Gap labelling in quasicrystals: from microwaves to ultracold atoms

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Abstract

Quasicrystals can be modeled with a collection of polygons (tiles) that cover the whole plane, so that each pattern (a sub-collection of tiles) appears up to translation with a positive frequency, but the tiling is not periodic. The frequency of presence of each pattern determines the spectrum of the system, and this is the subject of the gap labelling theory [1].

Using a microwave realization of a tight-binding Penrose-tiled quasicrystal [2], we measured the gap labelling and the spatial energy distribution of each eigenstate [3]. The energy-scaling behaviour of the hopping terms in this particular system, allowed us to identify the main patterns that determine the first hierarchical structure of the spectrum . Our energy-scaling analysis enabled us not only a straightforward interpretation of the gap labelling but also a full understanding of the wavefunction behaviour observed in each band.

The next goal will be the realization of a light Penrose-tiled quasicrystal for ultracold atoms, the underlying idea being to have access to samples with a lager number of tiles and thus to have the opportunity to observe the hierarchical effect of larger and larger patterns in the gap labelling. We have shown that this may be possible by mapping the gap labelling on a Brillouin zone (BZ) labelling and measure the areas of the extended BZs or the Bragg peak intensity distribution via different time-of-flight techniques [4].

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