A Vectorial Blue-Detuned Tweezer Array

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Blue-detuned optical tweezers are of interest for confining atoms at the intensity minima, reducing tweezer-induced decoherence and permitting trapping of negative polarizability Rydberg states [1, 2]. Current approaches to generate blue-detuned tweezer arrays generally suffer from low intensity uniformity - leading to escape channels for atom losses and requiring high power per minimum trap depth [2]. We propose a high numerical-aperture approach to design "optical bubble" arrays by utilizing the vector point spread functions of radially- and azimuthally-polarized backfocal fields. Numerical results show that vectorial optical bubble traps can be designed with high uniformity while maintaining a dark central minima, at numerical apertures compatible with modern neutral-atom array experiments. These optical bubbles exhibit quadratic potential minima, which will allow for the study of many-body spin-phonon dynamics with Rydberg-mediated interactions without motional state squeezing [3]. We also report our progress on the development of our high-numerical aperture (NA = 0.70) experimental apparatus with low phase-noise Rydberg lasers.

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