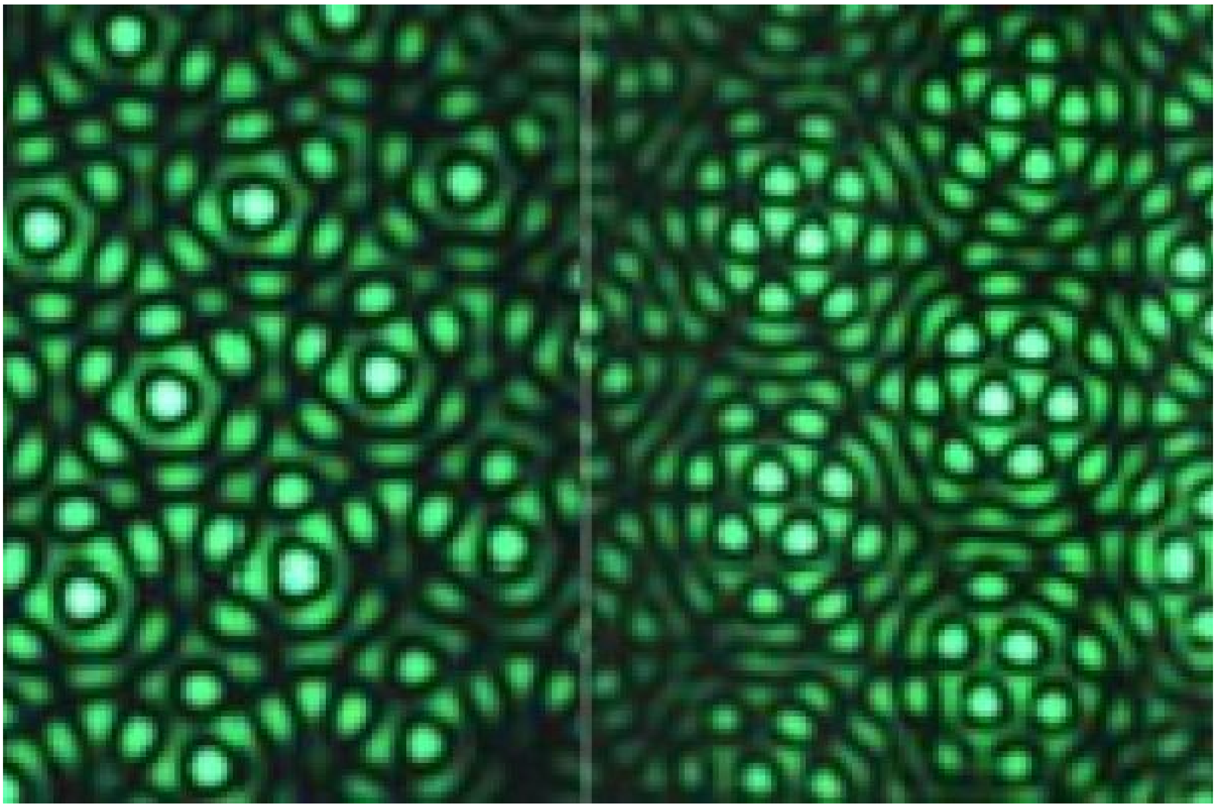

Photonic Moire lattices in Nature

Localization of light in reconfigurable photonic moire lattices with controllable symmetry has been observed.

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If you take two identical layers of semi-transparent material that have the same structure, you put them one on top of the other, rotate them and then look at them from above, hexagonal patterns start to emerge. These patterns are known as moire patterns or moire lattices.

Moire patterns appear often in every-day life applications such as art, textile industry, architecture, as well as image processing, metrology and interferometry. They can be seen in the East face of ICFO building every day! They are a matter of major current interest in science, since they can be produced using coupled graphene-hexagonal boron nitride monolayers, graphene-graphene layers and graphene quasicrystals on a silicon carbide surface and have proven to generate different states of matter upon rotating or twisting the layers to a certain angle, opening to a new realm of physics. Two years ago scientists at MIT found a new type of unconventional superconductivity in twisted bilayer graphene that forms a moire lattice, and a team of ICFO researchers recently unveiled a new zoo of unobserved

states in the same structure
(https://www.icfo.eu/newsroom/news/4550-a-plethora-of-states-in-magic-angle-graphene).

Now in a study published yesterday in Nature, a team of scientists in a long-standing collaboration between ICFO researchers Dr Yaroslav Kartashov and Prof Lluis Torner, the former post-doctoral researcher in the same ICFO group Dr Fangwei Ye (currently professor at the Shanghai Jiao Tong University, where the experiments were conducted), and Prof Vladimir Konotop in Lisbon, have reported on the propagation of light in photonic moire lattices, which, unlike their material counterparts, have readily controllable parameters and symmetry, allowing researchers to explore transitions between structures with fundamentally different geometries (periodic, general aperiodic, and quasicrystal).

The paper shows the creation of the lattices by two superimposing periodic patterns with either square or hexagonal primitive cells, and tunable amplitudes and twist angle. Depending on the twist angle, a photonic moire lattice may have different periodic (commensurable) structure or aperiodic (incommensurable) structure without translational periodicity. The angles at which a commensurable phase (periodicity) of a moire lattice is achieved are determined by Pythagorean triples or by another Diophantine equation depending on the shape of the primitive cell. Changing the relative amplitudes of the sublattices allowed researchers to smoothly tune the shape of the lattice without affecting its rotational symmetry.

Then, using commensurable and incommensurable moire patterns, researchers observed for the first time the two-dimensional localization-delocalization transition of light. The used photonic moire lattices can be readily constructed in practically any arbitrary configuration consistent with symmetry groups, thus allowing the creation of potentials that may not be easily produced in tunable form using material structures. Therefore, in addition to their direct application to the control of light patterns, the availability of photonic moire patterns allows the study of phenomena relevant to other areas of physics, particularly to condensed matter, which are harder to explore directly.