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Interaction of electromagnetic fields with the environment/Interaction du champ électromagnétique avec l'environnement

Foreword

Except in very particular cases, communicating objects (an emitter and a receptor) are not directly visible. The quality of communications is strongly dependent on the properties of the environment of the electromagnetic wave. Indeed, pieces of furniture, people, buildings, trees or any other obstacle can attenuate, reflect, diffract or diffuse the wave being propagated in open space. Thus, the wave received by a receptor is not only the wave emitted by an emitter, but the sum of a multitude of counterparts of the emitted wave. These counterparts follow paths, differing according to topography of places at the moment of the exchange of information, and they are characterized by a delay and an attenuation which are specific to them. This phenomenon of multi-trajectories can cause interference and degrade the quality of the communications. For more certain and the most faithful exchanges possible, whatever the desired situation of the communications (in a crowd, at the seaside, in a room, in a workshop), many studies of the physics of propagation, signal processing, are still necessary.

Electromagnetic modelling plays a more and more important role in the study of complex systems involving Maxwell phenomena such as the interaction of radiowaves with the human body. Simulation then becomes a credible means of decision-making related to the engineering of complex electromagnetic systems. To increase confidence in the models with respect to reality, validation, and uncertainty, estimation methods are needed. The different dimensions of model validation are illustrated through dosimetry, i.e., quantification of human exposure to electromagnetic waves (Man-Fai Wong and Joe Wiart [1]).

The limits of numerical modelling when dealing with the real environment are presented in the Matshek's paper [2]. Lack of knowledge on materials is common in the simulation of radioprotection in urban environments. This article proposes a way to tackle with this uncertainty by combining a Genetic Algorithm with the EM model based on optical techniques.

'Fast algorithms for layered media', written by Chew et al. [3], is a sound presentation of computational electromagnetics from its beginning to its latest developments: fast algorithms for large problems such as those of electromagnetic field interactions with the environment. The paper smoothly converges to the extension of the fast multipole method (FMM) to layered media. It gives a physical taste of the FMM method with reference to its mathematical background. The paper discusses the breakdown of the full-wave solver when the frequency is decreased to the static regime, identifying both the physics and the computational issues. As FMM is primarily developed in free space, its extension to layered media is a challenge. The paper presents the key principles to achieve this task.

'Shared issues of wavefield inversion and illustrations in 3-D diffusive electromagnetics' (Lesselier et al. [4]) presents clearly the issues related to wavefield inversion with a number of useful references. It gives also 2 examples in the 3-D diffusive low frequency regime of electromagnetics.

Molinet et al. [5] give a review on computational methods for the prediction of Radar Cross-Sections (RSC) and antenna–platform interactions. Boundary elements methods, finite difference time domain methods, finite elements-finite volume methods, hybridisation and factorisation techniques are reviewed. Asymptotic methods are mainly discussed to study the antenna–platform interactions.

Gati et al. [6] propose a technique which allows the development of effective models taking into account objects close to antennas. It is based on the decomposition of a source, of arbitrary geometry whose dimensions do not allow a direct use of asymptotic methods in its vicinity, into smaller equivalent sources, which make possible the calculation of the field radiated close to the transmitter. The equivalent geometry sources are represented by their spherical modes.

To know the radiation pattern from sources in the presence of perfectly conducting objects is of a great interest in the design of antennas. The optimal antenna location is particularly hard to find. Zerbib et al. [7] propose a reliable and fast electromagnetic code, able to model antenna/structure couplings. In the case of large multilayer dielectric objects, Chabory et al. [8] propose to evaluate the ability and utility (rapidity and accuracy) of Gaussian beam techniques to compute the radiation of an antenna protected by a radome.

Diffuse reflection by rough surfaces is discussed by Michel Sylvain [9]. This paper is an introduction to the problems of electromagnetic wave scattering by a rough surface. The case of the sea surface is studied by Saillard et al. [10]. This

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article describes radar experiments aimed at probing the sea surface from the coast. To capture small-scale changes in a coastal environment, a flexible high resolution, Doppler L-band radar with high resolution has been used.

At least two papers show the influence of artificial structures on the wave propagation. Decoopman et al. [11] review the electromagnetic properties of photonic crystals and metamaterials with a main emphasis on backward (left-handed) propagation media. Some artificial structures yield a negative refractive index. In connexion with negative index media, one can predict focusing for a flat lens and phase advance for a left handed transmission line. From microwaves to visible region, Daniel Maystre et al. [12] show that, due to the heterogeneous nature of a metamaterial, a material able to focus the light more efficiently than the current devices could exist. The authors show that a plane slab of dielectric photonic crystal can also focus light, a property which could be crucial for the construction of superlenses in the visible and infrared regions.

As shown by this brief summary, the various contributions in this special issue highlight new fundamental questions raised by the interaction of an electromagnetic field with the environment. We hope that the reader will find in the presented contributions, *issued from Journées Scientifiques du CNFRS (URSI France) 24–25 February 2005*, numerous stimulating reflections on these complex interactions, depending strongly on the nature of the environment.

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Pierre-Noël Favennec
Président de Comité National Français de
Radioélectricité Scientifique (URSI-France),
37, rue Dareau,
75014 Paris, France
E-mail address: pierre-noel.favennec@wanadoo.fr (P.-N. Favennec)