Laguerre-Gaussian modes generation from a self-Raman $Nd:GdVO_4$ laser using a shaped pump beam with spherical aberration

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1. Introduction

Laguerre-Gaussian (LG) modes [1] possess an annual spatial form with a central dark spot and an orbital angular momentum owing to their helical wavefronts. It has been widely attracting significant interests in various fields, such as optical manipulation and trapping, optical communication, and super-resolution microscopes.

Self-Raman solid-state lasers, in which laser crystals act as a Raman gain medium, enable us to develop ultra-compact laser systems with versatile wavelengths. In fact, several continuous-wave self-Raman LG mode lasers have been demonstrated by employing a damaged mirror or an Axicon lens to fill up the wavelength gap of solid-state lasers for the aforementioned applications [2,3].

In this paper, we propose a novel approach to generate LG modes from a self-Raman $Nd:GdVO_4$ laser by employing a shaped pumping geometry simply formed of two plano-convex lenses with spherical aberration. Maximum LG Stokes output (1.173 μm) power was measured to be 1.3 W, which is the highest, to the best of our knowledge, obtained in the self-Raman LG mode lasers, at the absorbed pump power of 13.1 W.

2. Experiments and Results

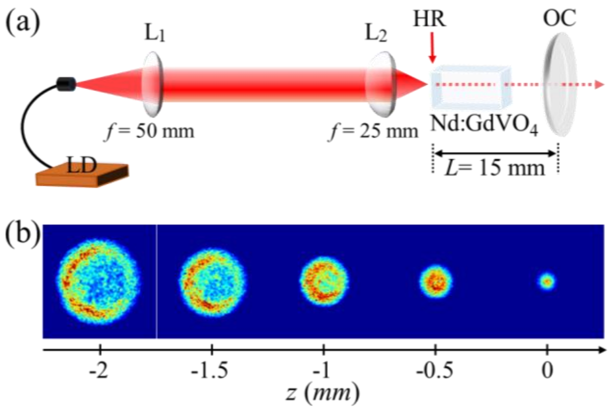

Fig. 1. **(a)** Experimental setup for a self-Raman $Nd:GdVO_4$ LG mode laser. **(b)** Beam propagation of the pump beam in the crystal.

Figure 1(a) shows a schematic diagram of self-Raman LG mode laser. The pump source was an 879 nm fiber-coupled laser diode, and its output was collimated and focused by two plano-convex lenses (L_1, f = 50 mm; L_2, f = 25 mm) onto an a-cut 0.3 at.% $Nd:GdVO_4$ self-Raman crystal with spherical aberration. A linear self-Raman laser cavity consisted of the crystal input facet (R > 99.99 % for 1.0-1.2 μm), and a concave output coupler (OC) (R > 99.99 % for 1.063 μm and R = 99.00 % for 1.173 μm), thereby operating at 1.173 μm owing to the 882 cm^{-1} Raman shift.

The Stokes output exhibited typically a first-order LG mode property owing to Raman beam cleanup effects (Fig. 2), while the remaining fundamental output showed a high-order mixed transverse mode with a central dark spot [3]. Maximum Stokes output power of 1.3 W was obtained at the pump power of 13.1 W, corresponding to the optical-optical conversion efficiency from pump beam to Stokes output of ~10%.

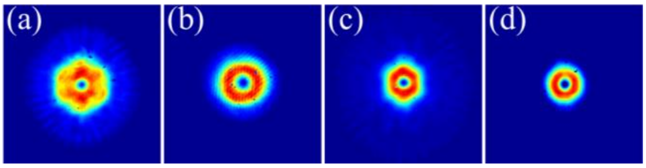

Fig. 2. Spatial forms of **(a)** the fundamental (1.063 μm) and **(b)** 1.173 μm Stokes LG modes in the near field. Corresponding far-fields of **(c)** the fundamental (1.063 μm) and **(d)** 1.173 μm LG mode.

3. Conclusions

We have successfully demonstrated the direct generation of a 1.173 μm LG mode output from a self-Raman $Nd:GdVO_4$ laser by employing a shaped pumping geometry simply with two plano-convex lenses with spherical aberration. Maximum output power of 1.3 W was measured at the pump power of 13.1 W.

References

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