Séminaire exceptionnelle IMPMC

Atom-by-atom engineering of electronic states of matter

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Abstract

Feynman's original idea of using one quantum system that can be manipulated at will to simulate the behavior of another more complex one has flourished during the last decades in the field of cold atoms. More recently, this concept started to be developed in nanophotonics and in condensed matter. In this talk, I will discuss a few recent experiments, in which 2D electron lattices were engineered on the nanoscale. The first is the Lieb lattice [1,2], and the second is a Sierpinski gasket [3], which has dimension D = 1.58. The realization of fractal lattices opens up the path to electronics in fractional dimensions. Finally, I will show how to realize topological states of matter using the same procedure. We investigate the robustness of the zero modes in a breathing Kagome lattice, which is the first experimental realization of a designed *electronic* higher-order topological insulator [4]. Then, we investigate the importance of the sample termination in determining the existence of topological edge modes in crystalline topological insulators. We focus on the breathing Kekule lattice, with two different types of termination [5]. In all cases, we observe an excellent agreement between the theoretical predictions and the experimental results.

[1] M.R. Slot, T.S. Gardenier, P.H. Jacobse, G.C.P. van Miert, S.N. Kempkes, S.J.M. Zevenhuizen, C. Morais Smith, D. Vanmaekelbergh, and I. Swart, *"Experimental realisation and characterisation of an electronic Lieb lattice",* Nature Physics **13**, 672 (2017).

[2] M. R. Slot et al., *"p-band engineering in artificial electronic lattices"*, Phys. Rev. X **9**, 011009 (2019).

[3] S.N. Kempkes, M.R. Slot, S.E. Freeney, S.J.M. Zevenhuizen, D. Vanmaekelbergh, I. Swart, and C. Morais Smith, *"Design and characterization of electronic fractals*", Nature Physics **15,** 127(2019).

[4] S.N. Kempkes, M. R. Slot, J. J. van den Broeke, P. Capiod, W. A. Benalcazar, D. Vanmaekelbergh, D. Bercioux, I. Swart, and C. Morais Smith "*Robust zero-energy modes in an electronic higher-order topological insulator: the dimerized Kagome lattice*", ArXiv: 1905.06053, to appear in Nature Materials (2019).

[5] S. E. Freeney, J. J. van den Broeke, A. J. J. Harsveld van der Veen, I. Swart, and C. Morais Smith, "*Edge dependent topology in Kekulé lattices",* submitted (2019).

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