Shift Current Response in Twisted Double Bilayer Graphenes

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We present our numerical results on the shift current response in AB-AB and AB-BA stacked twisted double bilayer graphenes (TDBG).

The shift current is a second order nonlinear optical response where light is rectified into dc current in noncentrosymmetric materials [1]. Due to its relation to the Berry connection, it has the potential to probe the topology and quantum geometry of various materials.

TDBG is a moiré system composed of two sheets of AB-stacked bilayer graphene (BLG) stacked with a relative twist angle. The two stacking configurations of TDBG, known as AB-AB and AB-BA, have completely different valley Chern numbers while hosting similar band structures [2]. Here, we are motivated to study the how this contrast between the two variants is reflected in the shift current response.

We have performed a systematic study, investigating the dependence of the signal on the twist angle, the vertical bias voltage and the Fermi level [3]. The numerical analyses demonstrate that a large signal is generated from the formation of the moiré minibands. Notably, we also found that there is a systematic sign reversal of the signal in the two stacking configurations below the charge neutrality point for large bias voltages. We qualitatively explain the origin of this sign reversal by studying the shift current response in AB-stacked BLG.

References

[1] J. E. Sipe and A. I. Shkrebtii, Phys. Rev. B, **61** (2000) 5337.
[2] M. Koshino, Phys. Rev. B, **99** (2019) 235406.
[3] T. V. Joya, T. Kawakami and M. Koshino, arXiv (2025)

Figures

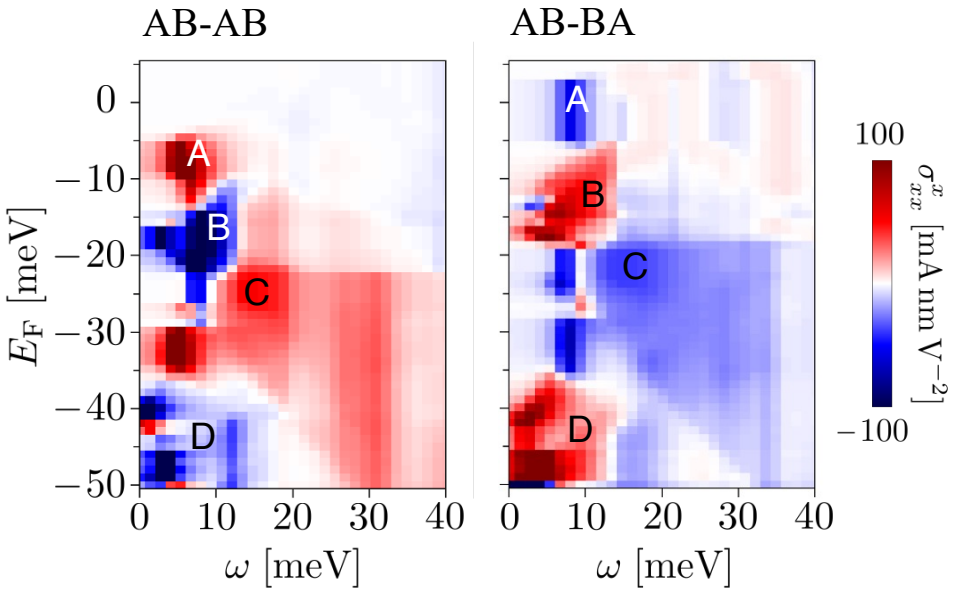

Figure 1: The shift current in AB-AB and AB-BA stacked TDBG. The signal is shown as a colour density plot with the Fermi level on the vertical and the frequency on the horizontal axis. We have labelled the corresponding regions where a sign reversal can be seen between the two stackings.