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Invisibility of a Rectangular Prism Made of Anti-Isorefractive DNG Metamaterial Immersed in a Standing-Wave Field

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In many applications, it is desirable to blunt the scattering by sharp edges. In the case of metallic (PEC) structures, this objective can be achieved either with the use of absorbers, or by impinging upon the edge with several plane waves [1-2] of appropriate amplitude, phase, polarization, and direction of incidence. If the scattering structure has characteristic dimensions, additional conditions involving such dimensions and the wavelength must also be imposed [2]. When the scattering by the edges is eliminated, the structure is immersed in standing-wave fields and geometrical optics (GO) provides the exact solution to the boundary-value problem. For example, the 2D scattering by a PEC cylinder of rectangular cross-section requires four incident plane waves for GO to be the exact solution [3].

An exact GO solution exists for some structures involving penetrable wedges (see, e.g., [4-7]). However, the only known exact GO solution for a single wedge under incidence by a single plane wave is the scattering by a right-angle wedge made of anti-isorefractive DNG metamaterial [8].

In the present work, a prism of infinite length and rectangular cross-section is considered. The prism is made of a lossless metamaterial that is anti-isorefractive to the surrounding medium, meaning that the intrinsic impedance is the same inside and outside the prism while the refractive indexes have opposite sign. On the assumption that the four edges of the prism do not scatter (to be verified a posteriori), a plane wave incident on a face of the prism is totally transmitted as though it were incident on an infinite plane, and re-emerges into the surrounding medium after a second total transmission through another face. If only one wave is incident, this process gives rise to field discontinuities across optical boundaries and therefore cannot constitute an exact solution. However, if two plane waves of equal amplitude, polarization, frequency and appropriate phases but propagating in opposite directions are incident on the prism, all field discontinuities across optical boundaries disappear and the GO field represents the exact solution: the presence of the prism does not perturb the standing-wave field that would be present in the absence of the prism. This situation is possible if two relations involving the dimensions of the rectangular-cross section, the wavelength of the incident waves, and the angle of incidence are satisfied. These two relations are those that would occur if the prism were made of a PEC material, but in that case four incident waves would be needed to avoid edge scattering.

The exact GO solution presented herein constitutes a novel canonical solution of a boundary-value problem, and may be of practical interest in the validation of computer solvers.

References

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