

Mutual-Coupling-Matrix-Based Approach to Improve Modal Purity in Orbital Angular Momentum Links

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Orbital angular momentum (OAM) has gained attention as a multiplexing technique due to the spatial orthogonality between different OAM modes at any given frequency. Despite their higher spectral efficiency, OAM links suffer from important limitations such as susceptibility to angular misalignment and poor multipath performance. Moreover, coupling between opposing elements in OAM-generating uniform circular arrays (UCAs) introduces radiation pattern ripples (H. Chireix, “Antennes à rayonnement zénithal réduit,” *L'Onde Electrique*, vol. 15, 1936), which degrade OAM modal purity. Although various antenna structures have been used to reduce coupling, this often results in larger arrays that may still suffer from reduced modal purity (G. A. Muniz-Negron and J. T. Bernhard, “Orbital angular momentum from an antenna engineer’s perspective,” *2024 Antenna Applications Symposium*, 2024).

In this study, we perform numerical simulations of a resonant monopole OAM-generating UCA and calculate its mutual coupling matrix (MCM) and OAM spectrum. Drawing from direction finding techniques, we apply the MCM to calculate an array manifold that could produce pure OAM modes. This array manifold accounts for the mutual coupling effects across the array to produce the desired phase front.

Preliminary results demonstrate a 13.18 dB improvement in modal purity for the $l = +1$ mode by applying this MCM compensation approach. These results show that MCM compensation enhances OAM modal purity without requiring changes to the antenna structure. This method can be used to improve the probability of OAM detection in smaller, closely spaced UCAs. Additionally, this approach enables the use of a wider range of antenna elements for the generation of highly pure OAM beams.