Exact geometrical optics scattering by DNG metamaterial structures.

P. L. E. Uslenghi
Department of ECE, University of Illinois at Chicago, USA
uslenghi@uic.edu

The propagation of electromagnetic waves in a double-negative metamaterial entails phase regression in the direction of energy propagation, because of the negative value of the refractive index. When DNG materials are in contact with DPS materials (positive refractive index), this property can lead to phase compensation and, depending on the geometry of the overall structure, to an exact solution of the boundary-value problem that is valid independently of frequency.

In this work, three classes of geometries of structures are considered for which exact geometrical optics solutions have been obtained. In all cases, the DNG material has a real refractive index that is the opposite of the refractive index of the surrounding DPS material, whereas the intrinsic impedances of the two media have the same value. The first structure is the well-known Veselago-Pendry lens, which is here examined in the light of an exact solution to a boundary-value problem. Its behavior in the optical limit coincides with the exact solution only for a particular location of the image point, and in this case super-resolution occurs. For all other cases, geometrical optics introduces discontinuities at optical boundaries and cannot provide the exact solution.

The second class of problems is concerned with geometries that are derived from the exact geometrical optics solution for a right-angle DNG wedge (P.L.E. Uslenghi, *IEEE Trans. Antennas Propagat.*, vol. 54, pp.2301-2304, August 2006). These geometries consist of trenches in a PEC half-plane that are partially filled with DNG prisms of rectangular or triangular cross-section. For a certain polarization of the incident plane wave, these trenches are invisible at all frequencies for which the DNG material behaves as postulated (P.L.E. Uslenghi, "Invisible metamaterial trenches", *Metamaterials 2007*, Rome, Italy, Oct. 2007).

The third class of problems is concerned with a plane wave axially incident on a paraboloidal radome consisting of one or more layers of DNG material. Again, geometrical optics yields the exact solution (J. Liang and P.L.E. Uslenghi, "A metamaterial lens: the DNG paraboloid", *URSI EMT Symposium*, Ottawa, Canada, July 2007). A time sequence of the wave propagation through the structure will be shown.