**Stochastic-deterministic Approach to the Brain and Eye Dosimetry**

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**INTRODUCTION**

This work aims to investigate the influence of the variability in the morphology and the tissue properties of the brain and eye, respectively, to the induced Specific Absorption Rate (SAR) due to the exposure to high frequency (HF) radiation. Stochastic-deterministic modeling provides a satisfactory theoretical basis for estimating the effects of the related uncertainties on the maximum induced local and average SAR, respectively. An efficient Method of Moments (MoM) scheme applied to the brain exposure and hybrid boundary element method (BEM)/finite element method (FEM) used to handle the eye exposure are considered. A simple stochastic collocation (SC) formalism [1], [2] is then used to accurately account for uncertainties and to assess confidence intervals in the set of obtained numerical results.

**DETERMINISTIC AND STOCHASTIC MODELING**

Performing some mathematical manipulations, the following set of integral equations is obtained [1]:

\[ j \omega \mu_n \int_S \bar{J}(r') G_n(r, r') \, dS' - \frac{j}{\omega \varepsilon_n} \int_S \nabla' \cdot \bar{J}(r') \nabla G_n(r, r') \, dS' + \]
\[ + \int_S \bar{M}(r') \times \nabla' G_n(r, r') \, dS' = \begin{cases} \bar{E}^{inc}, & n = 1 \\ 0, & n = 2 \end{cases} \]  

where \( \bar{J} \) and \( \bar{M} \) is equivalent electric and magnetic current density, respectively, \( G_n \) is the interior/exterior Green function [1], while \( k_n \) denotes the wave number of a medium \( n \). Plane wave incident on the corneal part of the eye representing an unbounded scattering problem can be expressed in terms of Stratton-Chu formulation, i.e. the time-harmonic electric field at the exterior domain is given by the following boundary integral equation [2]:

\[ \alpha \bar{E} = \bar{E}_i + \int_{\partial V'} \bar{n}' \times (\nabla' \times \bar{E}) G dS' + \int_{\partial V'} [\bar{n}' \times \bar{E}] \times \nabla' G + (\bar{n}' \cdot \bar{E}) G dS' \]  

where \( E_i \) stands for the incident electric field.

Mathematical details on MoM, BEM/FEM and SC procedures could be found elsewhere, i.e. in [1] and [2].

**COMPUTATIONAL EXAMPLES**

Figure 1 shows the SC convergence with 3, 5 and 7 points for the SAR values calculations and different random variables (RV_k; k=1, . . . ,5). Although the output (maximum SAR) is...
highly non linear, SC provides an assessment of the 1st statistical moment with 5 simulations only.

Figure 1: Mean of maximum SAR

Figure 2 gives an information of the 1st order sensitivity of the model for the SAR assessment in the eye exposed to plane wave, i.e. the SAR variance - var(SAR). As depicted in Fig. 2, higher levels of var(SAR) are concentrated inside the vitreous body.

CONCLUSIONS
The paper deals with an analysis of the exposure of the brain and eye to the HF radiation on the basis of stochastic and deterministic modeling thus taking into account the uncertainty variations of input parameters. The expansion of statistical output in terms of mean and variance over a polynomial basis (via SC) is shown to be robust and efficient technique providing a satisfactory convergence rate of SC technique.

REFERENCES