Chaoticity enhancement in reverberation chambers

F. Moglie[(1)], G. Gradoni [(2)], and V. Mariani Primiani [(1)]
(1) Università Politecnica delle Marche, DII, Ancona, Italy.
(2) University of Nottingham, School of Mathematical Sciences, Nottingham,UK.

The reverberation chamber (RC) is an electrically large cavities whose field is modelled as an idealized statistically uniform and isotropic random field. Reverberation chambers are widely used in electromagnetic compatibility (EMC) to carry out compliance tests. These properties are achieved through an overmoded metallic cavity, i.e. having high modal density in the higher frequency range. Lowering the operating frequency results in a degradation of RC performances. Static diffractors can be used to restore a good chamber operation at relatively low frequencies. Specifically, it has been shown that the insertion of spheroidal scatterers creates wave-chaos. In this contribution, we analyze the effect of multiple hemispherical scatterers inside the RC. This extremely complex geometry is numerically analysed using an in-house parallel finite-difference time-domain (FDTD) code. The code is divided into three modules that are managed by a unique, single-step job: the electromagnetic solver based on the FDTD method; a fast Fourier transform (FFT) to obtain the frequency domain behaviour; a statistical tool to extract the RC properties. A unique run produces statistical results for all the investigated stirrer angles, without the burden of saving intermediate data. The code implements a hybrid parallelization as function of stirrer angle and cavity volume. Specifically, such a computation is known to be ``embarrassingly parallel" with respect to the stirrer angle. The excitation is a Gaussian pulse modulated sinusoid at 1.1 GHz: the 95% bandwidth is 0.2 and 2 GHz. After the FDTD simulation is completed, the FFT module gives the frequency behaviour of the fields in each point with a resolution of about 50 kHz. Chamber performances are checked varying the number, the dimension and the position of the scatterers. In particular, the number of uncorrelated positions of a rotating mechanical ``carousel stirrer", made of eight vertical blades, is computed with and without the metallic hemispheres. Fig. 1 reports a scheme of the analysed chamber with four scatterers in the corners of the chamber, far from the carousel, and one on the ceiling, right on top of the carousel. Fig. 2 shows the computed independent positions. The improvement in the number of uncorrelated cavity realizations can be clearly noticed in the low frequency regime, upon insertion of the hemispheres, and where the efficiency of the mechanical mode stirrer is low. The chaotic dynamics introduced by the spherical surfaces is evident, as it results in the creation of more ergodic modes at lower frequencies, even though the presence of the scatter reduces the total volume of the chamber. Besides EMC, achieved results are of interested in 3D microwave billiards, and low frequency dynamics of chaotic systems within quantum chaos studies.

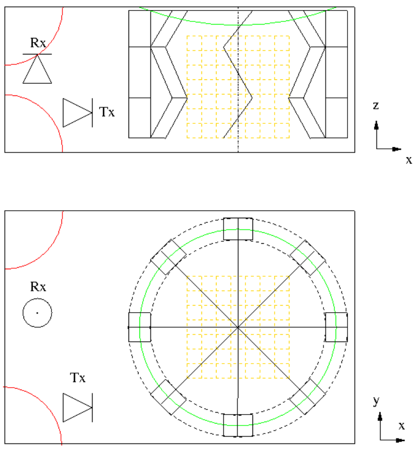

Fig. 1. RC plant showing the rotating carousel and the hemispherical scatters positions. The RC dimensions are 6 x 4 x 2.5 m^3.

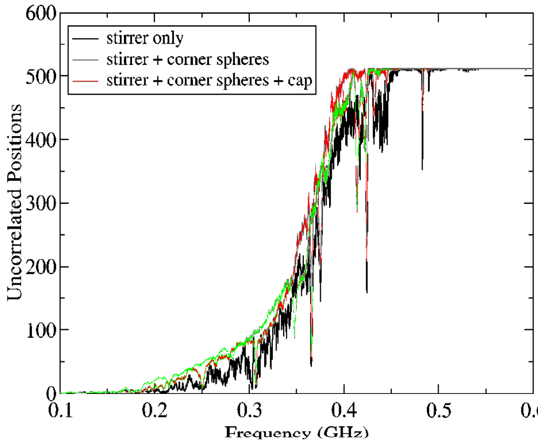

Fig. 2. Stirrer uncorrelated positions with and without the hemispheres.