Generation of multiple OAM states from an optical vortex parametric oscillator

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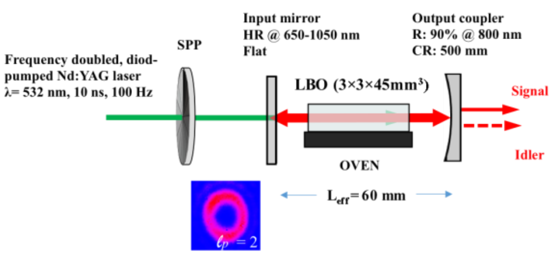
Helical light beams, i.e., optical vortices, carry an orbital angular momentum (OAM), characterized by an azimuthal phase term, $e^{i\ell\Phi}$, where ℓ is a topological charge and Φ is the azimuthal angle [1]. Optical vortices have been attracting much attention in a variety of research fields, for instance, material processing for chiral structured materials [2], and microscopy with high spatial resolution [3]. The above-mentioned applications strongly desire controllable OAM states versatility to optical vortex sources.

In this paper, we report on the first demonstration of the selective generation of multiple OAM states with ℓ =-2~4, including an up-converted and negative OAM states, from an optical vortex-pumped non-critical phase matching LiB_3O_5 (NCPM-LBO) optical parametric oscillator (OPO) with a singly resonant cavity configuration by simply tuning the wavelengths of signal and idler outputs.

Figure 1 shows a schematic diagram of our optical vortex-pumped OPO. The cavity was singly resonant for signal (higher energy photon), and its cavity length was ~60mm. With this system, the signal and idler (lower energy photon) from the OPO shared the OAM of the pump ($\ell_p = 2$), according to OAM conservation. The lasing wavelength of the signal output was tuned by controlling the LBO crystal temperature.

Figure 2 shows the tunability and spatial forms of signal and idler outputs. The system produced six OAM states, i.e. the signal with $\ell_s = 4, 3, 2$ and the idler with $\ell_i = -2, -1, 0$. Also, the vortex output could be tuned within a wavelength region of $0.74-1.87\ \mu$m, and its maximum pulse energy was measured to be 1.2mJ at the pump power of 7.7 mJ.



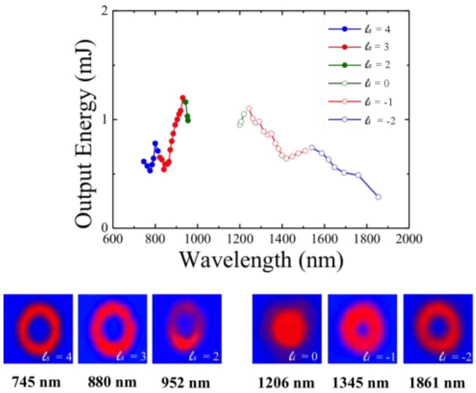


Fig.1 Experimental setup of LBO-OPO. Fig. 2 Tunability and spatial forms of signal and idler outputs.

References

[1] L. Allen, W. Beijersbergen, R. C. Spreeuw, and J. P. Woerdman, Phys. Rev. A 45, 8185 (1992).

[2] F. Takahashi, K. Miyamoto, H. Hidai, K. Yamane, R. Morita, and T. Omatsu, Sci. Rep. **6**, 21738 (2016).

[3] S. Bretschneider, C. Eggeling, and S. W. Hell, Phys. Rev. Lett. **98**(21), 218103 (2007).