A Review on Novel Canonical Scattering Problems Solved by the Wiener-Hopf Technique with the Help of Fredholm Factorization and Network Formalism

A Review on Novel Canonical Scattering Problems Solved by the Wiener-Hopf Technique with the Help of Fredholm Factorization and Network Formalism

Vito Daniele[(1)], Guido Lombardi [(2)], and Rodolfo S. Zich[(2)]

(1) Politecnico di Torino, Torino, Italy, (vito.daniele@polito.it)
(2) Politecnico di Torino, Torino, Italy, (guido.lombardi@polito.it)
(3) deceased, Politecnico di Torino-ISMB, Torino, Italy

In 2010s, Vito Daniele and Guido Lombardi started a new collaboration with Rodolfo S. Zich on the analysis of scattering problems in electromagnetics in spectral domain. Soon, the group selected the Wiener-Hopf technique (WHT) as one of the most promising techniques to develop new canonical solutions with physical insights (V.G. Daniele, R.S. Zich, The Wiener-Hopf Method in Electromagnetics, SciTech Publishing Inc, 2014). The development of WHT has been first extended from rectangular problems, as in classical literature, to angular region problems (V.G. Daniele, G. Lombardi, R.S. Zich, Network representations of angular regions for electromagnetic scattering, PLoS ONE, 12 (8), art. no. e0182763, 2017). Unsolvable problems of factorization were treated with the introduction of a semi-analytical general-purpose factorization method, known as Fredholm Factorization (V.G. Daniele, G. Lombardi, Fredholm factorization of Wiener-Hopf scalar and matrix kernels, Radio Science, 42(06):1-9, 2007). This tool is effective, and it aims to be a technique that avoids cumbersome mathematical specialization often encountered in WH factorization. This evolution of WHT has a strong impact in general application of the method (also in different subjects), and it has a special impact on the analysis of the physics of electromagnetism, since its semi-analytical nature maintains the spectral interpretation of the problems as analytical closed form solutions but at the same time extends the class of solvable problems (V.G. Daniele, G. Lombardi, The Wiener-Hopf Fredholm factorization technique to solve scattering problems in coupled planar and angular regions, In Advances in Mathematical Methods for Electromagnetics, pp. 279-302, SciTech Pub.-IET, 2020). Moreover, one of the main benefits of the proposed semi-analytical solutions is to allow the computation of field components by using asymptotics and analyzing spectral structural and source singularities, similarly to what is done with closed-form spectral solutions (V.G. Daniele, G. Lombardi, and R.S. Zich, The Electromagnetic Field for a PEC Wedge Over a Grounded Dielectric Slab: 2. Diffraction, Modal Field, Surface Waves, and Leaky Waves, Radio Science, 52(12), pp. 1492-1509, 2017). At the same time, the development of this framework has been studied following the paradigm of Bresler and Marcuvitz (A.D. Bresler, N. Marcuvitz, Operator methods in electromagnetic field theory, Report R-495-56, PIB-425, MRI Polytechnic Institute of Brooklyn, 1956) provided for the analysis of stratified media by using transverse equation theory. We apply and extend the same methodology to represent problems of higher complexity where angular regions are combined with rectangular finite regions and stratifications (V.G. Daniele, G. Lombardi, R.S. Zich, Radiation and Scattering of an Arbitrarily Flanged Dielectric-Loaded Waveguide, IEEE Trans. Antennas Propag, 67(12), art.n.8886592, pp.7569-7584, 2019). All these types of basic geometric/material bricks, that decompose complex problems, can now be delt with WH formulations and Fredholm factorization where all equations can be represented by circuit/network modelling that allows to describe the technique with systematic steps avoiding redundancy (V.G. Daniele, G. Lombardi, R.S. Zich, Physical and Spectral Analysis of a Semi-Infinite Grounded Slab Illuminated by Plane Waves, IEEE Trans. Antennas Propag,70(12),pp.12104-12119, 2022). Examples of solved complex scattering problems are proposed in Fig.1 and they will be discussed during the presentation.

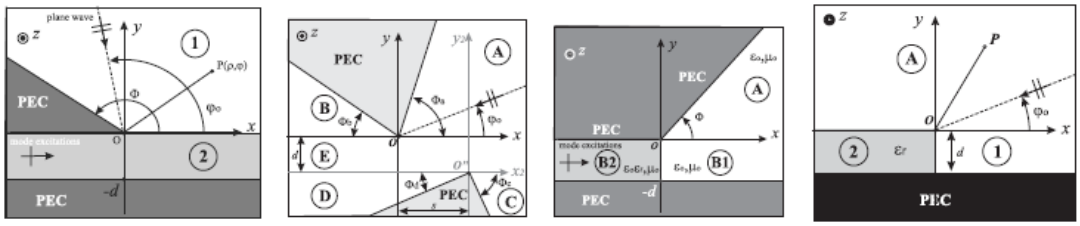

Figure 1. Complex scattering problems analyzed with the proposed technique.

This work was supported by PRIN Grant 2017NT5W7Z GREEN TAGS