High-order bottle beam from a frequency-doubled Nd:YVO_4 laser

1. Graduate School of Engineering, Chiba Univ., 1-33, Yayoi-cho, Inage-ku, Chiba, 263-8522, Japan,

2. Molecular chirality research center, Chiba Univ., 1-33, Yayoi-cho, Inage-ku, Chiba 263-8522, Japan,

3. Department of Electrophysics, National Chiao Tung Univ., Hsinchu 30010, Taiwan

°Yuanyuan Ma[1], Jung-Chen Tung[2], Katsuhiko Miyamoto[1,2], Yung-Fu Chen[3], Takashige Omatsu[1,2*]

E-mail: omatsu@faculty.chiba-u.jp

Optical bottle beams[1,2)] carry a 3D dark core, i.e. 'zero intensity' region, surrounded by bright region, and they have widely received much attention in a variety of fields, such as optical tweezers for atom trapping and particle guiding, optical imaging and fluorescence microscopes with high 3D spatial resolution.

In this work, we report on the first demonstration of high-order bottle beam generation by employing intra-cavity second harmonic generation in a strongly pumped hemispherical Nd:YVO_4 laser resonator.

Figure 1(a) shows the experimental setup for directly generating high-order bottle beam by intra-cavity SHG in a nearly hemispherical cavity. The laser cavity was composed of a 30-mm radius-of-curvature concave input mirror, a 2-mm-long Nd:YVO_4 crystal, a 1-mm-long KTP crystal, and a flat output coupler. The Nd:YVO_4 crystal was pumped by a 3.0 W 808-nm fiber-coupled laser diode (core diameter: 100 μm, numerical aperture: 0.16). The laser output was relayed by an imaging system formed of a pair of lenses (focal lengths of 125 mm and 400 mm) onto a conventional silicon CCD camera mounted on a translator to observe the beam propagation of the output. Figure 1(b) shows the experimental spatial intensity forms at various propagation positions. The laser output exhibited a typical beam propagation as a bottle beam, such as a 3D dark core at the longitudinal position z = $0.55z_R$ (z_R is Rayleigh length). Further, we numerically analyzed the generated bottle beam by coherent superposition of a series of frequency-locked Laguerre–Gaussian modes. There was good agreement between numerical analyses and the experiments.

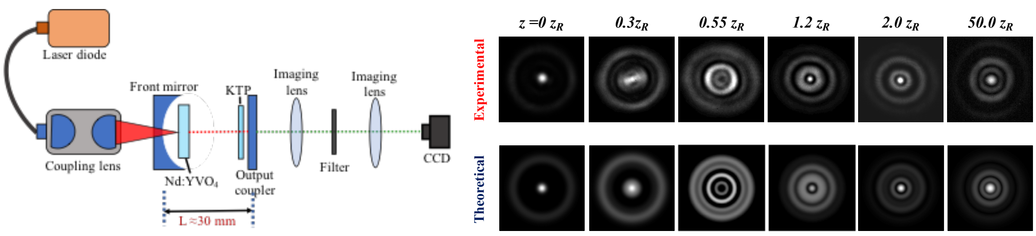

Fig1. **(a)** Experimental setup of the end-pumped solid-state laser with intra-cavity SHG. **(b)** Experimentally observed and simulated beam propagation of lasing modes.

References

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