Green bottle beam generation from a frequency-doubled Nd:YVO_4 laser with a hemispherical cavity configuration

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Optical bottle beam (OBB)[1)] carries a 3 dimensional dark spot surrounded by bright region, and it has been widely applied to a variety of research activities, such as optical tweezers, optical imaging and atoms guide. In particular, OBB will offer research opportunities, such as 3 dimensional trapping and 3 dimensional super-resolution microscope.

In this presentation, we extend our previous hemispherical cavity work[2)], in which radial order Laguerre-Gaussian modes have been successfully generated, to directly generate OBB from an end-pumped hemispherical Nd:YVO_4 laser in combination with intra-cavity second harmonic generation.

Figure 1(a) shows a schematic diagram of our system. The pump source used was an 808-nm fiber-coupled laser diode (4.5 W maximum output power, 100 μm fiber core diameter). The cavity was formed of a 2-mm-long Nd:YVO_4 crystal, a 1-mm-long KTP crystal, a concave spherical mirror, and a plane output coupler. The output coupler was mounted on a translation stage, so as to precisely control the cavity length (~30 mm). The laser output was relayed by a pair of imaging lenses with focal length 125 mm and 400 mm onto a conventional silicon CCD camera. The beam propagation of the laser output is shown in Fig. 1(b). The laser output exhibited the OBB properties, such as 3 dimensional zero dark spot around $0.65z_R$ (z_R is Rayleigh length). Also, we numerically simulated the laser mode and its beam propagation by utilizing mode decomposition analysis. There was a good agreement between the simulations and experiments.

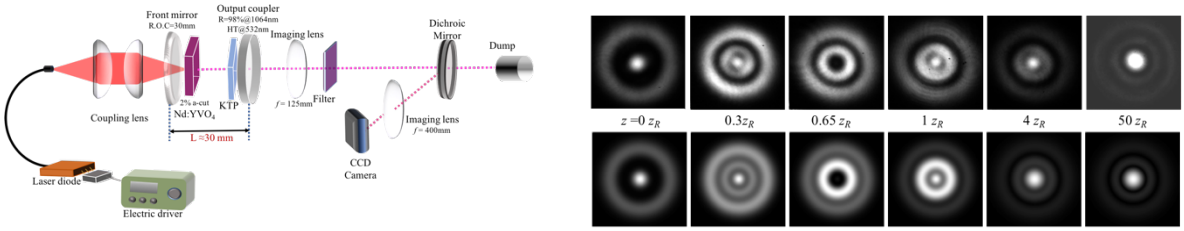

Fig1. **(a)** Experimental setup of the end-pumped solid-state laser with intra-cavity SHG. **(b)** Experimental (upper row) and simulated (bottom row) beam propagation of the laser mode.

References

[1] J. Arlt and M. J. Padgett, "Generation of a beam with a dark focus surrounded by regions of higher intensity: the optical bottle beam," Opt. Lett. **25**, 191-193 (2000).
[2] J. C. Tung, Y. H. Hsieh, T. Omatsu, K. F. Huang, and Y. F. Chen, "Generating laser transverse modes analogous to quantum Green's functions of two-dimensional harmonic oscillators," Photon. Res. **5**, 733-739 (2017).