



Nonlinear higher-order photonic topological insulator observed for the first time

In a work published in *Nature Physics*, an international team of researchers investigates the fate of topological boundary modes in the nonlinear regime of a photonic system.

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Topological insulators are a recently discovered state of matter. Among their unique features are chiral surface currents that are topologically protected from scattering at defects and disorder, while the bulk material remains insulating. Linear topological insulators were observed in many areas of physics, including photonics. Recently, the existence of novel type of higher-order topological insulators was proposed. In this new type of topological phase, the dimensionality of the topologically nontrivial boundary modes is more than one dimension below that of the bulk. Thus, a d -dimensional n -th order topological insulator supports $(d-n)$ -dimensional boundary states. For example, among the most interesting features of second-order topological insulators is the existence in them of zero-dimensional

states localized in the corners of such structures that are protected by the nontrivial topology of the system.

To date, research into the wave dynamics of photonic higher-order topological insulators in conservative optical systems has been confined to strictly linear conditions, and their extension in the presence of nonlinear self-action has yet to be explored. At the same time, the introduction of nonlinear effects in such systems promises a whole range of new phenomena, ranging from nonlinearity-induced topological phases, controllable coupling between edge and corner states, to new possibilities for control of localization, stability, and dynamics of topological excitations, including nontrivial corner states.

In recent landmark publication in *Nature Physics* the first example of nonlinear higher-order topological insulator was observed by a team of international researchers from the Institute of Spectroscopy of Russian Academy of Sciences, Xian Jiaotong University, ICFO and the University of Rostock, where the observation was conducted. The excitation of nonlinear higher-order topological corner states was demonstrated. The observation was performed in a Kagome array of laser-written waveguides, where a nontrivial topology is introduced by controllable displacements of one of the waveguides in the unit cell. The work paves the way towards the exploration of topological properties of matter in the nonlinear regime, and may herald a new class of compact devices that harnesses the intriguing features of topology in an on-demand fashion.