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Towards robust neutral-atom BEC production with the help of machine learning

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Producing neutral-atom Bose-Einstein condensation, despite being a routine procedure, remains susceptible to experimental imperfections. In order to reach the condensation of widely used atomic species such as rubidium, researchers require ultrahigh vacuum, high current sources, and stable, precision lasers. The BECs are sensitive to residual magnetic fields, low-power scattered resonant light, and even to the humidity of a room. Despite best efforts, we observed a significant atom number drift in our system with different timescales. Due to the process being divided into many temporal steps and multiple independent parameters associated with different cooling mechanisms, we were unable to identify some causes of the drift.

To address the problem of atom number drift in our system over varying time frames, we installed several sensors to track changes in the environment. The high dimensionality of the parameter space prompted us to use a multilayer neural network to identify all the underlying relationships. The trained neural network was successful in predicting atom number drifts.

With a neural network that predicts the atom number, we extend the work to correct for the instabilities.We created a second list of parameters, which could be controlled externally, and we started exploring it with Gaussian processes [1]. We concluded that it was crucial to combine two learning models: one of them has access to control parameters but does not account for drift (gaussian optimizer), while the second one was slower and thus not suited for real-time use, but could account for external parameter drift (neural network). We optimized this dual learning algorithm for our system and explored the parameter space to achieve optimal BEC production under a wide range of parameter settings, allowing our experiments to collect high-quality data continuously.

Keyword-1

cold atoms

Keyword-2

neural networks

Keyword-3

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