Generation of tunable broadband OAM beams in large ring core multimode fibers

Jiaqi LI,[1] Samuli RANTO,[1] John M. DUDLEY,[2] and Goëry GENTY*,[1]

[1] *Photonics Laboratory, Tampere University, Tampere, FI-33104, Finland*
[2] *Université Marie et Louis Pasteur, Institut FEMTO-ST, CNRS UMR 6174, Besançon, France*
**goery.genty@tuni.fi*

Keywords: nonlinear optics, multimode fiber, optical orbital momentum

Beams carrying orbital angular momentum (OAM) are of growing interest due to their applications in microscopy, imaging, quantum optics, and communications. Traditional generation methods using free-space optics, such as spatial light modulators or phase plates [1], often face limitations in efficiency, bandwidth, and power. Ring-core fibers offer an alternative for OAM transmission [2], and recent work has shown that nonlinear propagation can transfer OAM to new wavelengths via stimulated Raman scattering (SRS) [3,4]. However, this typically requires carefully shaped input beams and limits the range of accessible topological charges.

Here, we demonstrate a simple and scalable approach to generate OAM beams with tunable topological charge and wavelength, without any input field shaping. Nanosecond pulses at 515 nm are launched into a large ring-core fiber (50 μm core, 10 μm ring) supporting thousands of OAM modes (Fig. 1). In the deep-normal dispersion regime, group-velocity matching enables efficient cascaded SRS, progressively transferring energy to OAM modes aligned with the pump velocity (Fig. 1b–d). By adjusting the pump conditions, we achieve flexible generation of clean OAM beams at new wavelengths. This approach opens new opportunities for high-power, broadband, structured light generation.

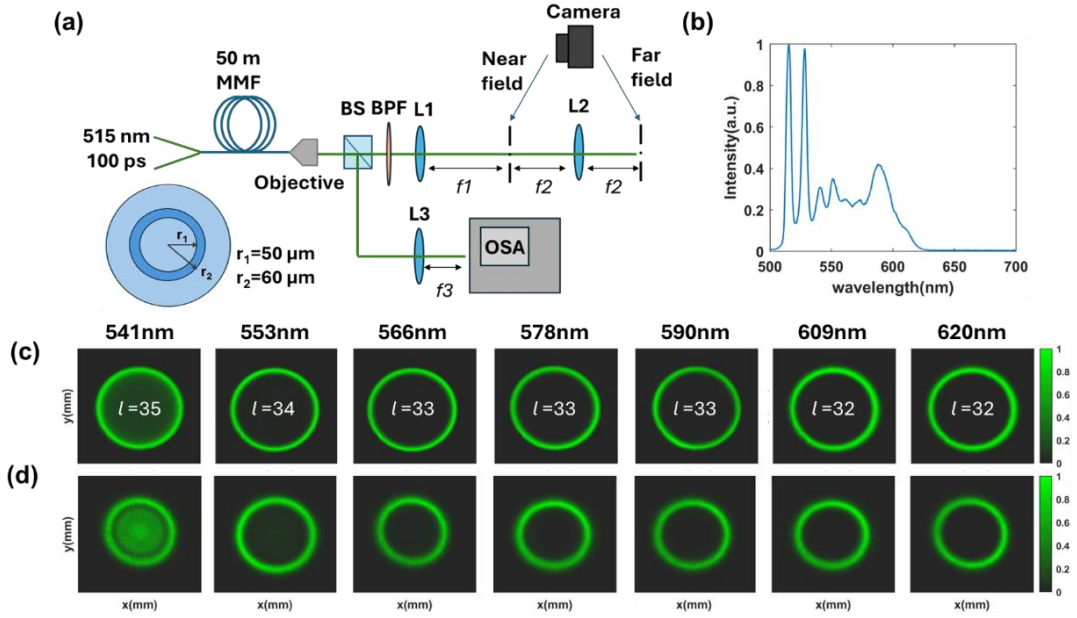

Fig. 1: (a) Experimental setup. Inset shows the structure of the fiber. (b) Spectrum. (c) and (d) are the near and far field images at different wavelengths as indicated with different topological charge *l* as indicated.

[1]. Y. Shen*et al.* ,"Optical vortices 30 years on: OAM manipulation from topological charge to multiple singularities," Light Sci. Appl. **8**, 90 (2019)
[2]. S. Ramachandran and K. Poul, "Optical vortices in fiber," Nanophotonics **2**, 455-474 (2013)
[3]. G. Prabhakar et al., "Octave-wide supercontinuum generation of light-carrying orbital angular momentum," *Opt. Express* **27**, 11547-11556 (2019)
[4]. X. Liu et al., "Nonlinear four-wave mixing with enhanced diversity and selectivity via spin and orbital angular momentum conservation," APL Photonics **5**, 010802 (2020)