Oblique Scattering by Penetrable Cylinders of Arbitrary Cross Section

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In 1955, J. R. Wait (*Can. J. Phys.,* vol.33, pp. 189-195, 1955) studied the scattering of a plane wave obliquely incident on an infinitely long circular cylinder made of a linear, homogeneous and isotropic material and surrounded by free space, in the phasor domain. He proved that an incident TE (or TM) wave whose electric (or magnetic) field is perpendicular to the cylinder axis produces a scattered field with a non-zero electric (or magnetic) field component parallel to the cylinder axis. Such cross-polarization always vanishes at normal incidence, and it vanishes at oblique incidence if the cylinder is either a perfect electric or a perfect magnetic conductor. Wait did not emphasize that polarization decoupling also occurs when the refractive index of the cylinder material equals plus one (isorefractive material) or minus one (anti-isorefractive DNG metamaterial).

In this work, Wait's results are generalized to cylinders of arbitrary cross-sectional shape. The analysis is conducted by setting up a local system of orthogonal curvilinear coordinates at any regular point of the cylinder surface. If the cylinder surface presents a wedge discontinuity, the local coordinate system can be set up on either side of the edge of the wedge and arbitrarily close to it. The continuity of the tangential components of the electric and magnetic fields and of the normal components of the electric and magnetic flux densities across the cylinder surface results in a system of equations. An analysis of the conditions under which the equations in such a system are compatible with one another leads to the conclusion that at oblique incidence, with the exception of incidence on a planar interface, a necessary condition for the decoupling of TE and TM polarizations to occur is that the material just inside the cylinder surface be either isorefractive or anti-isorefractive to the material in the medium outside the cylinder.