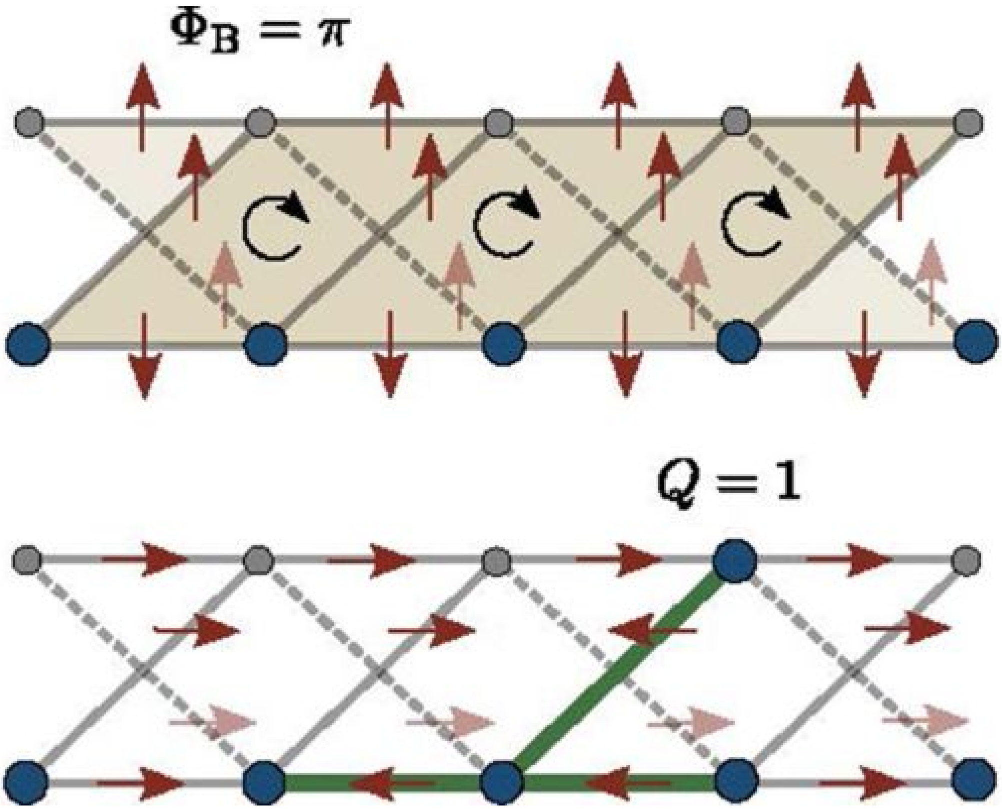

New mechanisms for topological order in atomic quantum simulators

Scientists from ICFO report on new methods for producing robust topological order in atomic systems, which could facilitate fault-tolerant quantum computation and quantum simulation of high-energy physics.

October 11, 2020

At low temperatures, certain quantum systems evade the standard forms of ordering that give rise to usual phases of matter, such as crystalline solids or magnetic materials. Instead, strong quantum correlations between their constituent particles lead to configurations characterized by topological order, where distinct global properties are protected against local perturbations. This allows one to encode information in a non-local manner, providing a promising avenue to fault-tolerant quantum computation. However, preparing such quantum states is a challenging experimental task, requiring a precise fine tuning of the system's parameters.

In a recent paper published in Physical Review X, ICFO researcher Daniel Gonzalez, led by

ICREA Prof. at ICFO Maciej Lewenstein, in collaboration with Luca Tagliacozzo from the ICCUB - University of Barcelona and also led by Alejandro Bermudez from the Universidad Complutense of Madrid, identify two mechanisms that could allow topological order to be found under more relaxed conditions in near-term atomic experiments.

In this work, they study a gauge theory model whose main building blocks have already been implemented using ultracold atoms in optical lattices. The use of gauge theories, characterized by local symmetries, is ubiquitous in theoretical physics, ranging from the description of fundamental particles such as quarks to the physics behind high-temperature superconductors.

In their model, they first show how an internal magnetic field is spontaneously generated, bringing about topological order to the system. Then, they identify a mechanism that allows these effects to survive under arbitrary, large fluctuations. This mechanism also leads to the presence of deconfined quasiparticles in the spectrum, another interesting but yet partially unexplored feature of gauge theories connected to open questions in particle physics.

The results of the study indicate the existence of novel methods to experimentally address strongly-correlated topological effects, which are relevant to condensed matter and high-energy physics, using controllable atomic systems.