# Tunable Valley Hall Effect in Graphene Superlattices

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Valleytronics – the proposed field of information processing based on the electron valley index in e.g. graphene – relies on the control of protected valley currents [1]. In this work we consider the model of graphene gated via a periodic array of holes in a dielectric resting on a bottom electrode (Fig. 1). We are inspired by the recent transport experiments in such structures [2]. Using tight-binding supercell calculations and an unfolding procedure [3], we demonstrate how the electronic structure of this system corresponds to a gapped graphene structure with an associated valley Hall effect. We characterize the valley polarized currents by extracting the valley Hall conductivity from the unfolded Berry curvature of occupied states, and find that these currents become tunable by the gate-potential (Fig. 2). We furthermore perform Boltzmann conductivity calculations in order to characterize the valley Hall angle and make predictions for the indirect detection of such currents in nonlocal transport experiments [4-5] when the Fermi level is tuned close to the band edge. Finally, we demonstrate the stability of the valley Hall effect in these systems when realistic potentials are considered which include the effect of disorder in the dielectric.

## References

[1] J. R. Schaibley et al., Nature Reviews Materials, 1 (2016) 16055
[2] C. Forsythe et al., Nature Nanotechnology, 13 (2018) 566-571
[3] T. Olsen and I. Souza, Physical Review B, 92 (2015) 125146
[4] R. V. Gorbachev et al., Science, 6208 (2014) 448-451
[5] M. Beconcini et al., Physical Review B (R), 94 (2016) 121408

## Figures

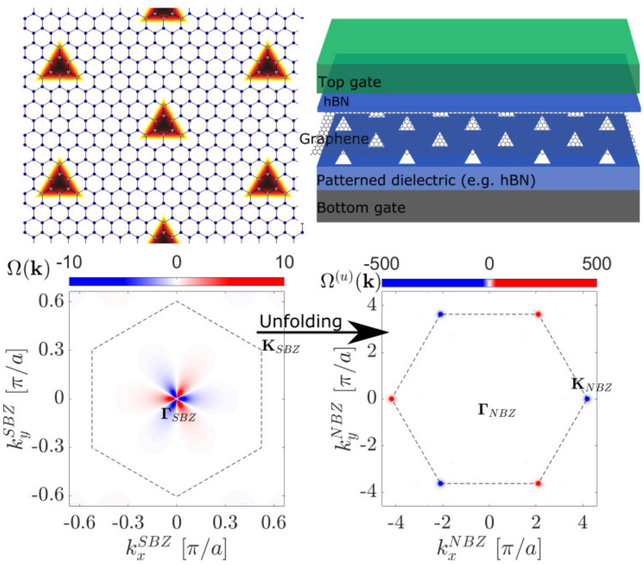


**Figure 1:** (top) A graphene sheet under a periodic gate-potential resulting from a nanostructured dielectric such as hBN with naturally occurring triangular holes. (bottom) Supercell Berry curvature and the unfolding into the graphene Brillouin zone, demonstrating the resulting valley Hall effect: Ω(k) is positive around K-parts and negative around K'-parts of the Brillouin zone.

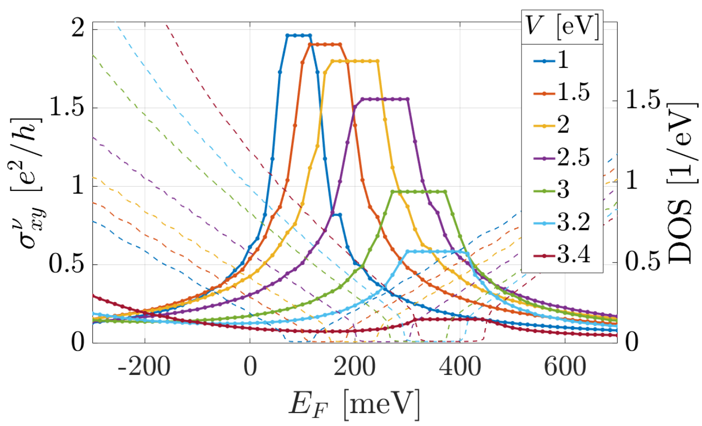


**Figure 2:** Valley Hall conductivity as function of filling (full lines) for varying values of the superlattice potential V, shown alongside the density of states (dashed lines).

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