Topological light-wave synthesis

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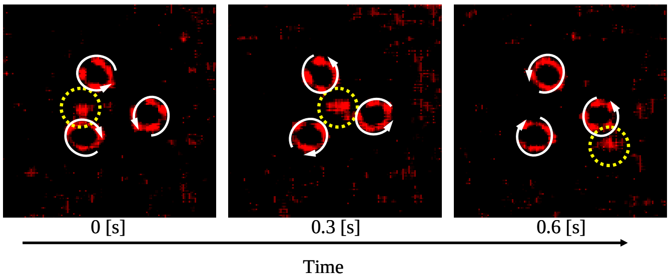
Optical vortices, having helical wavefront as well as an on-axis phase singularity, have been investigated intensely, because they exhibit orbital angular momentum. The existence of orbital angular momentum in the optical vortices has been experimentally verified by several demonstrations such as the rotation of trapped micro-particles in optical tweezers.

If high intensity and high quality optical vortices are created efficiently by utilizing high power laser technology based on diode-pumped solid state or fiber lasers, the orbital angular momentum of the optical vortices will be also potentially applied to laser ablation, coherent extra ultra-violet generation, nonlinear optics, and spectroscopy, etc. and it will open up new laser physics and technology. To date, we and our co-workers have successfully developed a >10MW high intense with average power of >30W pico-second 1μm laser based on a diode-pumped Nd doped vanadate bounce laser amplifier in combination with a photorefractive phase conjugate mirror. The maximum average power of the system was measured to be 92W with the peal power of 12MW at the pulse repetition frequency of 0.8MHz. The corresponding optical efficiency of >40% was achieved. We have also extended the system to produce high intense, high power optical vortices and demonstrated >15W vortex output and >5W radially polarized output from the system.

We also demonstrate transportation of nano-particles to a specified direction in mesoscopic field by utilizing independent three vortices with individually specified rotational speed and direction generated from a single laser beam, for the first time.



(c)

Fig. 1 Snap shot of temporal behaviour of a nano-particle marked by broken circle.

Two vortices A and B trapped polystyrene-particles and rotated them toward anti-clockwise direction, and the vortex C rotated the trapped polystyrene-particles toward clockwise direction. For pumping the fluorescent nano-particles inside the cell, a 532nm green laser was also introduced to the cell. Figure 1(c) shows a snap shot of the temporal behavior of a fluorescent nano-particle. The fluorescent nano-particle was transported toward the left and was directed downward. These indicate that the nano-particle was transported along the water flow produced by three optical vortices. This system, in which many independent vortices with individually specified rotational speed and direction are produced in mescopic field, thus, can be adapted to a wide range of applications, including sub-cellular engineering, and macromolecular sorting.

References

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