Condensation of light – from fundamental physics to optical computers
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Bose-Einstein Condensate platform

Here, we present photon Bose-Einstein condensate (pBEC) platform for spin-glass simulations.

The optical pump via interaction with dye creates macroscopic number of photons in ground state – a condensate.

The heating laser is used to change the refractive index of the polymer, hence in situ changing the potential landscape.

Mirror nanostructuring

Direct laser writing setup

The surface of ultra-high finesse mirror may be accurately nanostructured by direct laser writing [1]. This enables to construct precise and uniform height profiles with sub-nanometer resolution.

pBEC in an interferometer

We investigate the pBEC in an environment with controlled dissipation and feedback. We have found that pBECs naturally try to avoid particle loss and destructive interference [3].

Controlling coupling between condensates

By addressing controlled amount of heat we are able to adjust strength and sign of coupling between pBECs. This system behaves as a controllable Josephson junction [1].

Adding losses to interaction between pBECs transforms coupler into dissipative and makes antisymmetric states more favorable [2].

Both types of couplings can be used as a building block for analog spin-glass simulator.

Outlook

Finding a ground state of all-negatively coupled network of pBECs is equivalent to finding a solution for problems from NP-complete class which are hard to solve even for conventional supercomputers.

Network of pBECs is analogous to XY spin model governed by following Hamiltonian:

\[ H = - \sum_{i} J_{ij} \cos(\theta_i - \theta_j) - \sum_{i} h_i \cos \theta_i \]