Exact Geometrical Optics Scattering by Truncated Metal Gratings

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Electromagnetic scattering of incident plane waves by planar metallic gratings truncated by a metal plane oriented perpendicular to the grooves or ridges of the grating is studied in the phasor domain, with a time-dependence factor *exp (+jωt)* omitted throughout. The grating may be of either finite or infinite extent in the direction perpendicular to the grooves or ridges, i.e., it may consist of either a finite or an infinite number of grooves or ridges.

The exact analytical solution to the electromagnetic boundary-value problem is obtained in two steps. First, the two-dimensional problem of a grating of infinite length in the direction of the grooves or ridges on which the primary plane waves are incident perpendicularly to the edges of the grooves or ridges is considered. It is shown that under incidence by a finite number of plane waves of appropriate amplitude, frequency, direction of propagation, phase and polarization, geometrical optics provides the exact solution for gratings of certain cross-sectional shapes. More than one incident plane wave is needed in order to avoid discontinuities of the total field across optical boundaries, meaning that the metal edges of the structure do not scatter. Once the 2-D solution is obtained, it is extended to oblique incidence with respect to the direction of the grooves or ridges, and to truncation by a metal plane perpendicular to the grooves or ridges, by utilizing the general method in [1].

Two gratings are studied in detail. The first structure consists of a (finite or infinite) number of parallel and equally spaced metallic half-planes whose edges are in a plane perpendicular to the half-planes. It is shown that if a certain relationship is satisfied between the distance of neighboring half-planes and the wavelength, one or more angles of incidence exist for which two primary plane waves lead to an exact geometrical optics solution. If the two Wiener-Hopf solutions for scattering by a single plane wave are added together, it is verified that the geometrical optics solution is indeed exact, for both an infinite number of half-planes [2] and two parallel half-planes [3].

The second structure consists of a (finite or infinite) number of either grooves or ridges of rectangular cross section on a metal plane. As in the previous case, under certain conditions two incident plane waves cancel edge scattering and lead to an exact geometrical optics expression for the total field. The particular case of a single groove was studied previously [4].

Numerical results for the current density on the metal surface of the structures are displayed and discussed.

References

[1] P.L.E. Uslenghi, “Electromagnetic scattering by metallic cylinders perpendicularly truncated by a metal plane,” *IEEE Trans. Antennas Propag.*, **63**, 5, May 2015, pp. 2228-2236.

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[3] M.D. Poort, V.G. Daniele, and P.L.E. Uslenghi, “Electromagnetic scattering by a pair of semi-infinite metal plates perpendicularly truncated by a metal ground plane,” *IEEE Trans. Antennas Propag.*, **66**, 5, May 2018, pp. 2515-2521.

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