Dielectric-Filled Circular Waveguides for Multimodal Vortex Wave Propagation

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Modern data-multiplexing techniques are not enough to sustain the continuously increasing data-rate requirements in wireless comunication. Vortex waves present a potential solution to efficiently exploit the wireless spectrum. Therefore, there is an increasing interest in the multimodal vortex wave communication. Any electromagnetic system produces Angular Momentum (AM) beside it's linear momentum or radiation. The AM consists of Spin Angular Momentum (SAM) which is related to circular polarization and Orbital Angular Momentum (OAM) which is associated to the spatial distribution of the phase. Notably, as per prior eperiments in optics, waves with varying orbital angular momentum can be multiplexed in the same region of space and at same frequency.

In this paper, we propose methods to generate, transmit and receive multimodal waves in cylindrical waveguides. Specifcially we propose waveguides of dielectric material in fully and partially filled modality. The generation of higher order of OAM modes ($\ell=\pm1$, $\ell=\pm2$, $\ell=\pm3$ and $\ell=\pm4$) by combination of different TE and TM waveguide modes of the dielectric filled waveguide will be discussed. Notably, propagating waves, which show vortex behavior with phase front following $e^{jl\phi}$ will be demonstrated using full-wave simulation designs. Here, φ is the azimuthal angle and ℓ is the topological charge, commonly also known as OAM mode number. Futhermore, the study will investigate the isolation between the modes, when two or more such OAM modes are propagating in the waveguide. In essense, a multimodal behavior of the waveguide will be demonstrated using the proposed OAM type wave propagation.