Summary

In the last decades, topological insulators have attracted great interest and also have promising applications in topics such as metrology or quantum computation. These exotic materials go beyond the standard classification of phases of matter: they are insulating in their bulk, conducting on their edges, and characterized by a global topological invariant, in contrast to a local order parameter as in the conventional Ginzburg-Landau theory of phases of matter.

Such topological phases have been experimentally observed in condensed matter systems and more recently in quantum simulators. The latter are very versatile platforms that allow one to simulate a material with another quantum system in a very controllable environment. In the case of topological insulators, this degree of control is particularly promising to unveil the mechanisms leading to these phases.

The quantum simulation of these exotic materials typically relies on the generation of artificial gauge fields. However, recent studies have shown that topological phases can also emerge from particle interactions. The latter mechanism leads to the concept of interaction-induced topological phases, in which topology is acquired through a spontaneous symmetry breaking process. The interplay of the spontaneous symmetry breaking with the global topological properties can lead to very interesting effects.

In a recent article published in Physical Review Letters and highlighted as an Editor's suggestion, a collaboration of researchers Sergi Julià-Farré, Maciej Lewenstein and Alexandre Dauphin from the Institute of Photonic Sciences (ICFO) with Markus Müller from RWTH Aachen University and Forschungszentrum Jülich, reports how such interplay can lead to new strongly-correlated topological effects.

The team of researchers has shown how interactions can localize particles in the insulating bulk, leading to self-trapped polarons. Moreover, they have also shown how the interacting nature of the topological insulator gives rise to domains in the bulk. Interestingly, the nontrivial topology associated to each domain leads to the appearance of protected conducting states in the bulk, localized at the domain boundaries. They also discussed the possibility of quantum simulating such phases with cold laser-excited Rydberg atoms in an optical lattice.