# Integer Multiplier for Orbital Angular Momentum of Light

**Hirokazu Kobayashi[1], Satoru Takashima[1], and Katsushi Iwashita[1]**
*[1]School of Systems Engineering, Kochi University of Technology, 185 Tosayamada-cho, Kochi 782-8502 Japan*
*Author e-mail address: kobayashi.hirokazu@kochi-tech.ac.jp*

**Abstract:** In this research, we propose and demonstrate new method to implement integer multiplier for orbital angular momentum (OAM) of light by using the multi-valued conformal mapping of the optical complex amplitude. We experimentally confirmed sufficiently accurate and efficient OAM multiplication by using only two phase masks.

## 1. Introduction

Creation or manipulation of light wave with orbital angular momentum (OAM) can be accomplished by using various optical technique, such as q-plate and computer-generated holograms. However, all of these conventional methods are capable of performing only shift operation (additive or subtractive operations) on the OAM mode. In addition to shifting the OAM mode, it is valuable to perform the multiplication of the OAM state.

Recently, it is proposed that the OAM multiplier can be implemented by using log-polar coordinate mapping of the complex amplitude [1], which has been utilized for OAM mode sorting[2]. This simple method has an excellent property that in principle lossless and reversible conversion is possible. However, there is also a fundamental problem for log-polar coordinate mapping that accuracy of OAM multiplication decreases due to loss of the periodic boundary condition along the azimuthal angle of the OAM modes

In this research, we propose and experimentally demonstrate new coordinate mapping for the OAM multiplier to overcome the limitations of the log-polar OAM multiplier. Proposed method for implementing $N$-fold OAM multiplier is based on the multi-valued coordinate mapping from the input polar coordinate $(r,\theta)$ to the output coordinate$(\rho,\phi) = \left(r^{\frac{1}{N}}, -\frac{\theta+2n\pi}{N}\right)$, where integers $N$ and $n = 0,\cdots,N-1$. To implement the multi-valued coordinate mapping by single phase mask on spatial light modulator (SLM), we use double-phase hologram proposed in Ref. [3].

## 2. Experimental setup and results

Figure 1 shows experimental setup. The 633-nm LD light is split into two paths by the fiber coupler, one for preparing the OAM modes by q-plate and the other for reference beam to observe interferogram. The required two phase masks $\Phi(r,\theta)$ and $\Psi(\rho,\phi)$ for the coordinate mapping are displayed on the halves of the single SLM. The transformed beam intensity is observed by CCD, following the spatial filter composed of lenses and pinhole. Figure 2 shows experimental results for OAM doubler and tripler with input OAM mode of $l = +1, \pm1, +2, \pm2$, where $\pm l$ represents balanced superposition of $+l$ and $-l$. It is confirmed that sufficiently accurate OAM multiplication can be obtained.

## 3. Conclusion

We proposed and experimentally demonstrated the OAM multiplier by using multi-valued coordinate mapping.

## 4. References

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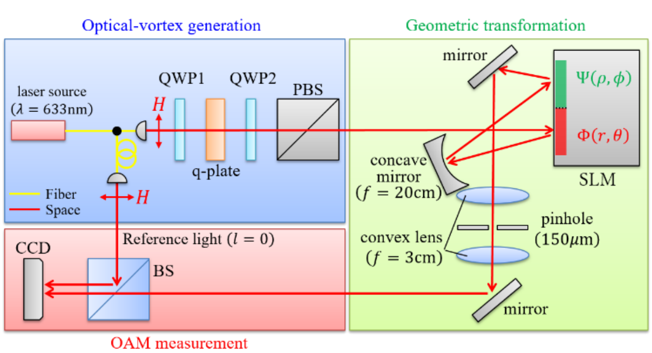


Fig. 1. Schematic of the experimental setup. BS, PBS, and QWP denote beam split- ter, polarization BS, quarter waveplate, respectively.

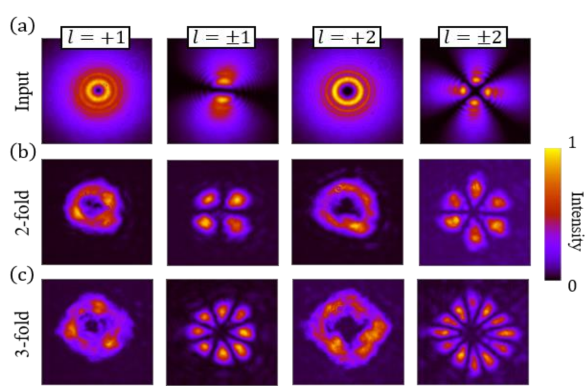


Fig. 2. Experimentally-obtained intensity distribution of (a) input, (b) 2-folded, and (c) 3-folded OAM modes by coordinate mapping.