EE Festival Presentation High-Capacity Millimeter-wave Communications with Orbital Angular Momentum Multiplexing





Yan Yan

Advisor: Prof. Alan E. Willner



Nov 11th 2014



Orbital Angular Momentum – LG Beams : Concept



OAM Applications – OAM Communications



- □ OAM multiplexing applied to optical and RF wireless communications to increase capacity and spectral efficiency.
- Compatible to other multiplexing technique: Pol-mux and WDM...
- Application scenarios might include: back-haul, data center, building-to-building communications.

Generation and Back-conversion of OAM Beams by Using Spiral Phase Plates



> The spiral phase plate (SPP) is defined by its thickness, which varies azimuthally according and acquires a maximum thickness difference of $\Delta h_{\ell} = \ell \lambda / (n-1)$. λ is the wavelength and n is the refractive index of the material. ([1] G. Turnbull, et al., *Optics Communications*, 1996) > These SPPs are manufactured through the computer numerical control (CNC) milling of a solid block of high-density polyethylene (HDPE), which has a refractive index of n = 1.52 at 28 GHz.

∆h₊₁ =2.07cm

 Δh_{+3} =6.21cm

Measured Intensity and Interferogram of OAM Beams $\ell =\pm 1$ and $\ell =\pm 3$



Top figures depict the ring-shaped normalized intensity profile of the generated OAM beams.
The state number of the OAM beams can be deduced from the number of rotating arms in their interferograms, which are generated by interfering the different OAM beams with a Gaussian beam through a coherent superposition using a beamsplitter (BS).

Each beam carries a 1 Gbaud 16-QAM signal, thereby achieving a capacity of 32 Gbit/s
After propagating through 2.5 meters, each channel is recovered with bit-error rates (BERs) below 3.8×10⁻³

Bit-Error Rates and EVMs of Received OAM Channels



>Each OAM channel is detected in single-pol (Y-pol) and dual-pol (X-and Y-pol) cases.

>Channels having higher crosstalk will consequently have worse EVM and BER performance.

Each channel is able to achieve a raw RED below the 3.9×10-3 forward error Y. Yan, Nature Communications, 5,4876 (2014)

Summary

OAM multiplexing can increase both capacity and spectral efficiency

- OAM multiplexing has potential applications in high speed back-haul, data center, building-to-building communications.
- Demonstration of 32 Gbit/s mm-wave wireless communication by multiplexing 8 OAM channels (Four different OAM beams of state numbers -3, -1, +1, and +3 on each of two polarizations)



