MAR16-2015-020125

Abstract for an Invited Paper
for the MAR16 Meeting of
the American Physical Society

Measuring Chern numbers in Atomic Gases: 2D and 4D Quantum Hall Physics in the Lab

NATHAN GOLDMAN, Université Libre de Bruxelles (ULB)

Optical-lattice experiments have recently succeeded in probing the geometry of 2D Bloch bands with cold neutral atoms. Beyond these local geometrical effects, which are captured by the Berry curvature, 2D Bloch bands may also display non-trivial topology, a global property captured by a topological invariant (e.g. the first Chern number). Such topological properties have dramatic consequences on the transport of non-interacting atoms, such as quantized responses whenever the bands are uniformly populated. In this talk, I will start with the first experimental demonstration of topological transport in a gas of neutral particles, which revealed the Chern number through a cold-atom analogue of quantum-Hall measurements[1]. I will then describe how this Chern-number measurement could be extended in order to probe the topology of higher-dimensional systems. In particular, I will show how the *second Chern number* – an emblematic topological invariant associated with 4D Bloch bands – could be extracted from an atomic gas, using a 3D optical lattice extended by a synthetic dimension[2]. Finally, I will describe a general scheme by which optical lattices of subwavelength spacing could be realized[3]. This method leads to topological band structures with significantly enhanced energy scales, offering an interesting route towards the experimental realization of strongly-correlated topological states with cold atoms.

[1] *Measuring the Chern Number of Hofstadter Bands with Ultracold Bosonic Atoms*,
M. Aidelsburger, M. Lohse, C. Schweizer, M. Atala, J. T. Barreiro, S. Nascimbene, N. R. Cooper, I. Bloch and N. Goldman,
Nature Physics **11**, 162 (2015).
[2] *Four-Dimensional Quantum Hall Effect with Ultracold Atoms*,
H. M. Price, O. Zilberberg, T. Ozawa, I. Carusotto and N. Goldman,
Phys. Rev. Lett. **115**, 195303 (2015).
[3] *Dynamic Optical Lattices of Subwavelength Spacing for Ultracold Atoms*,
S. Nascimbene, N. Goldman, N. R. Cooper and J. Dalibard,
Phys. Rev. Lett. **115**, 140401 (2015).