Guided Waves and Negative Refraction

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This paper presents an analysis of a wedge-type structure comprised of RF metamaterials. The composition of the wedge is presumed to be created by unit cells arranged in rows of progressively longer lengths. At frequencies near the resonance of the unit cells, it is well known that the wedge may exhibit the type of negative refraction associated with negative index materials. The purpose of the paper is to view negative refraction from the standpoint of each unit cell contributing to a phase shift that exceeds 180 Degrees and discuss how that phase shift can lead to negative refraction. For each row of unit cells, the last cell is considered to act as a radiator.

Negative refraction and the association with grating lobes can be understood from a simple analysis of classical array theory. This unusual association of grating lobe beam for radiators spaced closely together (i.e., each radiator being spaced less than a half of a wavelength) is discussed and clarified.

The analysis of the paper supports the existence of negative refraction. But the investigation then suggests that the in-phase addition generating the negatively refracted beam results from spherical wavefront from each of the radiators being 360 Degrees out of phase with each other. Such in-phase addition is commonly associated with a grating lobe in antenna theory. Accordingly, it is evident that when modulated, a negatively refracted beam must exhibit spatial dispersion.