Full Simulative Approach to OAM Transmissions between Antenna Arrays

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OAM beams: waves carrying Orbital Angular Momentum (OAM), characterized by a doughnut-shaped intensity profile and an azimuthal phase variation of $2\pi|\ell|$.

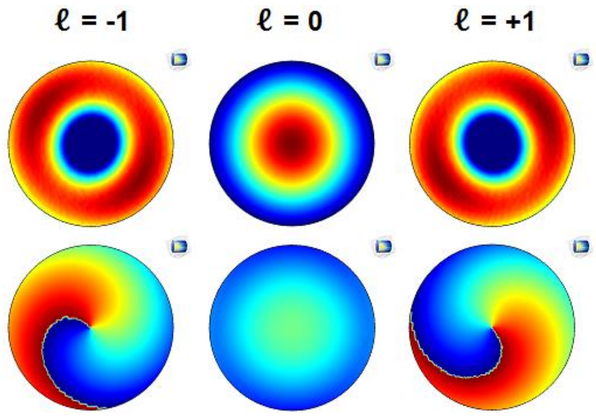

Fig. 1 Intensity and phase

Such beams can be generated using a *N*-element Uniform Circular Array (UCA) with a progressive phase shift: $2\pi\ell/N$.

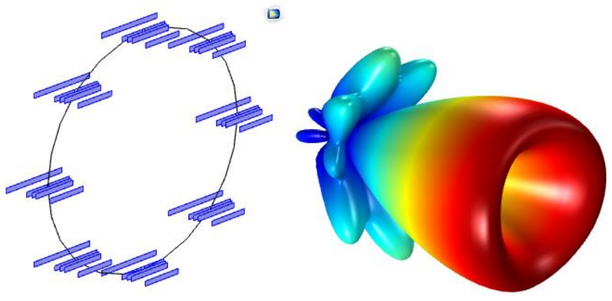

Fig. 2 OAM Radiation Pattern

COMSOL model: COMSOL allowed us to model an OAM communication link and proved to be an essential support for the experimental implementation of a multimode transmission scheme between UCAs [1].

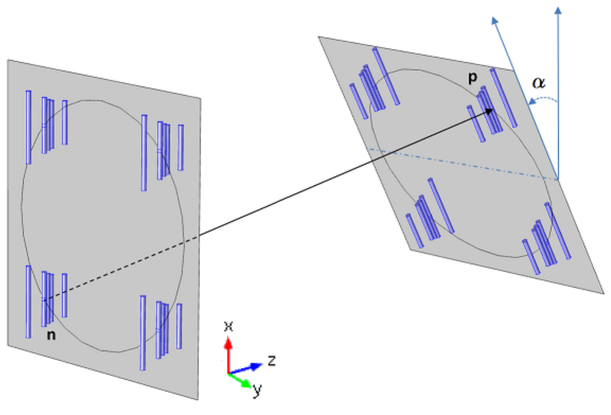

Fig. 3 Communication link

First approach:

A transmission link of 40 m is simulated in a unique model.

- High memory cost
- Indicated for near-field transmissions

Second approach:

The TX and the RX stages are treated separately, *i.e.* the TX far-field is provided as a background field to the RX model.

- Faster computation
- Far-field scenarios

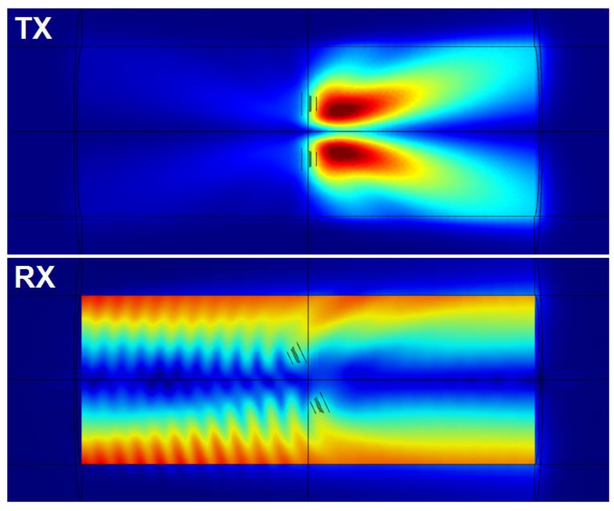

Fig. 4 Electric field norm

Results: The OAM link budget can be estimated in COMSOL by:

$$\frac{P_{out}}{P_{in}} = \frac{\left| \frac{1}{\sqrt{N}} \sum_{p=1}^{N} \Phi_p^{-\ell} V_{port}^{p} \right|^2}{\sum_{n=1}^{N} |V_n^{\ell}|^2} \qquad (1)$$

- V_n^{ℓ} : input OAM voltage to the *n*th TX radiator;
- V_{port}^{p} : voltage on the *p*th RX port (post-processing);
- $\Phi_p^{-\ell}$: RX OAM phase-weighting

Formula (1) as a function of the RX array rotation angle α shows an on-axis power maximum [2] and fits very well the experimental results:

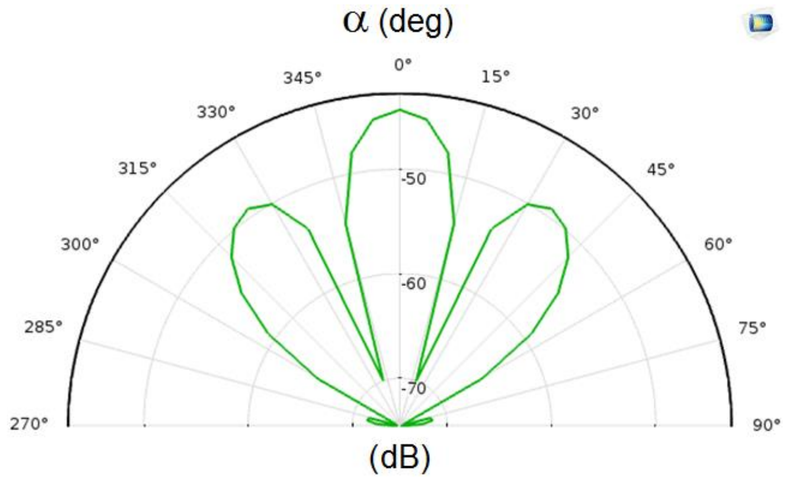

Fig. 5 OAM-link pattern (ℓ = 1)

Table 1. Link budget comparison

Link budget (dB)	$\ell = 0$	$\ell = 1$
Friis equation	-24.40	-
COMSOL simulation	-24.69	-42.96
Experiment	-25.50	-42.99

Conclusions: COMSOL proved to be a very efficient tool for our preliminary investigations and led to reliable results in good agreement with the experiment.

References:

1. R. Gaffoglio *et al.*, "OAM multiple transmission using uniform circular arrays: numerical modeling and experimental verification with two digital television signals", *Radio Science* **51**, 645-658 (2016).
2. A. Cagliero *et al.*, "A New Approach to the Link Budget Concept for an OAM Communication Link", *IEEE Antennas and Wireless Propagation Letters* **15**, 568-571 (2016).

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