ABSTRACT

Phase Transitions and Polariton Dynamics in Disordered Coupled Cavity Arrays

Abuenameh Ifedapo Aiyejina

This thesis examines the effect of disorder in the laser intensity of a laser that drives atoms in an array of coupled optical cavities. These cavities are described by a Bose-Hubbard model for combined photon-atom excitations called polaritons. In order to investigate this system we use three techniques. We use a Gutzwiller approximation, a canonically transformed Gutzwiller approximation, and numerical integration of the Schrödinger equation. With the Gutzwiller approximation, we find that disorder causes the appearance of the Bose glass phase as expected, and that adding the canonical transformation greatly improves the phase diagram of the system. With the time-dependent Gutzwiller approximation, we find that disorder dampens oscillations in the defect density, relaxation of the superfluid order parameter, and excess energy as a function of the ramp time of a ramp in the laser intensity. Here, however, the canonical transformation has little effect on the dynamics obtained. We find that with respect to a ramp in the laser intensity, disorder in the laser intensity does not affect the overall behaviour of polariton correlation functions, but just suppresses any oscillations in them. We also find that by increasing the laser intensity we can make the polaritons entirely photonic and that by varying the coupling between the atoms and the cavities we can produce bunching of the polaritons. Finally, we examine the phase diagram and dynamics of a system of polariton dimers. We find that the phase diagram exhibits only incompressible phases with uniform filling and that for the dynamics the addition of disorder suppresses the propagation of a dimer on a lattice, but not the propagation of a single polariton. Thus, disorder has a localizing effect on polariton dimers.

Keywords: Bose-Hubbard model; coupled cavity arrays; polaritons; disorder.