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Nonlinear current responses in van der Waals nanomaterials

The effect of inversion symmetry breaking on the electric and optical properties is one of the central issues in condensed matter physics. Such inversion symmetry breaking can be easily realized in van der Waals nanomaterials by using the recently developed ionic liquid gating technique or crystal engineering. In this presentation, I will talk about recent our studies on the nonlinear current responses in van der Waals nanostructures without inversion symmetry.

Nonreciprocal electric transport, which represents the rectification effect originating from symmetry breaking and can be understood as the second order nonlinear electric transport, has been observed in various noncentrosymmetric van der Waals nanomaterials including low dimensional superconductors [1-3]. I will briefly review the van der Waals nanomaterials in which we have successfully observed the nonreciprocal transport and introduce the characteristic behaviors reflecting the peculiar electronic states or vortex dynamics.

Another topic is the anomalous photovoltaic effect in van der Waals nanostructures [4]. Anomalous photovoltaic effect indicates the emergence of photo-induced spontaneous current without semiconductor *p-n* junction nor bias voltage and generally appears in polar crystals. I will suggest a simple strategy of symmetry engineering using the van der Waals nanostuructures and resultant anomalous photovoltaic effect. Potential microscopic mechanism of the anomalous photovoltaic effect, i.e., shift current mechanism, will be also discussed.

References

[1] T. Ideue *et al*., Nat. Phys. **13**, 578 (2017).
[2] F. Qin *et al*., Nat. Commun. **8**, 14465 (2017).
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[4] Y. J. Zhang *et al*., Nature (2019). Accepted.

Figures

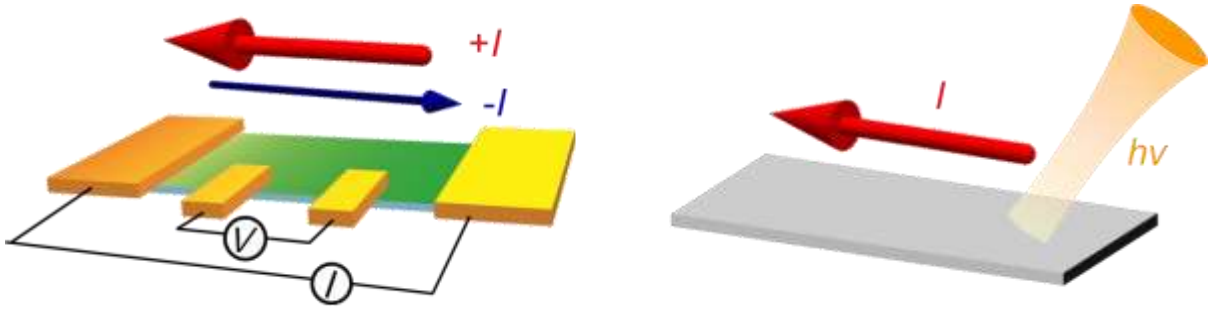

Figure 1: Schematics of nonreciprocal transport (left) and anomalous photovoltaic effect (right)