

# “An Introduction to Topological Order”

The Master ICFP 2nd year already has an introduction to topological phases “Dirac matter, topology and interactions in many-particle systems.” These lectures provide the fundamental notions while mostly focusing on non-interacting systems. To give another perspective on this topic, we propose to organize lectures that would focus on their long range entanglement analogue where exotic excitations may emerge. These two lectures would be coordinated, not to avoid duplication (getting another perspective is pedagogically fruitful) but to ensure their coherence and complementarity.

A tentative program would address the following aspects:

1. From the integer quantum Hall effect to the topological insulators: a primer on non-interacting topological phases (Lectures 4h + tutorials 2h) .
2. Topological Superconductors in 1D and 2D: Majoranas and non-abelian statistics (Lectures 4h + tutorials 2h).
3. The realm of strong interactions: the fractional quantum Hall effect (Lectures 4h + tutorials 4h).
4. The big picture: the topological quantum field theory (Lectures 3h).
5. Detecting topological phases: introduction to the entanglement entropy and its relation to matrix product states (Lectures 3h + tutorials 4h).

Tutorials offer the opportunity to dive into some concrete examples. While analytical calculations are usually favored, tutorials are also a unique moment to explore the numerical tools. Indeed these play a crucial role in the understanding of topological phases. Thus we propose that numerical calculations to be on par with the more traditional analytical calculations. Beyond their practical purpose, the numerical calculations sometimes provide a direct illustration of more conceptual problems. Even the simple evaluation of a topological invariant allows to illustrate the notion of smooth gauge. These tutorials will greatly benefit from the Master ICFP 2nd year lectures “Numerical Physics: Algorithms and Computations”. They would be a direct application of the concepts that have been learned during the first semester.