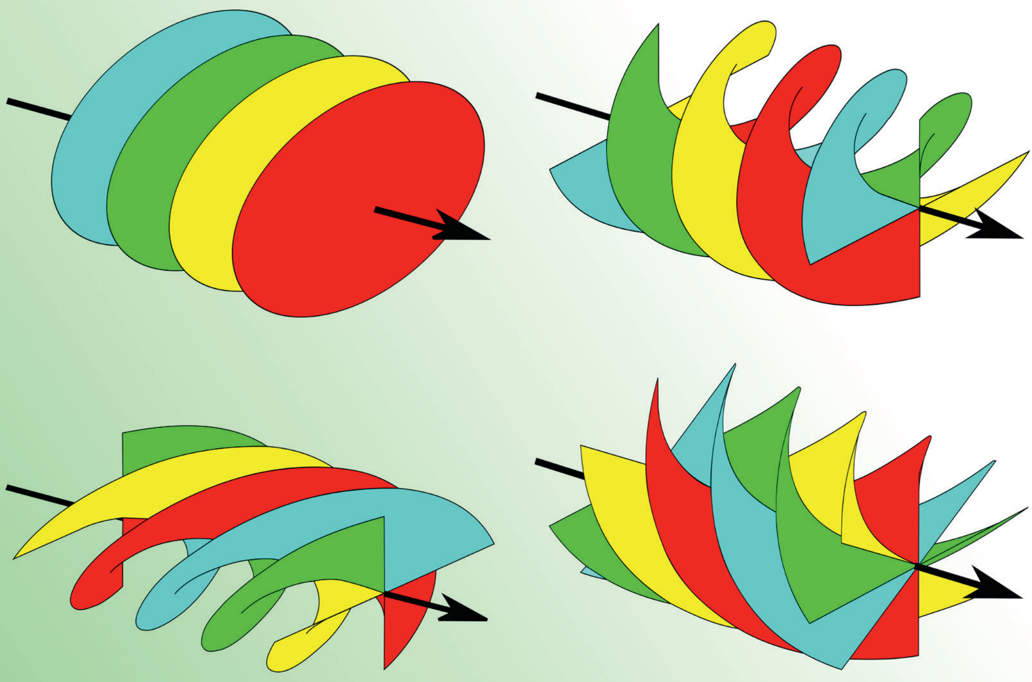
Numerical Analysis of Orbital Angular Momentum Waves Regarding Wave Propagation and Communication

Michael Wulff



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Summary

In this work, the propagation behavior of orbital angular momentum (OAM) waves is numerically studied in scenarios commonly encountered in radio frequency (RF) communication links.

In the RF domain, OAM waves comprise an orthogonal mode system, where the different OAM modes distinguish themselves in their spacial phase pattern. One method to excite OAM waves in free space is using a uniform circular array (UCA). Currently, two main applications of OAM waves are being discussed. First, they can be used in future communication systems as a type of multi-input multi-output (MIMO) system, where the orthogonality of the mode system allows the OAM modes to be used as independent communication channels. One challenge here is that the orthogonality of the modes is disrupted by some environments. Second, OAM waves can be used in the sensing domain, improving the resolution of the target by evaluating the reflection of different OAM modes.

To improve the fundamental understanding about the behavior and interactions of OAM waves, this thesis numerically evaluates the wave behavior in different scenarios. To that aim, the OAM mode system is introduced generally for N-ports and the symmetry requirements for the network parameters to retain mode orthogonality are derived. In addition, the numerical challenges in the simulation are discussed. The behavior of the OAM modes is subsequently investigated in scenarios encountered along a communication link in terms of mode transmission and mode orthogonality. After utilizing a matching and mode excitation network, the OAM modes can be guided along a transmission line, for which multiple types and geometries are investigated for their ability to retain the mode orthogonality. The UCAs that translate the guided OAM modes into radiated OAM modes can vary widely, e.g., in terms of the array elements used or their orientation. The impact of these variations on the radiated OAM modes is explored. While the radiated OAM modes propagate, they can encounter different scenarios. This work evaluates simple environments, such as free space and communication over ground and more complex scenarios, such as aperture penetration, shielding, and interference from other antennas.

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Contents