Master / PhD Thesis Project

Simulations of anyons in topological quantum phases

Contact
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Title
Simulations of anyons in correlated topological quantum phases.

Simulations de particules anyonic (ni fermions ni bosons) dans des phases quantiques topologiques

Keywords
Quantum computing, quantum many-body problem, quantum simulations, Feynman diagrams.

Summary

Anyons are exotic particles that are neither fermions nor bosons. When one anyon makes a loop around another one the many-body wave function picks up a phase that is neither zero (bosons) nor pi (fermions) but that may take any value or even be a matrix (non-Abelian anyons). Anyons could be used for a new kind of quantum computers called “topological quantum computer”. This is the route currently followed by Microsoft. Although these particles do not seem to exist in nature, quasi-particles with these characteristics can be stabilized in semiconducting heterostructures at low temperature and under high magnetic field. An experiment demonstrating unambiguously the anyonic behavior for the first time has been performed earlier this year: https://www.nature.com/articles/s41567-020-1021-7 . The physics of anyons is fascinating but also very complex. In particular it is very difficult to study them from microscopic models and usual approaches are restricted to effective models.

In this internship, we will build a microscopic description of the propagating edge states of anyons in the fractional quantum Hall effect phase 1/3. Our group develop state-of-the-art numerical tools for addressing quantum transport both in

the stationary (see http://kwant-project.org) and time-resolved (http://tkwant.kwant-project.org) domain.
We will adapt the traditional approach to use the so-called “composite fermion” framework where the electrons have captured quantum of flux. With this approach, we shall be able to study how the anyons edge states are reconstructed by the topological terms that arise in their field theoretical description. The internship could be extended into a PhD where one would study the dynamics of these anyons and propose actual experiments to be performed. The project would culminate with a study on how anyons could pair to form a topological superconductor harboring Majorana fermions (particles that are their own anti-particles). The fractional quantum Hall effect phase 5/2 is believed to harbor such a phase. The master project could naturally be extended into a PhD thesis where the modeling would be extended to account of anyons dynamics by incorporating the Chern-Simon gauge fields generated by the anyons into a self-consistent T-Kwant simulation.

Good mathematical skills as well as scientific programming are necessary for the success of the project. The work will involve theoretical / formalism aspects as well as numerics. The Internship/PhD will take place within the theory group of CEA Grenoble, IRIG, PHELIQS (Photonics NanoElectronics and Quantum engineering). Our group contains 15-20 researchers working on nanoelectronics, superconductivity, magnetism and electronic correlations in close collaboration with experimental groups. The project itself will be done under the direction of Xavier Waintal and co-supervised by Christoph Groth and Thomas Kloss.

We seek highly motivated students with a strong background in theoretical physics, quantum nanoelectronics and/or numerical simulations.

APPLY NOW!

To apply for this position, send your application (including CV) by e-mail to: Xavier.waintal@cea.fr

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