Optical vortex spins biomaterials waveguide

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1. Introduction

Laser induced biomaterial-waveguides, formed of cyanobacteria and human red blood cells, have been studied [1].

Optical vortex with a helical wavefront carries an annular spatial form and an orbital angular momentum (OAM), characterized by a topological charge ℓ, arising from its helical wavefront [2]. In recent years, we and our co-workers have discovered that the optical vortex twists the irradiated materials, such as metal, silicon, polymer, and even liquid cured resin, to form helical nano/micron structures owing to OAM transfer effects [3,4]. However, to date, the interaction between optical fields and biomaterials has been mostly investigated by employing a conventional Gaussian beam with a planer wavefront, and there are still few reports on the interaction between biomaterials and optical vortices.

In this paper, we discover, for the first time to the best of our knowledge, that the optical vortex can spin a laser induced cyanobacteria-waveguide.

2. Experiments

A schematic of the experimental setup in this study is shown in Fig. 1. A continuous-wave green (532 nm) laser was used, and its output was converted into a first order optical vortex by employing a spiral phase plate. The generated optical vortex was tightly focused to be an annular spot with a diameter of 40 µm on a cyanobacteria suspension (concentration: 1.3×10^7 cells/mL, solvent: seawater) by using a lens. Temporal dynamics of the waveguide formation in the suspension was observed from the on-axis and side by using two CCD cameras. It is worth noting that linear and nonlinear refractive indices of the suspension was then controlled by appropriately adding glycerol in the suspension.

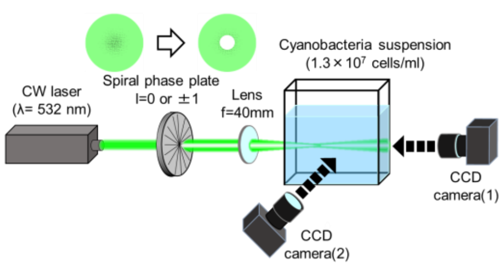

Fig1. Schematic of the experimental setup.

Self-focusing of the optical vortex occurred significantly in the suspension without glycerol at the incident laser power of >1.5 W. The optical vortex was then transformed into the Hermite Gaussian mode with two petals owing to the modal instability, as previously reported in the colloidal (non-biomaterial) suspensions [5]. It is noteworthy that such self-focusing phenomenon was never observed in a suspension without cyanobacteria.

To suppress the modal instability of the incident optical vortex, the glycerol was added to the suspension in the mixture ratio of 1:2. We then observed the spinning motion of the incident optical vortex along a clockwise (or counter-clockwise) direction fully assigned by the handedness of the incident optical vortex. This phenomenon manifests that the optical vortex forces a laser induced cyanobacteria-waveguide to spin along a clockwise (or counter-clockwise) direction owing to OAM transfer effects. In fact, the spinning speed of the incident optical vortex was proportional was expressed by a linear function of the incident laser power (Fig. 2).

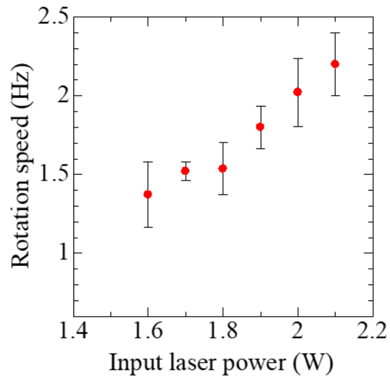

Fig2. Rotation speed of the transmitted light.

3. Conclusions

We have discovered that the optical vortex forces a cyanobacteria-waveguide to spin owing to OAM transfer effects. Such exotic phenomenon will offer a new physical insight of the interaction between optical angular momentum and biomaterials.

References

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