Study of Haldane-Bose Hubbard Model in a Honeycomb optical lattice

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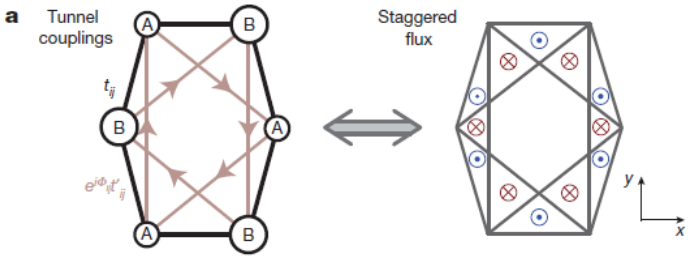
Introduction

Cold atoms in an optical lattice (OL)

Highly controllable quantum simulators

Experimental realization of artificial gauge field in an optical lattice

The Haldane model has been achieved



G. Jotzu *et al., Nature* **515,** (2014).

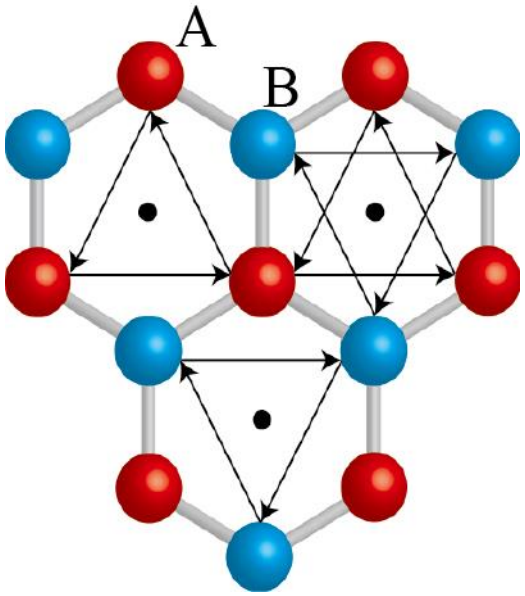
Fermionic system

We study a bosonic analog of the Haldane model
(Haldane-Bose Hubbard model)

Model

Haldane-Bose Hubbard model

$$H_{HBH} = -J_1 \sum_{\langle i,j \rangle} a_i^\dagger a_j - J_2 \sum_{\langle\langle i,j \rangle\rangle} e^{-i\phi} a_i^\dagger a_j$$
$$+U \sum_i a_i^\dagger a_i a_i^\dagger a_i$$

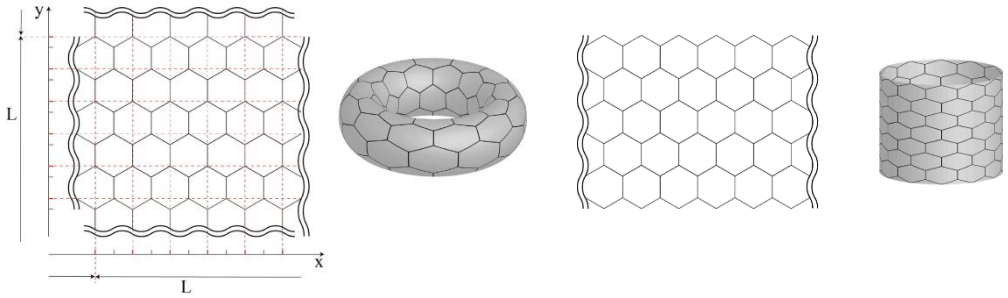


Extended Quantum Monte-Carlo simulation

$$S_{qXY}^L = \sum_i -\frac{1}{4U\Delta\tau} cos(\theta_{i+\tau} - \theta_i)$$
$$-J_1\Delta\tau \sum_{\langle i,j \rangle} \sqrt{\rho_i \rho_j} cos(\theta_i - \theta_j) - J_2\Delta\tau \sum_{\langle\langle i,j \rangle\rangle} \sqrt{\rho_i \rho_j} cos(\theta_i - \theta_j + \phi)$$
$$+\sum_i U\Delta\tau\rho_i^2$$

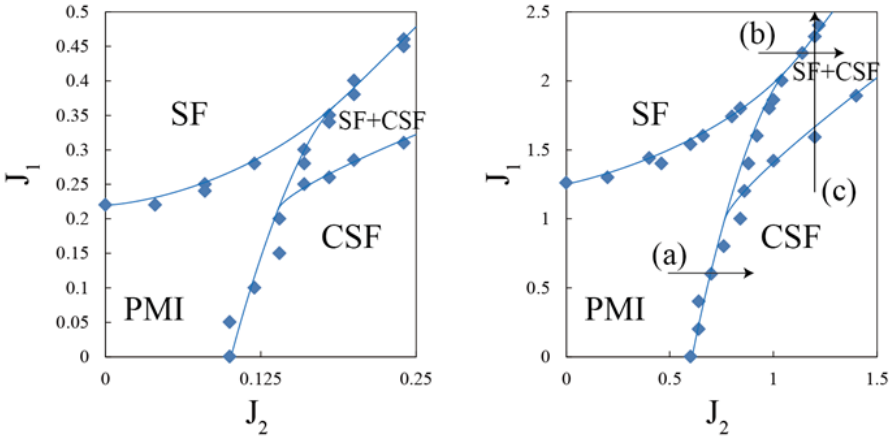
2D + 1 Time

Torus and Cylinder geometries are considered

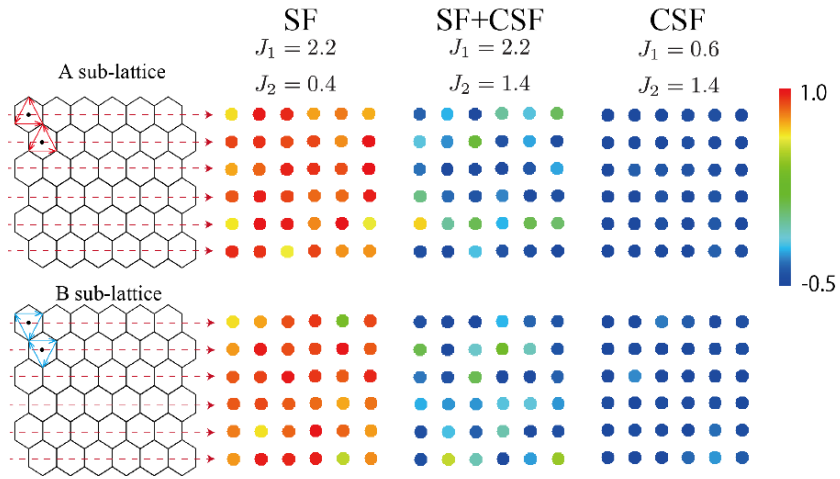


Numerical simulation

Global phase diagram



Quantum phase behavior



BEC behavior near the zigzag edges of the cylinder