Toward Quantum Simulations with Thulium Atoms

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Bose-Einstein condensation (BEC) is a powerful tool for a wide range of research activities, a large fraction of which is related to quantum simulations. Various problems may benefit from different atomic species. Thulium atoms possess dipole moment of 4 Bohr magneton in the ground state, allowing long-term interactions. It also has number of non-chaotic low-field Feshbach resonances, allowing fine control of the near-filed interactions. It also has relatively simple level structure compared to the other magnetic lanthanoids and thus is a quite promising subject for applications in quantum simulations.

Nevertheless, cooling down novel species interesting for quantum simulations to BEC temperatures requires a substantial amount of optimization and is usually considered to be a difficult experimental task. Here we report on implementation of the Bayesian machine learning technique to optimize the evaporative cooling of thulium atoms and achieved BEC in an optical dipole trap. Two dipole traps were used: 532 nm light and 1064 nm light, in both the condensation was achieved. We also analyzed the atomic loss mechanism for the 532 nm optical trap, used in the Bose-condensation experiment, and compares it with the alternative and more traditional micron-range optical dipole trap.

While the condensate of the thulium atom has a lot of applications in quantum simulations and other areas of physics, it can also serve as a unique diagnostic tool for many atomic experiments. In the present study, the Bose-Einstein condensate of the thulium atom was successfully utilized to diagnose an optical lattice and detect unwanted reflections in the experiments with the 1064 nm optical lattice, which will further be used in a quantum gas microscope experiment.

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