SPHERICAL ABERRATION CORRECTION USING ADAPTIVE LENSES FOR OPTICAL TWEEZERS MICROSCOPY

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KEY WORDS: adaptive optics, spherical aberration, optical trapping, optical tweezers.

Spherical aberration caused by refraction index mismatch is a well-known problem in microscopy. This usually happens because either the sample presents some refractive index inhomogeneities or because the average sample refractive index does not match the one of the objective. It can be shown [1][2] that the aberration caused by a focused beam traveling trough a refractive index mismatched is composed by defocus and various orders of spherical aberrations with decreasing strength. While defocus is very simple to correct, spherical aberration is usually the cause for signal deterioration and loss of resolution. A correction collar is used in higher quality microscope objectives, but the effectiveness for correcting spherical aberration is very limited [3]. A relatively recent approach to correct for these aberrations is to use an adaptive optics system (AO). Most common used AO systems involves deformable mirrors or spatial light modulators, implying a notable increase in the optical system complexity.

Our goal is to correct for mismatch-induced spherical aberration using a multi-actuator deformable lens that can be placed near the back-pupil plane of the objective, keeping the optical system compact and easy to use.

We will show a model to calculate the amount of spherical aberration as a function of NA and refractive index mismatch and we will compare it with an experimental setup to measure the spherical aberration with a wavefront sensor.

We will also present some results in the correction of spherical aberration with a multi actuator adaptive lens.

In a proof of concept optical tweezers correction experiment carried out at the Octopus facility (CLF, STFC, UK), we achieved a partial correction of spherical aberration, increasing the trapping depth (from 20 μm to 30 μm) in aqueous solution by applying -0.2 RMS of spherical aberration using a deformable lens placed in a conjugate plane of the illumination path (see Fig. 1).

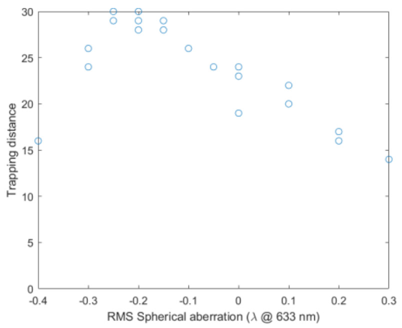

Figure 1: Trapping depth as a function of the corrected spherical aberration for 1 um PS beads in water

References:
[1] M.J. Booth et al; *Journal of Microscopy*, **Vol. 192 Pt.2**, 90-98 (1998).
[2] L. Silvestri et al; *Microscopy Research and Technique*, **77**, 483-491 (2014).
[3] R. Turcotte; *Biomedical Optics Express*, **Vol. 8 N°8**, 3891-3902 (2017).