OPTIMIZING OPTICAL POTENTIALS WITH PHYSICS-INSPIRED LEARNING ALGORITHMS

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Experiments with Bose-Einstein condensates demand a high level of control over trapping potentials for getting smooth density distributions. We present a new experimental and theoretical framework that combines a broadband light source with fast learning algorithms to optimize one-dimensional optical dipole potentials. Our approach integrates control engineering and machine learning techniques to build an optical setup suitable for experiments with ultracold gases. We demonstrate the effectiveness of using laser dipole potentials shaped by digital micromirror devices for compensating inhomogeneities caused by the harmonic magnetic potential generated by Atomchips.

We leverage machine learning tools to train our physics-inspired model, enabling precise predictions of the optical system's behavior. We compare iterative model-based offline optimization with experimental feedback-based online optimization. Combining machine learning algorithms with iterative learning controls we achieve more than a tenfold acceleration in the optimization of optical potentials compared to heuristic methods.

Our methods hold great promise for the dynamic manipulation of ultracold gases and provide new insights into the possibility of using machine learning methods in experimental quantum physics.

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