Interconnection of complex cavities analyzed by the Random Coupling Model

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Today, the statistical analysis of complex electromagnetic cavities constitutes a very active field of research in electronics, electromagnetic compatibility, wireless communications, and, more broadly, statistical physics. The Random Coupling Model (RCM) provides a framework for predicting the statistics of scattering of radiation in complicated enclosures (S. Hemmady, IEEE T-EMC, 54-4, 2012). Starting from the rigorous solution of Maxwell's equations, the RCM makes use of results from wave chaos and random matrix theory (RMT) to model the mode spectrum of cavities whose geometry is complicated or unknown in detail. Such an approach should be relevant to mode-stirred reverberation chambers (RC).

The RCM was originally formulated for the impedance matrix of a quasi-planar microwave cavity with multiple ports (X. Zheng, Electromagnetics, 26-1, 2006). More recently, it has been extended to treat three-dimensional cavities excited by electrically large apertures. The distribution of cavity admittance elements in the case of rectangular apertures has been generated (G. Gradoni, USNC-URSI, Boulder, 2012, and G.Gradoni, EMC Europe 2012, Rome, 2012)

In this presentation, we discuss the extension of the RCM to account for the joint presence of localized ports (antennas/sensors) and multimode apertures. It is shown that this results in a compact ``hybrid'' model involving both impedance and admittance matrices. Then we use the hybrid RCM to study the scenario of two (or more) three-dimensional cavities interconnected by apertures. We imagine exciting the first cavity of the so formed chain with a small antenna, and receiving a signal in the last cavity with a similar antenna. A closed form solution of the trans-impedance between the two antennas is derived, and its statistics discussed. Variations of cavity losses and aperture geometry, including thickness, are discussed within our statistical framework, for which distribution functions are generated by the Monte Carlo method. In the high-loss limit, the small fluctuation approximation considerably simplifies the formulas, allowing for the identification of self- and cavity-cavity interaction terms. The extreme case of an irregular aperture connecting to an irregular cavity is also proposed and investigated.

Our results are of interest for radiated emission/immunity tests in RCs, emulation of wireless channels in RCs, as well as for the investigation of fundamental properties of mode-stirred enclosures.