High-Capacity, Free-Space Quantum Key Distribution Based on Spatial and Polarization Encoding

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Presented at the ONR Quantum Information Science Review, Arlington Virginia, December 9, 2015. (N00014-15-1-2635)

ARTICLES
PUBLISHED ONLINE: 24 JUNE 2012 | DOI: 10.1038/NPHOTON.2012.138
nature photonics

Terabit free-space data transmission employing orbital angular momentum multiplexing

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New J. Phys. **17** (2015) 033033 doi:10.1088/1367-2630/17/3/033033

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Published in partnership with: Deutsche Physikalische Gesellschaft and the Institute of Physics

PAPER

High-dimensional quantum cryptography with twisted light

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Simulating thick atmospheric turbulence in the lab with application to orbital angular momentum communication

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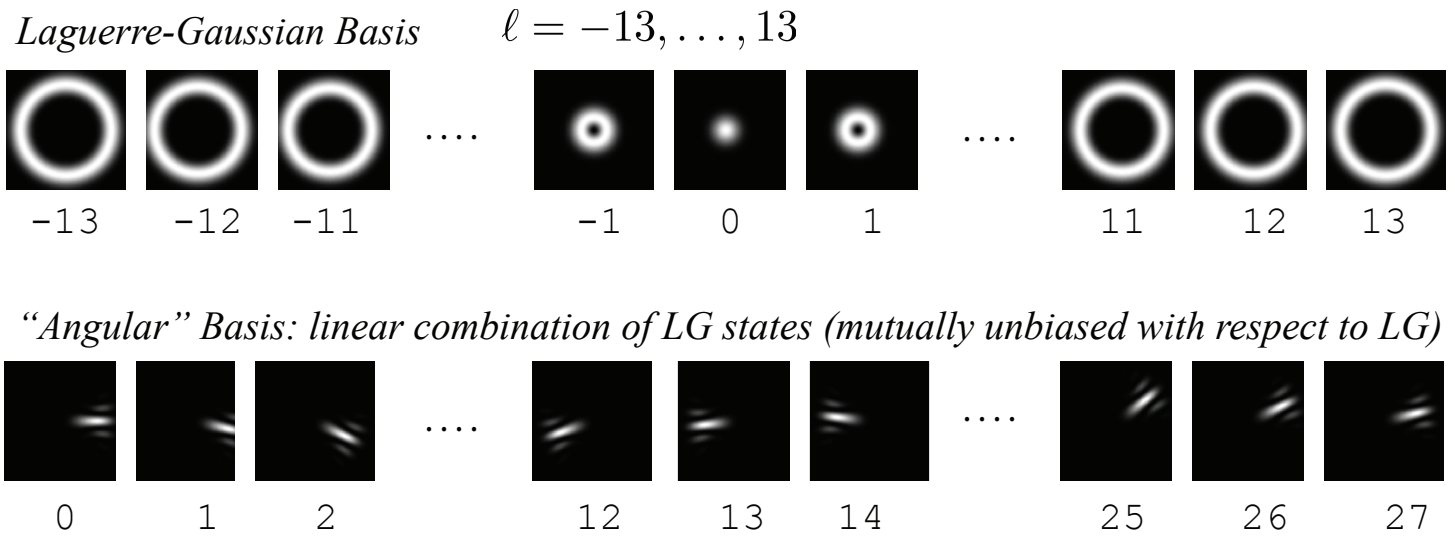
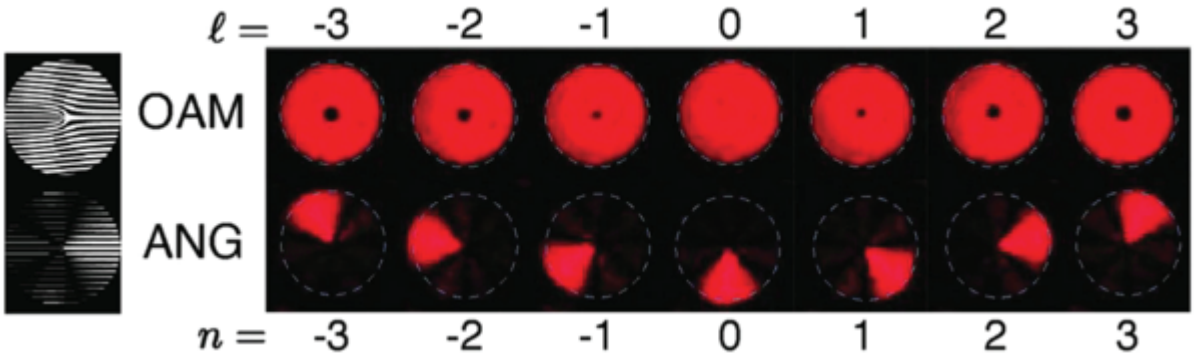
Received 1 October 2013, revised 25 January 2014
Accepted for publication 28 January 2014
Published 19 March 2014
New Journal of Physics **16** (2014) 033020
doi:10.1088/1367-2630/16/3/033020

The OAM-QKD Concept

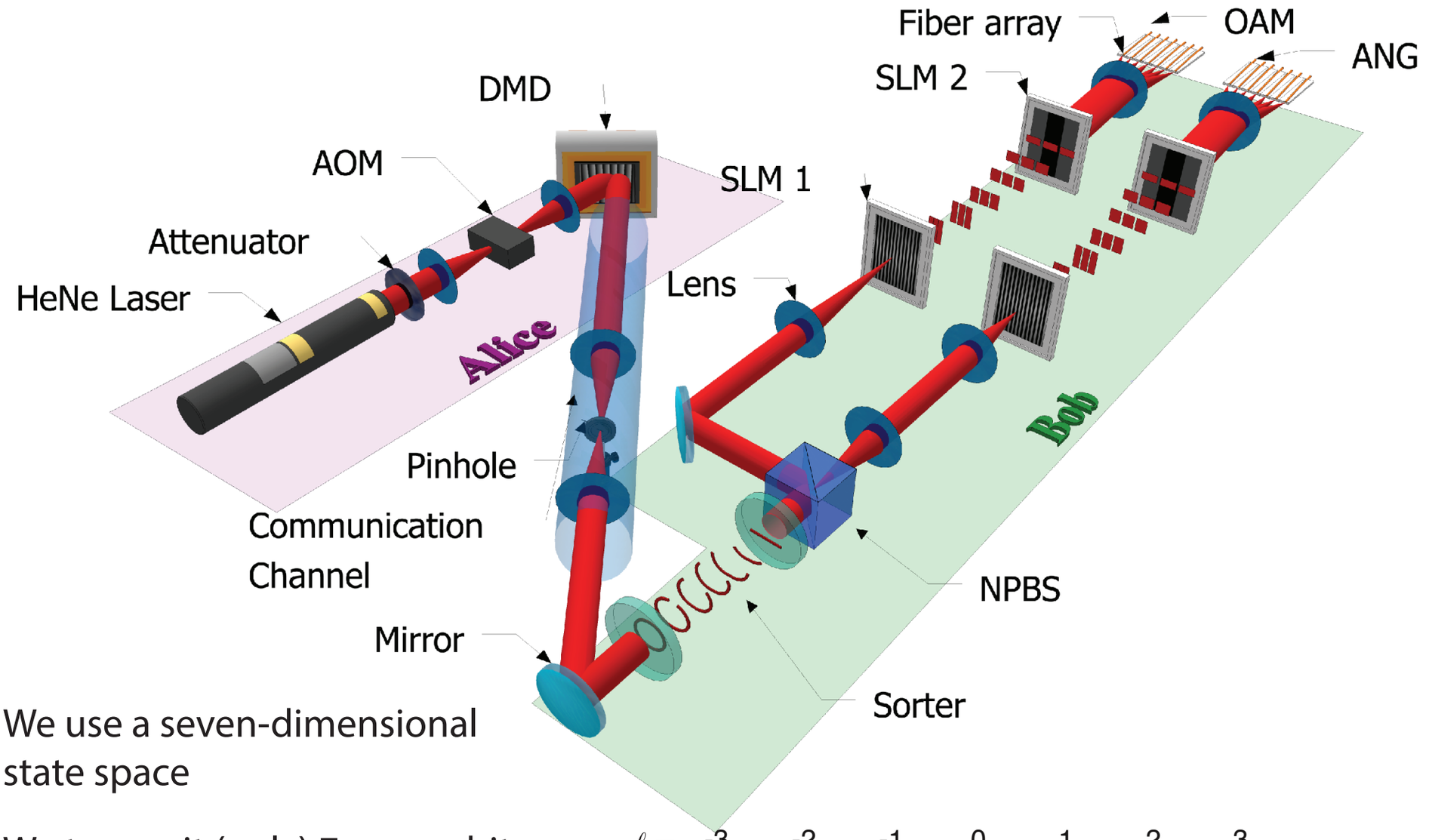
- We encode randomly in one of two mutually unbiased bases



- Our actual implementation (N=7)

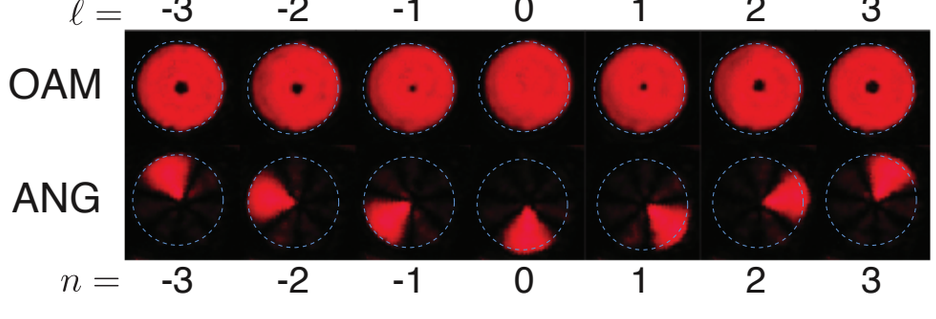


Our Earlier OAM-QKD Implementation



We use a seven-dimensional state space

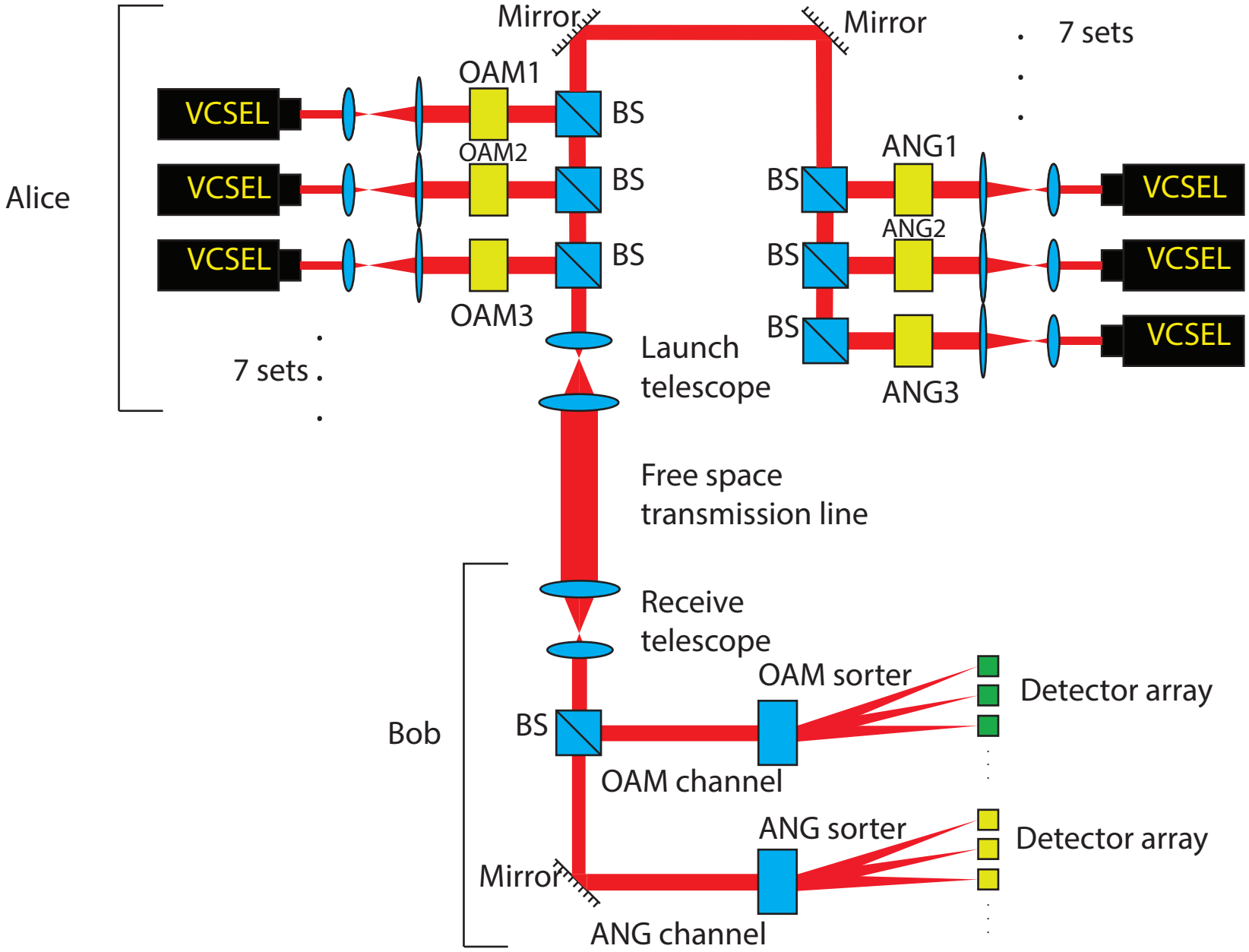
We transmit (only) 7 secure bits per second.



Mirhosseini, Magaña-Loaiza, O'Sullivan, Rodenburg, Malik, Lavery, Padgett, Gauthier and Boyd, New J. Phys. 17, 033033 (2015).

Next Step: gigabit-per-second OAM-based QKD system

- Use direct modulation of laser diode and static holograms to achieve gigabit rates.



Theoretical / Conceptual Issues

What is best strategy?

Assume that we have M OAM states (take M = 9) and assume initially that we will implement 2 MUBs

Do we include all 9 channels in the QKD protocol with N=9?

Or do we implement 3 channels each with N=3?

Or do we implement 9 channels each with of N=1?

Current Thinking:

Data rate is largest for pure multiplexing (9 channels of N=1)

But security can be enhanced by including more states in the QKD protocol

The best tradeoff probably depends on environmental issues such as atmospheric turbulence levels, and can be adjusted in real time.

Further Issues:

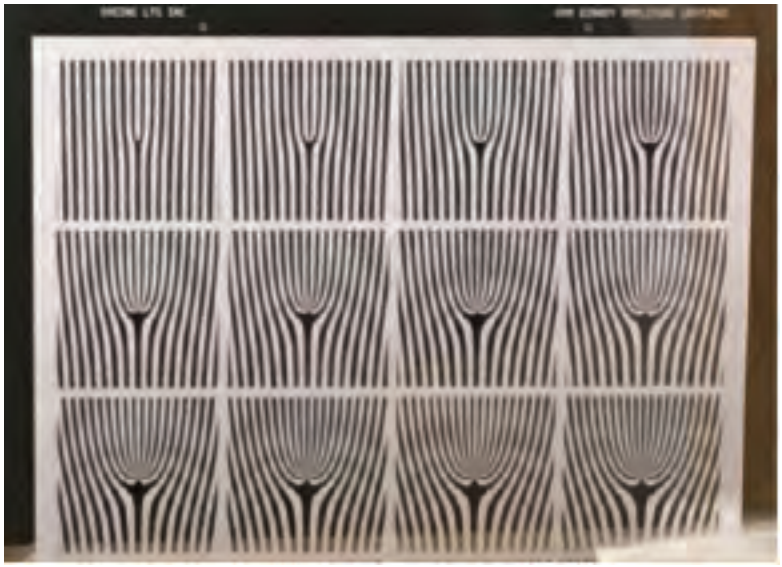
How do this tradeoff change if we implement more MUBs in our protocol?

How do we perform security analysis for finite-length keys

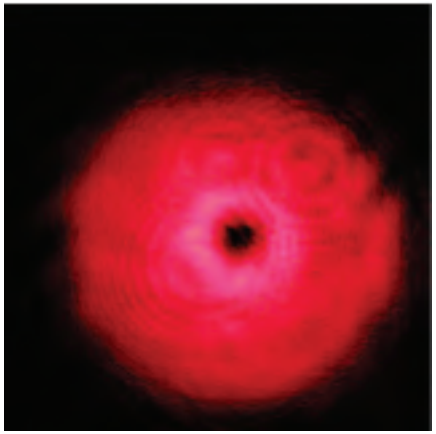
Collaborators: Anne Broadbent, Robert Fickler, and Kamil Bradler, U. Ottawa

Development of Static Holograms

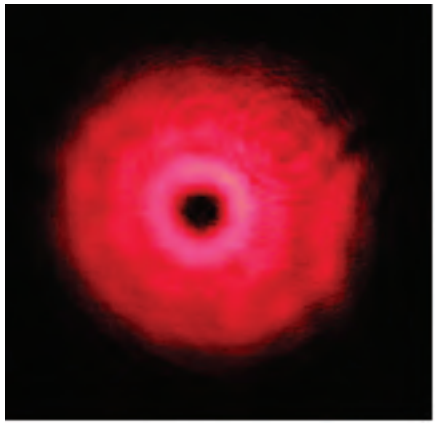
Hologram array



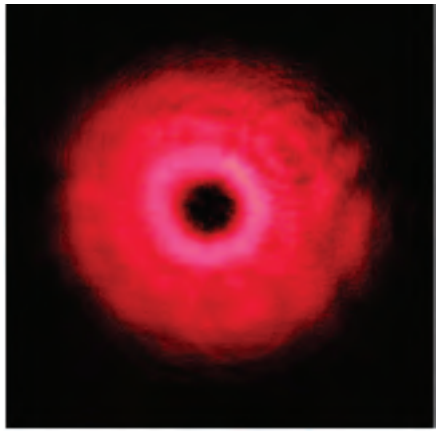
Far-field diffraction patterns



$\ell = 2$



$\ell = 2$

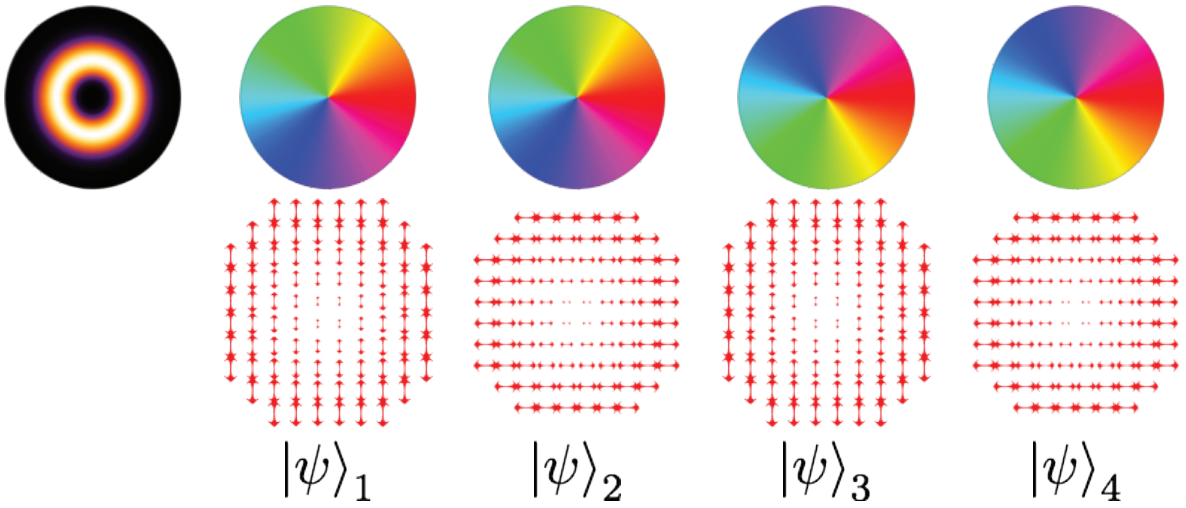


$\ell = 4$

We will simultaneously encode in polarization

- One possibility: use "vector beams"

MUB1



MUB2