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OAM-MIMO Antenna Performance for Short Range NLOS Communications

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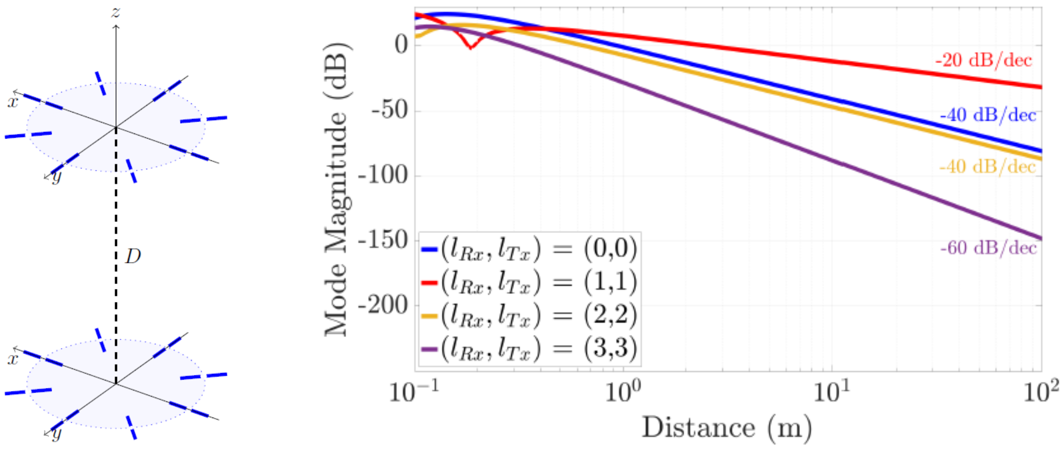
EM waves carrying orbital angular momentum (OAM) [1] have recently been studied for modern communication systems. OAM is regarded as a technology for improving spectral efficiency by multiplexing different propagating modes. In the radio domain, the employment of a uniform circular array (UCA) featuring a phase shift between consecutive elements is the most common technique employed in the literature to generate OAM carrying waves. This work will analyze the generation and transmission performance of different OAM eigenmodes for short range communications use cases evaluating the performance of different OAM modes under NLOS conditions, representing scenarios such as V2V communications and/or short-range indoor communications.
The channel transfer function H_{mn}^{T} between the n-th Tx and the m-Rx elements with their respective effective vector lengths $\boldsymbol{F}_n^T$ and $\boldsymbol{F}_m^R$ respectively may be expressed as:

$$H_{mn} = jk\eta_0 I_n \frac{e^{-jk|r_m^R - r_n^T|}}{4\pi|r_m^R - r_n^T|} (\boldsymbol{F}_m^R(\theta,\phi))^H \cdot \boldsymbol{F}_n^T(\theta,\phi) \qquad (1)$$

where k is the wavenumber, η_0 is the impedance of the medium, $I_n$is the input current, $r_n{}^T$ and $r_m{}^R$ the position of the respective elements, and $(\,)^H$ stand for the transpose vector. Then the coupling $\boldsymbol{\Lambda}$ between two arbitrary modes may we expressed as [2]:

$$\boldsymbol{\Lambda} = \boldsymbol{W}_{\boldsymbol{Tx}} \boldsymbol{W}_{\boldsymbol{TxRx}}^{\boldsymbol{H}} \qquad (2)$$

where $\boldsymbol{W}_{\boldsymbol{TxRx}}^{\boldsymbol{H}}$ is the coupling matrix and $\boldsymbol{W}_{\boldsymbol{Tx}}$ and $\boldsymbol{W}_{\boldsymbol{Rx}}^{\boldsymbol{H}}$ are the modal vectorial weights of the **Tx** and **Rx** antennas respectively**.**



(a) (b)

Figure 1. (a) 8-element Tx and Rx antennas geometry for two UCAs separated a distance D, (b) mode transmission Λ for the radial configuration of (a) and different distances D

1. J. Ren, K. W. Leung, D. Q. Liu, K. M. Luk, and J.-F. Mao, “Orbital angular momentum radiator multiplexing electromagnetic waves in free space,” Optics Express, vol. 28, no. 1, pp. 345–359, 2020. [Online]. Available: https://opg.optica.org/oe/abstract.cfm?uri=oe-28-1-345
2. Franco DeFlaviis, Luis Jofre, Jordi Romeu, Alfred Grau, ”Multi-Antenna Systems for MIMO Communications”, Morgan & Claypool Publishers, 2007.