Second harmonic conversion of light beams carrying OAM in a periodically-poled $LiTaO_3$ crystal

Zhongyu Lin, Yan Chen, Xiaopeng Hu*, Yong Zhang, and Shining Zhu
National Laboratory of Solid State Microstructures, College of Engineering and Applied Sciences, and School of Physics, Nanjing University, Nanjing 210093, China
Email: xphu@nju.edu.cn

Abstract: We realized second harmonic conversion of light beams carrying orbital angular momentum (OAM) in a periodically-poled $LiTaO_3$ crystal. Due to using the quasi-phase-matching technique, the conversion efficiency reached 2.6% even when the OAM index of the fundamental wave (FW) was 15. In addition, we have figured out the optimal phase-matching temperature will vary with the OAM index of the FW.

Light beams carrying OAM [1] have some unique characteristics such as spiral phase front and intensity null in the beams, and have found applications ranging from micro-manipulation, super-resolution imaging, precision measurements, to high capacity communication [2]. Among the studies, frequency conversion of light beams carrying OAM are of particular interests [3]. For example, through second harmonic generation, light beams with shorter wavelength and higher OAM index can be obtained. Here in this work, we used a periodically-poled LiTaO3 which based on the quasi-phase-matching (QPM) technique as the nonlinear crystal, and realized second harmonic generation of OAM modes.

The conversion efficiencies varying with the OAM index was shown in Fig. 1 (a). The fundamental source was a home-build near-infrared laser at 1342 nm, with a repetition rate of 10 kHz and a pulse width of about 50 ns. The nonlinear conversion efficiency was 43% with a Gaussian-profiled input. The maximum OAM index of the FW was 15, and the corresponding OAM index of the SH wave was 30. Due to using the periodically-poled crystal, the conversion efficiency was 2.6% with the maximum OAM index.

In addition, we found that the optimal phase-matching temperature will increase with the OAM index increasing, as shown in Fig. 1 (b). This mainly attributed to the changing of the transverse component of the wave-vector of the OAM modes when the interacting waves propagating inside the nonlinear crystal. We investigated the frequency doubling process with different OAM index by numerically solving the nonlinear coupled-wave equations, which matches well with the experimental observations.

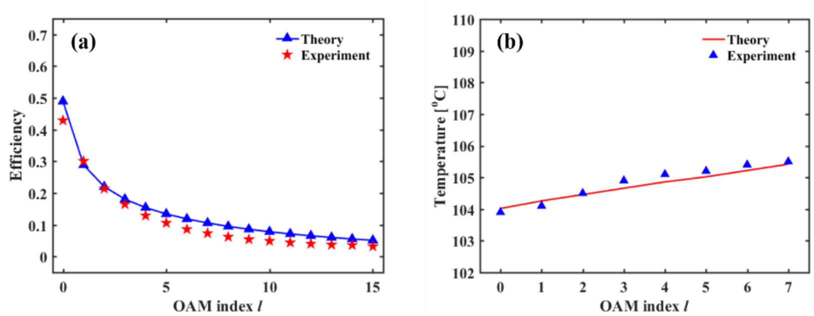

Fig. 1. (a) The conversion efficiencies and (b) the optimal phase-matching temperature at different OAM index of the FW.

References

[1] L. Allen, *et al.*, "Orbital angular momentum of light and the transformation of Laguerre-Gaussian laser modes," *Phys. Rev. A* **45,** 8185 (1992).
[2] Miles J. Padgett, "Orbital angular momentum 25 years on [Invited]", *Opt. Express* **25**, 11265 (2017).
[3] R. Ni, Y. F. Niu, L. Du, X. P. Hu, Y. Zhang, and S. N. Zhu, "Topological charge transfer in frequency doubling of fractional orbital angular momentum state", *Appl. Phys. Lett.* **109**, 151103 (2016).