Simultaneous optical trapping and imaging in axial plane

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Optical tweezers has demonstrated great success in widespread applications, such as in life science, atom cooling and fundamental physics. Since most existing optical tweezers systems use single objective lens for both trapping and imaging, the trapping and imaging planes are confined to the same focal plane. To track the trapped micro-particles along axial direction, different volumetric imaging and tracking techniques have been developed to extract the axial information from the 3D image stacks, but at the cost of complex measurement schemes and challenging calibration procedures [1]. Therefore, a direct visualization method of trapped objects is highly desirable in many studies. G. Thalhammer et al. [2] employed a right-angle prism to directly image the trapped particles in axial plane in 2011, but the method was limited in macro-trapping with low magnification. Here, we further advance this approach by implementing the prism into a tight-focusing holographic optical tweezers setup combined with fluorescent imaging. Simultaneous optical trapping and imaging in axial plane are demonstrated with several types of optical traps structured by addressing the designed computer-generated holograms to the spatial light modulator. We have successfully trapped 3 silica beads along axial direction with Gaussian traps array of 1×3, as given in Fig. 1(b), and axially aligned the silica beads like a chain with focused Bessel beam, as shown in Fig. 1(c). Moreover, the trajectory of the transported micro-particle driven by an Airy beam has been obtained, which is superposed by the time sequential images of the polystyrene bead at different position. The technique proposed here may provide a new angle of view in optical trapping and imaging, and promote the combination of optical trapping and microscopic imaging.

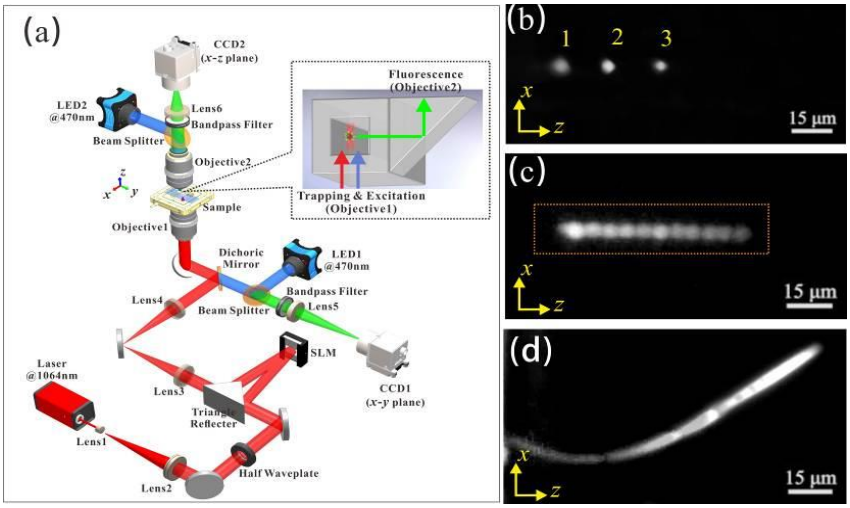

Figure 1. (a) Schematic of holographic optical trapping and axial-plane fluorescent imaging; (b) fluorescent image of multi-trapped silica beads in x-z plane; (c) a line of silica beads trapped in x-z plane by using a focused Bessel beam; (d) Time-lapse x-z trajectory of the transported polystyrene beads driven by a focused Airy beam for 0.5 s, measured at the frame rate of 60 Hz.

Reference:

[1] A. Curran, S. Tuohy, D. G. A. L. Aarts, et al., "Decoupled and simultaneous three-dimensional imaging and optical manipulation through a single objective," Optica, **1**(4): 223-226 (2014).
[2] G. Thalhammer, R. Steiger, Bernet S, et al., "Optical macro-tweezers: trapping of highly motile micro-organisms," J. Opt., **13**(4): 044024 (2011).