Title : Multifrequency Optical Power Control in an Acousto-Optic Deflector for Optical Tweezer Applications in Quantum Simulation

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ABSTRACT

Large-scale arrays of individually controlled neutral atoms created with optical dipole traps are essential for quantum computing and quantum simulation. To achieve fully loaded atom arrays, moving optical tweezers are required for rapid and individual atom rearrangement. However, normal optical tweezers exhibit variations in optical power while moving atoms, leading to atom loss and reduced efficiency. In this work, we generate a Radio Frequency (RF) signal to drive an Acousto-Optic Deflector (AOD), enabling the creation of optical tweezers with uniform optical power to manipulate atom positions. First, we calibrate the RF circuit to obtain the frequency and power characteristic curves, ensuring its compatibility with the AOD. This RF is then applied to the AOD to create an optical tweezer, and the relationships between the RF drive parameters and the tweezer position and optical power are investigated. Subsequently, the system is extended to operate with multifrequency RF to create multiple optical tweezers, where the RF powers are controlled to achieve uniform optical power. The results demonstrate that the RF circuit operates reliably with the AOD, that the RF frequency exhibits a linear relationship with the tweezer position, and that uniform optical power is maintained across multiple tweezers during dynamic translation. This work paves the way for the reliable preparation of large, fully loaded atom arrays, expanding the scale and complexity for future use in quantum simulations.

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