strong spin-orbit interaction (e.g., valence-band edges), bilayer MoS_2 can be regarded as a mere superposition of two decoupled monolayers when we focus on the $\pm K$ valleys [5,6]. Consequently, we can imagine that nonvanishing Berry curvature and VHE can occur in both upper and lower layers of bilayer MoS_2. It is worth noting that nonvanishing Berry curvature localized in the upper or lower layer (referred to as hidden Berry curvature) has been revealed in bilayer MoS_2 by theory [7] and in bulk WSe_2 through experiments [8]. Because the lower layer in bilayer MoS_2 is a 180° rotation of the upper layer [Fig. 1(d)], the $K(-K)$ valley of the lower layer is equivalent to $-K$ (K) of the upper layer [Fig. 1(e)], such as the same Berry-curvature and valley-magnetic moment [5,6,9,10]. Consequently, when applying an in-plane ***E***, carriers in the K ($-K$) valley of the upper (lower) layer flow in the same transverse direction; while carriers in the $-K$ (K) valley of the upper (lower) layer flow in another direction [Fig. 1(f)]. Since in each transverse direction, K and $-K$ valleys contribute the equal current, the net valley current is nil. Rather than being intrinsically absent (nonvanishing valley current exists in each monolayer), the zero net valley current would instead be concealed by compensation. This is dubbed as hidden VHE, a concept akin to hidden spin polarization [11,12], hidden Berry curvature [8], and hidden orbital polarization [13,14]. Remarkably, hidden VHE in bilayer MoS_2 can contribute to a net valley orbital angular momentum current, because carriers with the same valley magnetic moment (e.g., K of the upper layer and $-K$ of the lower layer) flow in the same direction. Moreover, owing to the contributions from both the upper and lower layers, the transverse valley orbital angular momentum current in bilayer MoS_2 should be essentially twice that in the monolayer case. Such a transverse valley orbital angular momentum current in bilayer MoS_2 may be responsible for the sizable Kerr rotation or nonlocal resistance signal

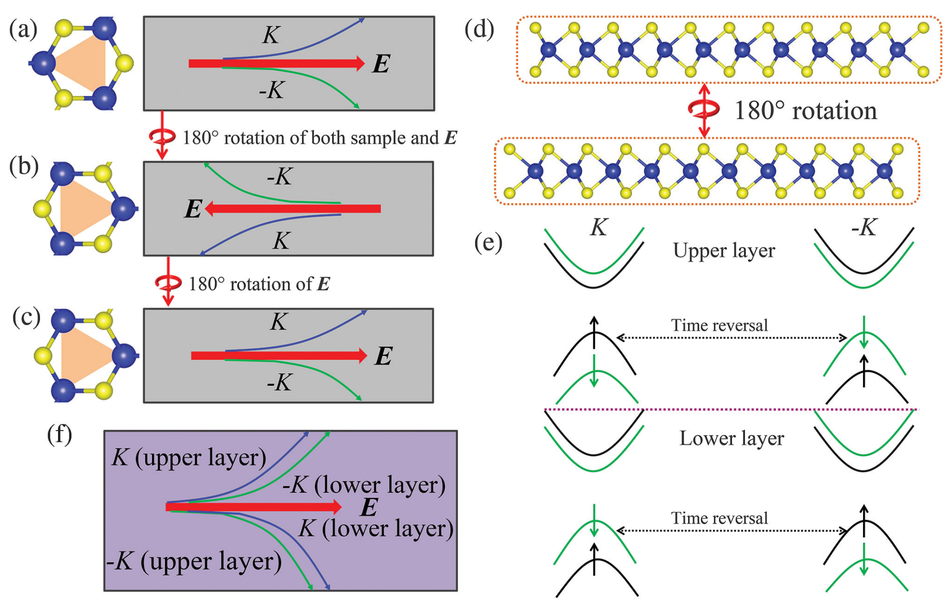

FIG. 1. (a)–(c) Schematics of VHE of monolayer MoS_2. Compared to (a), both monolayer MoS_2 and ***E*** in (b) are rotated 180°. ***E*** in (c) is rotated 180°, compared to (b). (d) Bilayer MoS_2 crystal structure. (e) Band structure of decoupled bilayer MoS_2. The spin splitting of the conduction band is magnified for clarity. (f) Hidden VHE in bilayer MoS_2. Left panels in (a)–(c) represent the crystal orientations.

previously observed at zero gate voltage [15,16]. Overall, hidden VHE with net transverse valley orbital angular momentum current exists in 2H-stacked bilayer MoS_2, and thus OHE cannot be distinguished from it.

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