Chaotic High-Fidelity and Quantitative Statistical Analysis for Wave System

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Even though we are seeking for the highest possible fidelity, the computer representation will not be exactly the same compared to the real world. These uncertainties may arise from the imprecise knowledge of the system, small differences in the manufacturing, or numerical errors in the simulations. In most cases, those small differences can be considered as local perturbations of the entire system. Hence, the numerical solution is still a very good approximation to the exact solution of the physical problem. However, the situation can be completely different in complicated electromagnetic (EM) systems displaying wave chaos.

One wave chaotic system considered in this work is the IC and electronics within large and complicated enclosures. In high-frequency regime, wave solutions inside these enclosures show strong fluctuations that are extremely sensitive to the exact geometry of the enclosure, the location of internal electronics and the operating frequency. Minor changes in the shape of the enclosure, or the reorientation of internal IC or electronics, can result in significantly different EM environments within the enclosure. Further, imprecise knowledge of these parameters is another obstacle to predictability. Therefore, "numerically exact" solutions obtained by a deterministic approach for a specific structure may be of limited practical value. It necessitates a quantitative statistical analysis of the in-situ IC performance and system behavior.

This work concerns with a quantitative statistical analysis accounting for the uncertainty in complex wave-chaotic systems. The primary contributions are twofold: (i) a stochastic Green's function method for wave interaction with wave-chaotic media, which quantitatively describes the universal statistical property of chaotic systems through random matrix theory (RMT); (ii) a hybrid deterministic and stochastic formulation, in which small components (electronics, antennas, etc.) in the computational domain are modeled using first-principles and large portions (cavity enclosures, scattering environments, etc.) are modeled statistically. In this talk, we first introduce the concept of stochastic Green's function, and then illustrate the hybrid formulation for the statistical prediction of IC components within short-wavelength wave-chaotic enclosures (wave chaos in cavities).