Nonparaxial Circular and Weber beams from caustics

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Accelerating beams exhibit a curved trajectory of their point of maximum intensity. These beams have generated a tremendous interest in several fields of optics and important applications for all-optical manipulation, curved nonlinear optics and curved micromachining [1-5]. Although the first demonstrations of accelerating beams were confined in the paraxial regime, exact analytical solutions of nonparaxial beams from Maxwell equations were discovered for beams propagating on circular [6,7] and parabolic [8] trajectories.

Here, we show that using a caustic-based approach and an appropriate modeling of high-numerical aperture microscope objectives with Debye integral, analytical solutions for phase mask design can be also obtained. We report on numerical modeling of high aperture microscope objectives to reproduce our experimental results. This work allows for an enhanced flexibility in designing and modeling experimentally realizable curved beams since deviations from the pure analytical case can be taken into account. Fig. 1 shows experimental results of different beams obtained with this approach, in actually nonparaxial conditions (numerical aperture 0.8): for a Weber beam (a) produced from a continuous-wave HeNe laser at 632 nm and LCOS-SLM. A binary amplitude modulation also allows to easily produce periodic waves (Fig.1(b)).

We anticipate that this approach will both allow to predict other curved propagation solutions and enable diverse applications in photonics and biophotonics for an enhanced flexibility of all-optical manipulation.

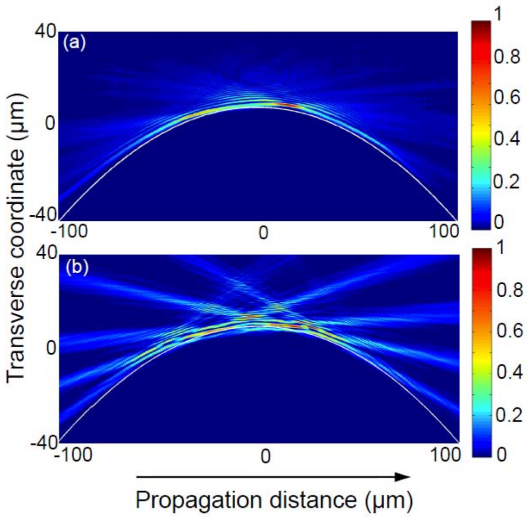

Fig1. Experimental high-numerical aperture (a) Weber beam (b) periodically modulated Weber beam

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978-1-4799-0594-2/13/$31.00 ©2013 IEEE