Construction of large-support basis functions for rigorous high-frequency integral equations

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During the last decade new matrix compression techniques characterized by the $N \log N$ solution complexity, where N is the number of unknowns, were introduced. Their implementation extended the spectrum of electromagnetic scattering and radiation problems tractable in terms of integral equations methods. These compression techniques require that the geometry discretization (typically about 10 points per wavelength) reproduces accurately variations of the electromagnetic field. Hence the numerical size of the problem increases with the increase of frequency.

Further reduction in the solution complexity constitutes a serious challenge which may be addressed by applying techniques including domain decomposition, preconditioning, asymptotic evaluation of the matrix-vector product, as well as utilization of suitably chosen basis functions in selected areas of the scatterer surface. The latter approach utilizes the fact that, in the high frequency asymptotic, solutions (typically the surface current) can be parameterized as a sum of rapidly oscillating functions multiplied by functions varying slowly on the wavelength scale. The specific objective of these methods is to achieve an integral-equation discretization with a frequency-independent number of unknowns. In some approaches such parameterizations are built on the basis of approximate asymptotic high-frequency solutions, including Physical Optics approximation [1, 4] and multiple reflection effects [5]. In other approaches [2, 3] the known MoM solutions at a lower frequency are analyzed, and the characteristic oscillations are determined. This information is then used to construct basis functions defined on supports large compared to the wavelength and incorporating oscillatory factors. The basis functions are then extrapolated to a higher frequency.

In this contribution we present our recent results on the development of a particular realization of an LSBF based discretization model for solving scattering problem with frequency independent number of unknowns. The model consists of two components,

(i) LSBFs parameterized in terms of suitably chosen oscillatory factors representing contributions of incident, reflected and diffracted waves, coexisting with
(ii) locally confined small support basis functions needed to reproduce rapid variations of the solution near edges and corners.

We present the results of the validity tests of the above-mentioned LSBF model for representative scattering problems involving polygonal plates and their combinations. We find linear combinations of the LSBFs approximating the rigorous MoM solutions, and assess the approximations' accuracy by comparing the resulting scattered fields. We show that, if the relevant scattering mechanisms are incorporated in the LSBF construction, highly accurate approximations can be obtained in large frequency ranges with a frequency-independent number of parameters.

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