Parcours M2 « Systèmes Complexes, Optique, Lasers » : Stage de Recherche 2020-2021

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Thématique : Atomes froids

Simulations Quantiques avec des atomes ultrafroids : études théoriques des effets topologiques dans les systèmes désordonnés

Information transport is at the heart of communication technologies. Quantum effects are playing an increasing role in devices used for communications and information processing. For example, secure cryptography based on quantum entanglement between photons propagating in optical fibers has become nowadays a commercial technology.
Thanks to recent technological progresses, the quantum phase coherence length of an electron in a clean sample is becoming comparable to the typical size of the sample itself – which, at the same time, considerably dropped. The consequence is that in such devices classical physics is progressively replaced by mesoscopic physics, implying that quantum interferences are more and more important.Robustness to imperfections and disorder is necessary for reliable quantum technology. An avenue for robust quantum devices is topological phases of matter, a genuinely new form of quantum matter. Topological phases are characterized by the global properties of the system, and robust against local disturbances (induced for instance by disorder), and their theoretical description has led to the award of the 2016 Physics Nobel prize.
The Quantum Chaos group of the laboratory PhLAM is currently building a cold atom experiment aiming at the study of topological properties of matter in a "quantum simulator" system, called the Quantum Kicked Rotor (QKR), a paradigmatic model of quantum chaos and disordered systems. The goal of the internship is to investigate theoretically and numerically topological effects in this context. While topological phase transitions can be induced in the QKR [1,2], the proposed kick sequences up to now are not experimentally doable. One goal of the project is to devised a practical method to find relevant kick sequences for the future experiments conducted by the group, and to assess the experimental signature of the topological order.
The group has an ongoing collaboration with Chushun Tian of the Chinese Academy of Science in Beijing, who is an expert in disordered systems, quantum chaos, and topological phases in the QKR.

[1] Dahlhaus, Edge, Tworzydło, and Beenakker, Phys. Rev. B 84, 115133 (2011)
[2] Yu Chen, and Chushun Tian, Phys. Rev. Lett. 113, 216802 (2014))

Mots - clés : Gaz quantiques de bosons et fermions dégénérés, Condensats de Bose-Einstein, simulation quantique, phases topologiques

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