Flux lattices and topological flat bands in dipolar spin systems

N. Y. Yao, C. R. Laumann, A. V. Gorshkov, S. D. Bennett, E. Demler, P. Zoller, M. D. Lukin

1Physics Department, Harvard University, Cambridge, MA, 02138, 2ITAMP, Harvard University, Cambridge, MA, 02138
3IQIM, Caltech, Pasadena, CA, 91125, 4IQOQI, Austrian Academy of Sciences, A-6020 Innsbruck, Austria.

arXiv:1207.4479

Abstract

We propose and analyze a physical system that naturally admits two-dimensional topological nearly flat bands. Our approach utilizes an array of three-level dipoles (effective S=1 spins) driven by inhomogeneous electromagnetic fields. The dipolar interactions produce arbitrary uniform background gauge fields for an effective collection of conserved hardcore bosons, namely, the dressed spin-flips. These gauge fields result in topological band structures, whose bandgap can be larger than the corresponding bandwidth. Exact diagonalization of the full interacting Hamiltonian at half-filling reveals the existence of superfluid, crystalline, and supersolid phases. An experimental realization using either ultra-cold polar molecules or spins in the solid state is considered.

Motivation and Overview

Topological Flat Bands:
- Hopping interference
- Background synthetic gauge field to break time reversal symmetry

Natural System Yielding TBPs?
- 2D System of Pinned 3-level Dipoles
- Dipole-Dipole interaction is anisotropic
- Phases associated with and do d d

Fractional Chern Insulators:
- Lattice Quantum Hall states

Engineered Flat Bands

Ingredients:
1) flat-bands enabling interactions to dominate vs. dispersion
2) topologically non-trivial

Current approaches: engineer simple lattice models to enforce flat bands

Correlated Many-body Phases

Selected References

Outlook

- Non-abelian Hall States in higher Chern bands
- Theory of the critical point + many-body state preparation

Acknowledgements

We gratefully acknowledge conversations with Alex Zhai, Peter Maurer, Merrit Moore, Benjamin Lev, John Preskill, Jason Alicea, and Nate Lindner. This work was supported, in part, by the NSF, DOE (DE-FG02-97ER45753), CUA, DARPA, AFOSR MURI, NIST, Lawrence Golub Fellowship, Lee A. DuBridge Foundation, IQIM and the Gordon and Betty Moore Foundation.