Working with Professor T.B.A. Senior on Diffraction by Impedance Structures and Higher Order Boundary Conditions

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By 1980, I had good knowledge of Prof. T.B.A. Senior's diffraction papers and his contributions to scattering by impedance edges and wedges, including impedance boundary conditions. And after 2 years in industry (9/1982-9/1984), I was fortunate to start my academic career at The University of Michigan (since September 1984), and to work side by side with one of the giants in radar scattering and diffraction theory.

Having already studied Prof. Senior's pioneering impedance half plane work, I looked forward to working with him on impedance diffraction problems. A first step was the evaluation of the Maliuzhinets functions. These were still computationally intractable, limiting their practical use in calculating the pertinent wedge diffraction coefficients. Working with my first ever PhD student, Dr. Martin Herman, an initial focus was the simplification of the $K_{+/-}$ split and Maliuzhinets ψ_Φ functions. Indeed, using numerical simulations, to our surprise, these functions were associated with very simple plots (ψ or $K_{+/-}$ versus their argument) [1,2]. In fact, we found that $\psi_\pi(\alpha)=1-0.014\alpha^2$, and the simplicity of this expression was a remarkable observation. I recall the pleasant surprise by Prof. Senior, but being an "analytical person," he wanted to demonstrate this simple result via mathematical means. After a month and many pages of analysis, I recall his excitement when he visited me to announce that the "0.014" coefficient was actually "0.0139." For the next two years, we proceeded to collaborate on several other simplifications of impedance diffraction expressions, and use them to understand the impact of dielectric coatings on metallic surfaces.

Our second, and most impactful collaboration relates to the development of generalized impedance boundary conditions (GIBCs) and their associated generalized sheet transition conditions (GSTCs). The beginning of this research started in 1987 when I ran into a paper on diffraction by a thin dielectric half plane using 2nd order transition boundary conditions. The solution was non-symmetric with respect to the incidence and diffraction angles, implying a 'suspicion" on its validity. So, we began working on a new solution that would be symmetric with respect to incidence and diffraction angles. This was a very pleasant interaction with Prof. Senior and it led to a new class of diffraction coefficients for coated edges and wedges. A key aspect of the solution was the uniqueness of the split functions, and the introduction of a constant (to accommodate the splitting process) to arrive at the correct diffraction coefficient for thin dielectric and coated half planes [3]. Afterwards, we proceeded to generate a new class of diffraction solutions and a processes to generate diffraction coefficients for coated edges and edges using higher order or generalized boundary conditions. This work led to our book [4], published in 1995. Notably, today GIBCs and GSTCs are used for modeling metamaterial surfaces and a represent a form of absorbing boundary conditions in finite element and finite difference numerical solutions.

After 1995, much of the focus was on the topic of skew incidence diffraction by impedance wedges [6,7]. Prof. Senior continued this work for several years with Andrey Osipov [7]. At the meeting, we will review impedance diffraction coefficient with unpublished details that led to their generation. We will also discuss the impact of GIBCs and GIBCs.

References

[1] J.L. Volakis and T.B.A. Senior, "Simple Expressions for a Function Occurring in Diffraction Theory," *IEEE Trans. Antennas Propagat.*, pp. 678-680. June 1985.
[2] M.I. Herman, J.L. Volakis and T.B.A. Senior, "Analytic Expressions for a Function Occurring in Diffraction Theory," *IEEE Trans. on Antennas and Propagat.*, pp.1083-1086, Sept. 1987
[3] J.L. Volakis and T.B.A. Senior, "Diffraction by a Thin Dielectric Half Plane," *IEEE Trans. on Antennas and Propagat.*, pp. 1483-1487, Dec. 1987.
[4] T.B.A.Senior and J.L.Volakis, *Approximate Boundary Conditions in Electromagnetics*, IEE Press, New York and London, 1995 (ISBN-13: 978-0852968499).
[6] H. Syed and J.L. Volakis, "Skew incidence diffraction by an impedance wedge with arbirtrary face impedances," *Electromagnetics*, Vol. 15, pp. 291-300, 1995.
[7] A. V. Osipov and T. B. A. Senior, "Diffraction by a right-angled impedance wedge," *Radio Science*, Vol. 43 (4), May 2008. https://doi.org/10.1029/2007RS003787