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Modelling the Human Body Exposure to ELF Electric Fields

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Contents

PREFACE	xi
CHAPTER 1 INTRODUCTION	1
1.1 EXTREMELY LOW FREQUENCY EXPOSURE	2
1.1.1 <i>Different areas of research</i>	2
1.1.2 <i>Evidences of harmful effects</i>	2
1.2 COMPUTATIONAL DOSIMETRY AT ELF	4
1.2.1 <i>Models of the human body</i>	6
CHAPTER 2 ELF ELECTROMAGNETIC EXPOSURE	9
2.1 INTRODUCTION	9
2.2 EM EXPOSURE. BASIC CONCEPTS	9
2.2.1 <i>Non-ionising radiation</i>	10
2.2.2 <i>Dosimetry</i>	12
2.3 THEORETICAL MODEL FOR ELF	13
2.3.1 <i>Interface matching conditions</i>	16
2.4 DIFFERENT SOURCES OF EXPOSURE AT ELF	17
2.5 SUMMARY	19
CHAPTER 3 DIELECTRIC PROPERTIES OF BIOLOGICAL TISSUES	21
3.1 INTRODUCTION	21
3.2 MODELLING BIOLOGICAL SYSTEMS	22
3.2.1 <i>The scale</i>	22
3.2.2 <i>Coupling different scales problems</i>	23
3.3 AVAILABLE DATA ON DIELECTRIC PROPERTIES	23
3.3.1 <i>Measurements</i>	23
3.4 THEORETICAL ASPECTS. BIOLOGICAL MATTER IN ELECTRIC FIELD	24
3.4.1 <i>Definition of the dielectric properties</i>	24
3.4.2 <i>Dispersions</i>	27
3.5 GENERAL DIELECTRIC PROPERTIES OF SOME TISSUES	28
3.6 BIOLOGICAL TISSUE AT ELF	30
3.6.1 <i>Relative importance of conductive and displacement currents</i>	31
3.6.2 <i>Dielectric data below 100 Hz</i>	33
3.6.3 <i>Estimation of effective conductivity</i>	35

3.6.4	<i>Dielectric data of the pregnant woman</i>	37
3.6.5	<i>Dielectric data for the foetus</i>	38
3.7	SUMMARY	40
CHAPTER 4	NUMERICAL METHOD	41
4.1	INTRODUCTION	41
4.2	INTEGRAL FORMULATION	41
4.3	BOUNDARY DISCRETISATION	42
4.3.1	<i>Discontinuous elements</i>	44
4.4	INTERNAL SOLUTION	45
4.5	CONTINUOUS AND DISCONTINUOUS BOUNDARY ELEMENT METHOD	46
4.6	STAGGERED BOUNDARY ELEMENT	47
4.7	ANALYTICAL APPROACH FOR THE INTEGRALS	49
4.8	ACCURACY TESTS	54
4.8.1	<i>Example 1: Comparison of the S-BEM integrals against numerical quadrature</i>	54
4.8.2	<i>Example 2: Mass conservation in a unitary cube</i>	57
4.8.3	<i>Validation for low-frequency electric fields induced in biological tissues</i>	59
4.9	SUMMARY	60
CHAPTER 5	EXPOSURE TO OVERHEAD POWER LINES	63
5.1	INTRODUCTION	63
5.2	PHYSICAL MODEL	64
5.3	HUMAN BODY MODELLING	65
5.4	NUMERICAL IMPLEMENTATION. EXTREME AND MINIMAL DOMAIN DECOMPOSITION	67
5.5	GLOBAL RESULTS	69
5.6	ANALYSIS OF THE REFINEMENT OF GEOMETRY	71
5.6.1	<i>Influence of the cross-sectional area</i>	71
5.6.2	<i>Inclusion of arms</i>	73
5.6.3	<i>Inclusion of organs</i>	76
5.7	ANALYSIS OF VARIATIONS ON CONDUCTIVITY	78
5.7.1	<i>Variations on conductivity in the homogeneous representation</i>	78
5.7.2	<i>Variations on conductivity in the heterogeneous representation</i>	79
5.8	SUMMARY	86
CHAPTER 6	EXPOSURE IN POWER SUBSTATIONS ROOMS	87
6.1	INTRODUCTION	87
6.2	INDUCED CURRENTS IN THE HUMAN BODY INSIDE A POWER SUBSTATION ROOM	87
6.3	INDUCED CURRENTS IN THE HUMAN BODY RESULTING FROM THE PROXIMITY TO SURFACES AT FIXED POTENTIALS	90
6.4	SUMMARY	94
CHAPTER 7	PREGNANT WOMAN	97

7.1	INTRODUCTION	97
7.2	PHYSICAL MODEL	98
	7.2.1 <i>Foetal and embryo development</i>	98
	7.2.2 <i>Definition of sub-domains</i>	98
	7.2.3 <i>Geometrical definition</i>	99
	7.2.4 <i>Modelling scenarios</i>	102
7.3	BEM FOR VERTICALLY INCIDENT FIELD IN OPEN ENVIRONMENTS	102
	7.3.1 <i>Analytical approach for lateral walls and top surface</i>	104
7.4	NUMERICAL IMPLEMENTATION	106
	7.4.1 <i>Conceptual model</i>	106
7.5	RESULTS AND DISCUSSION	108
	7.5.1 <i>Current density along the foetus</i>	111
	7.5.2 <i>Mean and extreme values of current density in the foetus</i>	113
	7.5.3 <i>Dosimetry analysis</i>	114
7.6	SUMMARY	115
CHAPTER 8 CONCLUSIONS		117
8.1	CONCLUDING REMARKS	117
	8.1.1 <i>Pregnant woman</i>	118
BIBLIOGRAPHY		119
APPENDICES		127
	A AUXILIARY PRIMITIVES	127
	B IMPLEMENTATION NOTES	127
LIST OF FIGURES		129
LIST OF TABLES		131

Preface

The objective of this work is to investigate the behaviour of electric fields and induced currents in the human body exposed to different scenarios of extremely low-frequency (ELF), high-voltage, low-current electromagnetic fields by means of numerical modelling with improved boundary element methods (BEM). A variety of three-dimensional anatomically shaped human body models under different exposure conditions were examined.

The background for human exposure to ELF electromagnetic fields departing from Maxwell equations and for the electrical properties of biological tissue are provided. Then, a new improved BEM approach is introduced in order to solve this type of problems. This novel strategy, based on mixing continuous and discontinuous nodes and a new analytical integration scheme for the single and double layer potentials, has helped to speed up the calculations in the preprocessing and assembly schemes with respect to the classical BEM, leading at the same time to more accurate results. In particular, the integration method maintains high accuracy even when the internal observation points approach to the boundary of the domain. The developed methodology is applied to three different case studies: (i) overhead power transmission lines, (ii) power substation rooms and (iii) pregnant woman including foetus and evolving scenarios.

In all the cases, a sensitivity analysis investigating the influence of varying geometrical and electrical properties of the tissues has been conducted.

The results obtained in all cases allow to identify situations of high and low exposure in the different parts of the body and to compare with existing exposure guidelines.

M. Cristina Peratta and Andres Peratta