

Diode-pumped red-orange vortex $\text{Pr}^{3+}:\text{YLF}$ laser

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Optical vortex beams¹⁾ carry an annular spatial profile and a nonzero orbital angular momentum of $\ell\hbar$ (where ℓ is the topological charge) per photon, owing to the phase singularity, and they have been investigated in various applications, such as optical trapping, optical communication, quantum optics, and super-resolution fluorescence microscopes. In particular, visible vortex sources with a selective handedness should be applied to nano/micro fabrication, for instance, the formation of chiral structured materials.

In this work, we demonstrate, for the first time, the direct generation of red (640 nm) and orange (607 nm) vortex beams from a diode pumped $\text{Pr}^{3+}:\text{YLF}$ laser with an off-axis pumping configuration without any additional phase elements. We also address a selective handedness control of the vortex beam.

Figure 1(a) shows an experimental setup of our system. Two laser crystals with different coatings were used to lase red (640nm) and orange (607nm) vortex beams. An OC exhibited a concave curvature of 150mm and high reflection at 640 nm and 607nm ($R=98.7\%$ and $R=98.8\%$, respectively), and it was mounted on a 3-dimensional translator, thereby yielding laterally displacement along the x and y axes from an optical axis of the cavity, *i.e.* off-axis pumping. Thus, the cavity was allowed to lase at a vortex mode. The laser output exhibited a vortex mode at 640 and 607 nm, as evidenced by a doughnut-shaped spatial form with a central dark core and a pair of upward/downward (downward/upward) Y-shaped interference fringes produced by a self-referenced shearing interferometer²⁾, as shown in Fig. 1(b,c). Furthermore, maximum output powers of 808 mW and 211 mW for the vortex beam at 640 nm and 607nm were achieved at a pumping power of 3.16 W.

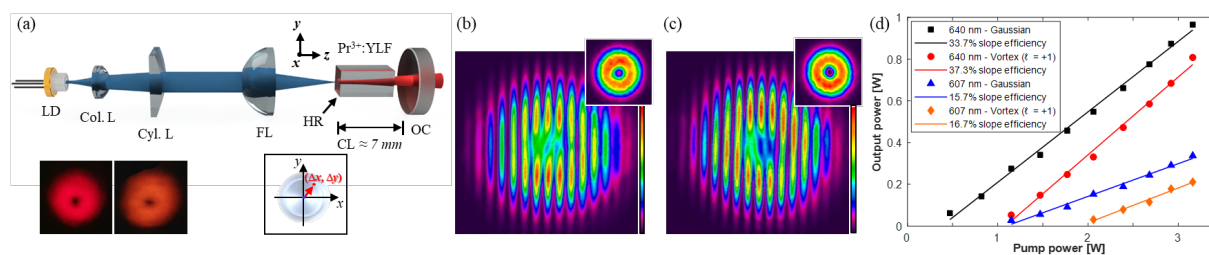


Fig1. (a) Experimental setup of the diode-pumped $\text{Pr}^{3+}:\text{YLF}$ laser with off-axis pumping. The inset shows the OC displacement for an off-axis pumping configuration example and two images of real color vortex beam. (b) Self-interference fringes of a right-handed ($\ell = +1$) and (c) of a left-handed ($\ell = -1$) vortex beam. The insets show the intensity profile for each vortex beam. (d) Output powers as a function of pump power for the Gaussian modes and the vortex modes ($\ell = +1$) at the wavelength of 640 nm and 607 nm. Slope efficiencies were measured to be 33.7% (black), 37.3% (red), 15.7% (blue), and 16.7% (orange), respectively.

References

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