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Energy spectrum, quantum Hall effect, and valley splitting in graphene on hexagonal boron nitride

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We theoretically investigate the electronic structure, quantum Hall effect, and valley splitting in graphene (monolayer and bernal-stacked bilayer) on hexagonal boron nitride. The beating of the mismatched lattices creates a superlattice potential, of which period can be much larger than intrinsic graphene. Using a low-energy approximation which incorporates the rigorous interlayer interaction [1], we describe the spectral evolution in a wide range of magnetic fields. We show that, at high magnetic field, even the zero energy Landau levels are completely reconstructed with a nonmonotonic sequence of quantized Hall conductivity (Fig. 1). And we find the lifting of valley degeneracy in this type of superlattice. The emergence of states with integer quantized conductance at noninteger filling of a single Landau level is well matched by the experimental results [2].

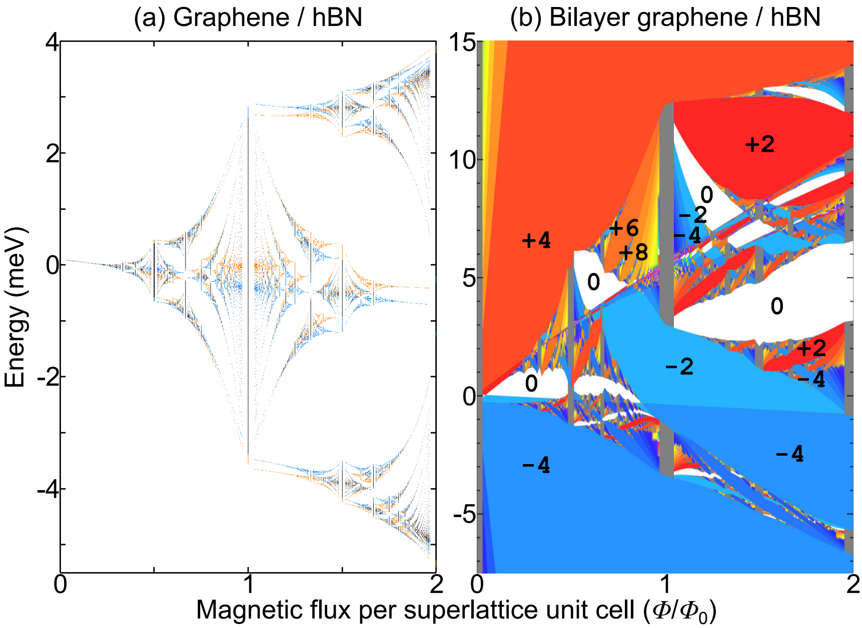

Figure 1: Energy spectrum of (a) monolayer graphene and (b) bernal-stacked bilayer graphene on hexagonal boron nitride with a 0° mismatch angle. The energy scale is chosen to highlight the lowest Landau level. The numbers in (b) label the quantized Hall conductivity in units e^2/h corresponding to each gap.

[1] P. Moon and M. Koshino, Phys. Rev. B **85**, 195458 (2012).
[2] C. R. Dean, L. Wang, P. Maher, C. Forsythe, F. Ghahari, Y. Gao, J. Katoch, M. Ishigami, P. Moon, M. Koshino, T. Taniguchi, K. Watanabe, K. L. Shepard, J. Hone, and P. Kim, arXiv:1212.4783 (2013).