

Direct generation of visible vortex beams from a diode-pumped Pr^{3+} :YLF laser

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Vortex beams^{1,2)}, *i.e.* optical vortices (scalar vortex) and radially or azimuthally polarized (vector vortex) modes, carries a doughnut-shaped spatial profile, nonzero orbital angular momentum, and self-healing effect, and they have been widely applied in various fields, such as optical manipulation, quantum optics, laser micro-fabrication, and super-resolution laser scanning microscopes. The direct generation of such vortex beams from laser resonators should allow us to generate high quality vortex beams at high efficiency without any additional optical elements. In this work, we present the first demonstration of the direct generation of visible vortex beams from a blue diode-pumped Pr^{3+} :YLF laser by employing an off-axis pumping technique.

Figure 1(a) shows a schematic diagram of the Pr^{3+} :YLF vortex laser. A *c*-cut 0.5 at.% Pr^{3+} :YLF crystal with a length of 5-mm was used, and its input face had high transmission for 445 nm and high reflectivity for 640 nm. The cavity was formed of the input face of the crystal and a highly-reflective concave output coupler ($R > 98.5\%$ @ 640 nm), and its length was ~ 11 mm. The cavity was off-axially pumped by a 1.3 W 445 nm InGaN laser diode: *i.e.* the pumped region of the crystal was slightly shifted from a center of the optical axis of the cavity, as shown in Fig. 1(a). The laser generated a scalar vortex mode, as evidenced by an annular spatial form with a central dark core and a pair of upward and downward Y-shaped fringes produced by a self-referenced shearing interferometer. A maximum output power was measured to be 102 mW at a pump power of 1.2 W, corresponding to a slope efficiency of 13.1%. After re-alignment of the cavity, the laser also produced a radial vector vortex mode, as evidenced by a twin lobe beam along the polarization direction with a maximum power of 90.4 mW.

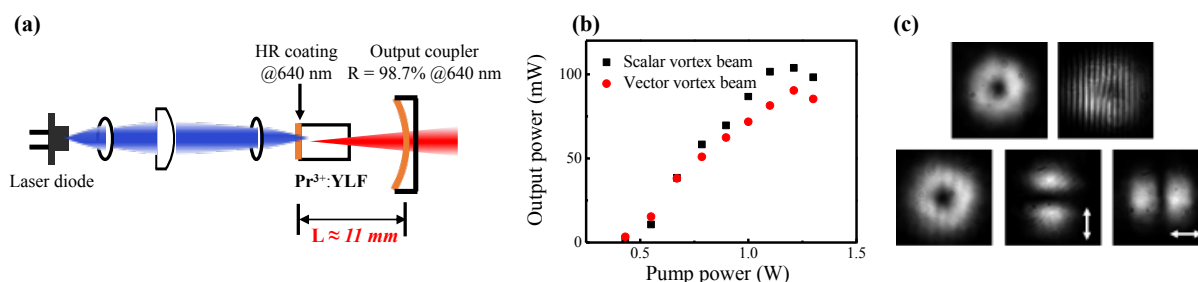


Fig1. (a) Experimental setup for Pr^{3+} :YLF vortex laser with the off-axis pumping. (b) Power scaling of the vortex output. (c) Spatial form and wavefront of the generated scalar vortex output (upper row). Total intensity distribution of vector vortex beam and intensity distributions after passing through a linear polarizer. Arrows indicate the direction of the polarizer (bottom row).

References

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