Direct measurement of Chern numbers in the diffraction pattern of a Fibonacci chain

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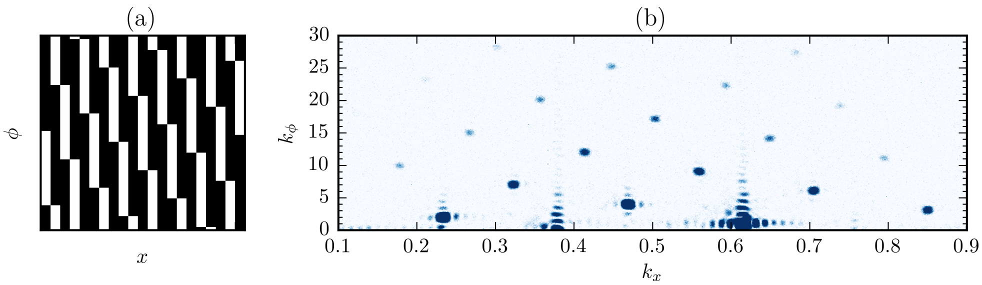

Set of Fibonacci chains where ϕ (phason) is scanned vertically (a) and the corresponding diffraction pattern (b). The position of the diffraction peaks gives information about the spectral gaps of the chain (k_x axis) and their associated Chern numbers (k_ϕ axis).

Topology plays an important role in many topics in physics by providing a general classification of some physical phenomenon in terms of a small number of topological invariants. It is of particular interest in the field of condensed matter, where the bands of gapped systems can be attributed a topological index – the so-called Chern number – which is instrumental to understand, from a topological perspective, the quantization of the Hall conductance in quantum Hall effect.

The topological properties of one-dimensional quasicrystals – aperiodic phases of matter with long-range order – happen to be non-trivial [1]. These properties are linked to the existence of an additional degree of freedom in the structure of the chain, corresponding to a shift of the origin of the quasiperiodic order. In the iconic case of the Fibonacci chain, this degree of freedom is a phase ϕ, known as "phason" in this context. The effect of this phase on the longitudinal scattering properties of a Fibonacci quasicrystal was recently studied [2].

We will present a diffraction experiment on an optical grating reproducing the Fibonacci sequence. The grating consists of a programmable array of micro-mirrors (DMD), which allows for the control of the phase. We will see that each diffraction peak corresponds to a (longitudinal) spectral gap, and that the Chern number of this gap can be measured by scanning the phase of the chain. We will also show that these Chern numbers can be directly read from the 2D diffraction pattern of a set of Fibonacci gratings (see above figure).

1. Y. E. Kraus *et al.*, Phys. Rev. Lett. **109**, 116404 (2012)
2. E. Levy *et. al.*, arXiv :1509.04028 (2015)