

Interaction-induced topology in symmetry-broken phase

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Symmetry is a fundamental characteristic in nature. Understanding the mechanisms that break symmetries is essential to scientific research. Spontaneous symmetry breaking (SSB), in particular, occurs when

thermal or quantum fluctuations drive a system from a symmetric state into an ordered state, as it occurs when a liquid turns into a solid. This mechanism allows researchers to classify different phases of matter according to the different patterns generated by the broken symmetry.

In the last decades, topology has also been recognized as a crucial characteristic to describe how matter is organized at the fundamental level. In this case, it is no longer the breaking of certain symmetries, but their conservation, which gives rise to novel states of matter, the so-called symmetry-protected topological (SPT) phases. Different topological phases might present the same symmetries, but they can be distinguished by a global topological invariant, which takes integer values and is preserved under continuous deformations.

Current research in condensed matter physics aims to understand how symmetry breaking and symmetry protection compete, in particular in the presence of interactions. In a recent paper published in *Nature Communications*, ICFO researchers Daniel Gonzalez and Przemyslaw Grzybowski, led by Alexandre Dauphin and ICREA Prof. at ICFO Maciej Lewenstein, in collaboration with Alejandro Bermudez from the Universidad Complutense in Madrid, report how these two processes cooperate, giving rise to new strongly-correlated topological effects.

In their study, the researchers demonstrated how, in the presence of strong interactions, a protecting symmetry emerges at low energies from the set of configurations constrained by the breaking of a different symmetry. This emergent symmetry stabilizes an intertwined topological phase, where the topological properties coexist with the presence of long-range order. Moreover, they demonstrate how this interplay gives rise to interesting static and dynamical effects, such as a topologically protected particle transport quantized to fractional values. For this, they study a microscopic lattice model, the Z_2 -Bose–Hubbard model, which can be implemented experimentally using ultracold atomic systems.

The results of this study open a window into the field of topological phases in materials, paving the way for further exploration of exotic topological features in strongly-correlated quantum systems.

More information: Daniel González-Cuadra et al. Intertwined topological phases induced by emergent symmetry protection, *Nature Communications* (2019). [DOI: 10.1038/s41467-019-10796-8](https://doi.org/10.1038/s41467-019-10796-8)

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