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Artificial lattices made in an STM as quantum simulators for real materials

physikalisches

Mo. 17.12.18
16:00 Uhr
Ort: H34

The surface-state electrons of atomically clean and flat metal surfaces form a 2-D electron gas. These electrons can be forced into a two-dimensional lattice of any nanoscale geometry (2D square, Lieb, Honeycomb, Kagome, ...) by positioning repulsive scattering atoms or small molecules (CO) on top of the surface. The band structure of such a man-made artificial lattice is studied by measuring the density of electronic states. This is all done in-situ in a cryogenic scanning tunnelling microscope.

We prepared diverse honeycomb and Lieb lattices in this way, and showed that the density of states reflect Dirac bands and flat bands. We emphasize the orbital degree of freedom, which is absent in e.g. graphene. We also investigated Kagome and 2D-SSH lattices and investigated the topological edge and corner states.

Our results form an objective data set to judge the validity of theoretical models and to design real two-dimensional semiconductors with a specific Dirac-type band structure, decided by the nano-scale geometry.

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- 2 Drost, R., Ojanen, T., Harju, A. & Liljeroth, P. Topological states in engineered atomic lattices. *Nat. Phys.* 13, 668+, doi:10.1038/nphys4080 (2017).
- 3 Slot, M. R. et al. Experimental realization and characterization of an electronic Lieb lattice. *Nat. Phys.* 13, 672+, doi:10.1038/nphys4105 (2017).
- 4 Bercioux, D. & Otte, S. QUANTUM SIMULATION Solid-state platforms. *Nat. Phys.* 13, 628-629 (2017).
- 5 Boneschanscher, M. P. et al. Long-range orientation and atomic attachment of nanocrystals in 2D honeycomb superlattices. *Science* 344, 1377-1380, doi:10.1126/science.1252642 (2014).
- 6 Geuchies, J. J. et al. In situ study of the formation mechanism of two-dimensional superlattices from PbSe nanocrystals. *Nat. Mater.* 15, 1248-1254, doi:10.1038/nmat4746 (2016).

