Narrowing of laser beam propagating through biological suspension

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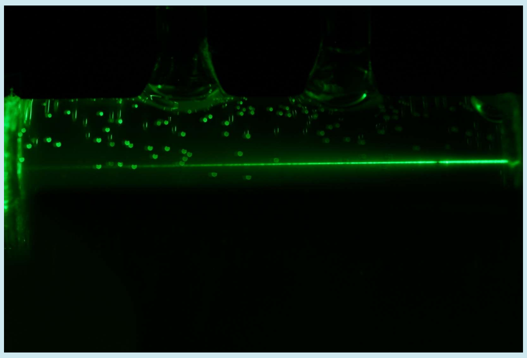
Recent demonstration of nonlinear self-action of laser beams in suspension of biological materials, like marine bacteria and red blood cells, have been reported [1-3]. In this work, we demonstrate nonlinear optical effects of laser beam propagation through the freshwater green microalga Chlorela sorokiniana, cultivated in Bold basal medium with 3-fold nitrogen and vitamins (3N-BBM+V).

Chlorella sorokiniana is a species of single-celled freshwater green microalga in the division Chlorophyta. Its spherical or ellipsoidal cells (3 x 2 µm in small cells to 4.5 x 3.5 µm in large cells, sometimes >5 µm) divide rapidly to produce four new cells every 17 to 24 hours [4]. The non-pathogenic species has been chosen as a model organism due to its small cell dimension, rapid growth, non-mobility and non-toxicity. The algae were kept in the light chamber and the temperature was maintained at 22 °C. Mid-exponential growth phase of algal culture was used for the experiments.

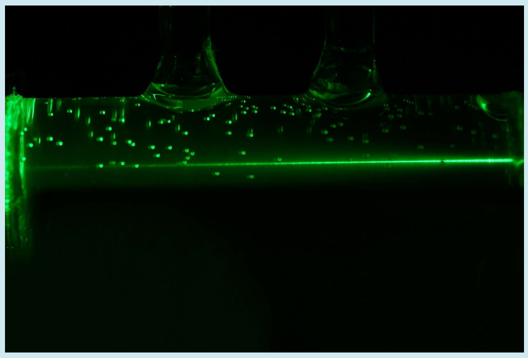
In the experiments, the 532 nm CW laser beam is directed to the glass cuvette that is filled either with the medium or with algae suspended in the medium. We have monitored the laser beam diameter at the entrance and exit of the cuvette, and its axial profile through entire cell length. The concentration has been determined by optical microscopy and optical density and has been varied between 10^6 and 10^8 cm^{-3}.

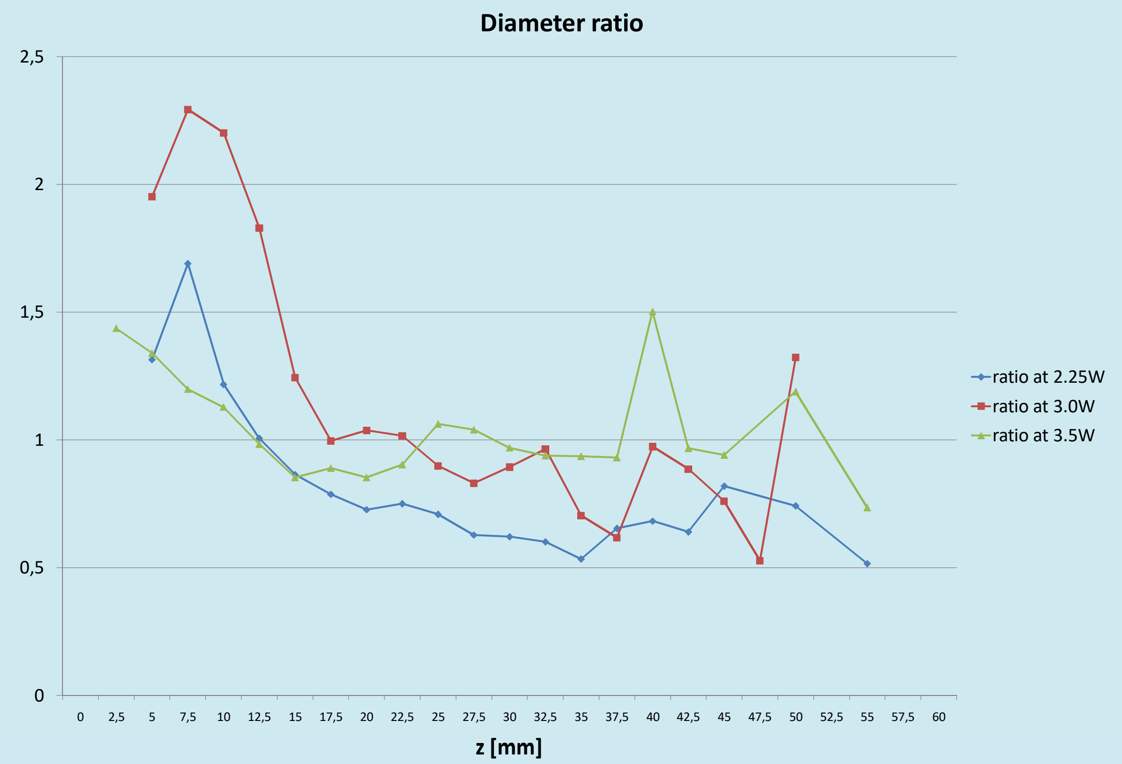
Propagation of a 532 nm, 2.25 W CW beam through a suspension

Propagation of a 532 nm, 2.25 W CW beam through a 10^7 algae concentration



Propagation of a 532 nm, 3 W CW beam through a 10^7 algae concentration

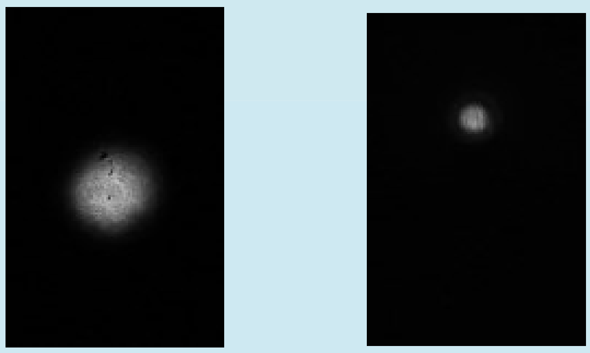




The graph shows the ratio between the diameter of beam in medium and of beam in algae suspension (concentration of 10^7 cm^{-3}). For 2.25 and 3 W, the diameter in algae is less then the diameter in medium for all distances between 22.5 and 47.5 mm from the entrance. For 2.25 W, the diameter is smaller for **all** distances over 12.5 mm from the entrance.

Propagation of a 532 nm, 2.25 W CW beam through a $5*10^7$ algae concentration

Beam profile at exit for 2.25W:
Left: medium, diameter=0.7mm
Right: 10^7 concentration, diameter=0.27 mm



The concentration of the algae and the laser beam power affect the beam radius. Our results show the effect of light self-trapping, i.e., the decrease of laser diameter when the algae concentration exceeds 10^6 cm^{-3} while laser power is above 1 W. The difference of the refractive indexes of the algae and the medium can induce optical trapping of algae, which subsequently changes the concentration of the algae within the laser beam. This in turn can explain different behavior of the beam in the medium with and without algae.

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