Salient Features of Cylindrical Leaky-Wave Antennas with Metamaterial Loadings

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The application of metamaterials to antenna setups is nowadays becoming a topic of interest in the engineering community. Special media, suitably tailored and designed to achieve anomalous wave interaction effects, may in fact overcome some well known limitations that standard materials present when utilized to load antenna elements. Our group has found some interesting properties of the pairing of materials with oppositely signed constitutive parameters to design sub-wavelength resonant patch antennas, sub-diffraction components and low-profile leaky-wave antennas. All these anomalous effects rely on the compact "interface" resonance arising at the "complementary" interface between materials with negative permittivities or permeabilities and standard media.

In this context, the idea of applying these concepts to the cylindrical geometry has been recently proposed by us (A. Alù, F. Bilotti, N. Engheta, and L. Vegni, Proceedings of the 4th European Workshop on Conformal Antennas, Stockholm, Sweden, pp. 117-120, May 23-24, 2005) to design a sub-wavelength omni-directional leaky-wave radiator for satellite and cellular applications. In that work, an ENZ shell has been shown to support leaky-waves with azimuthal symmetry even in the sub-wavelength limit, a property consistent with our previous findings in the planar geometry.

Here we explore the possibility of extending this concept to more realistic antennas, modeling the feeding and the metamaterial realization. We also consider the possibility of studying circularly polarized modes, which may be preferable over the linear polarization for some applications. The case of anisotropic ENZ shells will be also considered, which may model better the realization of such metamaterials at microwave frequencies. The possibility of supporting higher-order modes will also be discussed, which may be useful for other antenna applications.