HUMAN EXPOSURE STUDY FOR SOME SCENARIOS (selected from CEMA'16 Conference)

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Abstract

In this article the main aim of the research is to investigate EM exposure influence on a human homogenous model located in a car and study possible resonant fields. This problem is very topical, because in some cases the excitation source is located in vicinity to the sensitive tissues. We have investigated several cases when a human with a cellphone is located inside a car and also the case when the EM source is the base station antenna. The problems are solved using the Method of Auxiliary Sources (MAS) with a user friendly program package, created for numerical experiments realization for these particular problems. The results of the numerical experiment are presented and analyzed.

1. INTRODUCTION

With the rapid development of new technologies, such as mobile phones and other communication systems, exposure of users to electromagnetic fields (EMF) has enormously increased in recent years. It is important to study their EM influence on human, because excitation source is located very close to the sensitive tissue. Also it is important to obtain some general conclusions about the nature of exposure process, in order to elaborate some safety recommendations and standards. Our goal in this research is to investigate EM influence on human, when it is located inside the car and study the fields' behavior in the near and far zone. There are many factors to consider, like complex body geometry [1], [2], location in an enclosed or semi-enclosed room, wall transparency and users hand position, etc. It is impossible to thoroughly quantitatively consider all these details, but we can estimate most importance of them.

In spite of many works on this issue, the problem is not studied completely. EM absorption by human is measured in terms of specific absorption rate (SAR) [3] and it is measured in watt per kilogram (W/kg) [4]. In the article [5] are investigated several scenarios with Mummy: one is when the Mummy is located inside of a room while talking over the mobile phone. The other is when the Mummy is located inside of the room but the EM source is a base station antenna located outside. For these cases are studied the influence of the room walls transparency on the formation of the near field inside the room and far field pattern. As the numerical experiments shows, in some cases, the room behaves as a resonator and amplifies the radiated field. The field value may be amplified and be dangerous for the user. The Method of Auxiliary Sources is used to solve efficiently all these problems [6].

2. MODELS, METHODS AND RESULTS OF NUMERICAL SIMULATIONS

During the EM Exposure influence investigation, it is forbidden to conduct real experiments on humans. Because of this the main tools of investigation represents the computer modeling based on numerical methods. There are studied two cases: first when EM source is inside the car and second case when EM source is base station antenna located outside, for both cases human is located inside the car. We use a homogenous dielectric human shaped body 'Mummy' with averaged permittivity and losses values (according to muscle, bone and blood), since their inhomogeneity does not affect the final results significantly. The use of such model is needed to implement the Method of Auxiliary Sources for calculations diffraction problems on human model for the big scenarios, when it is located inside the car. It is important to take into account the possible resonant effects in the car, study SAR distributions for the human model and near and far field distribution in case of mobile phone and base station antenna.

Application of the MAS is deduced to the construction of two couples of closed auxiliary surfaces inside and outside of the "Mummy" and also inside and outside of the surrounded semi open surface like the car (figure 1). Along the surfaces of the "Mummy" and so called the car, as it is possible homogeneously, we distribute the N and M numbers of points, correspondingly. On these auxiliary surfaces from both sides are distributed the same numbers combined auxiliary sources with unknown complex coefficients, which have meaning of the criterion weigh. These unknown complex amplitudes of the auxiliary sources must be found by the boundary conditions satisfaction using the collocation method for the scattered field on the human body model - as on the dielectric (the continuity of the electric and magnetic field tangential components). On the semi open surface inside and outside (the tangential component of the electric field must be zero) and on the open parts (windows) of the car (as on the dielectric) – continuity of the fields.

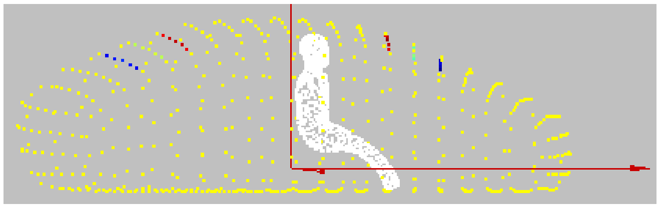
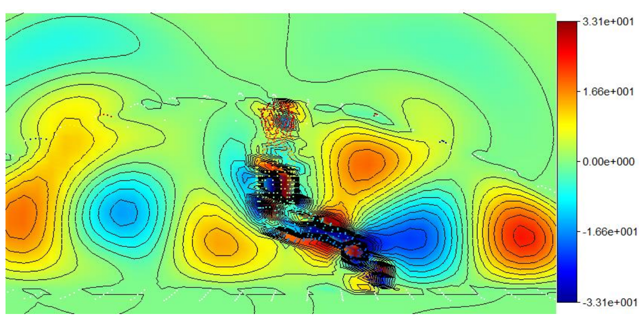


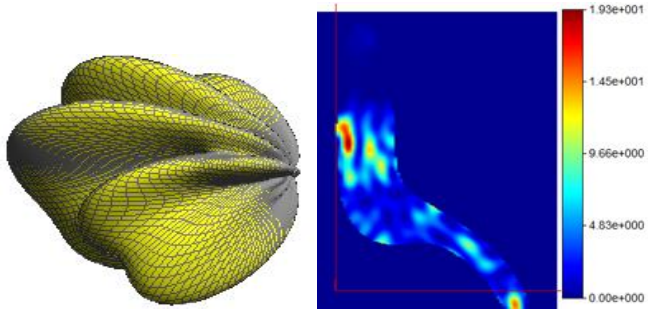
Figure 1. MAS model of cavity with using auxiliary surfaces.

The calculations were conducted at the 300 MHZ and 450 MHZ frequencies. The combined dipole (Huygens source) was used as auxiliary source for the calculations.

In this paper we introduce a new approach to use the MAS methodology. Our final goal is to find the near field distribution inside of the human body as well as inside and outside of the car. We consider human homogenous model like Mummy, with complex permittivity, ε=45+i2, (an averaged value considering blood, muscle and bones). Several scenarios have been studied (when source is mobile phone and base station antenna). The EM field incidence angle is 30^0 which means, that base station antenna is located sufficiently near. Obtained results are presented below. Values of the near field distribution and SAR are provided in the relative units.



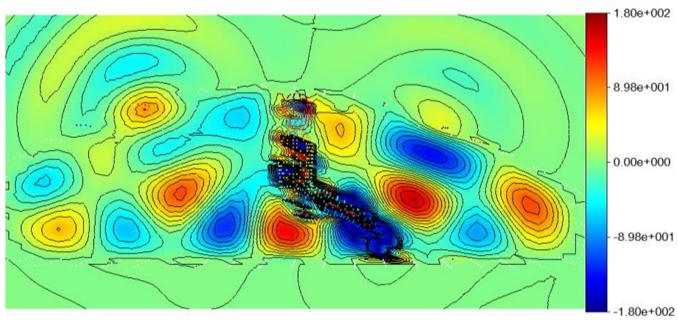
a)



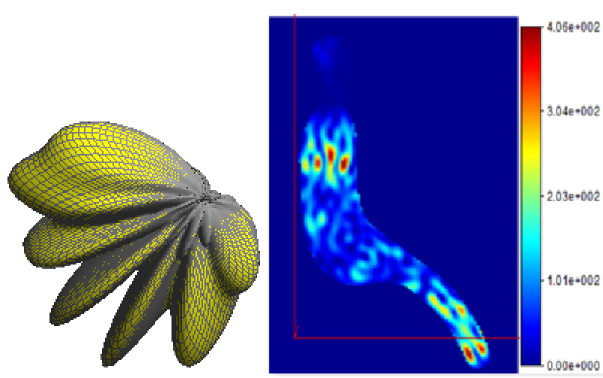
b) c)

Figure 2. Near field distribution in the car (a) and far field pattern (b), SAR distribution inside of human body (c) at 300 MHz (source is inside the car).

In the fig.2 a) and fig.3 a) are presented near field distribution in the car, far field pattern and SAR distribution inside of the head at the 300 MHz and 450 MHz, when source is mobile phone are shown on fig.2 b), fig.3 b) and fig.2 c) and fig.3 c) respectively. As it seen from the obtained results at the 300 MHz inside the car is created high reactive field, which might be dangerous for human.



a)

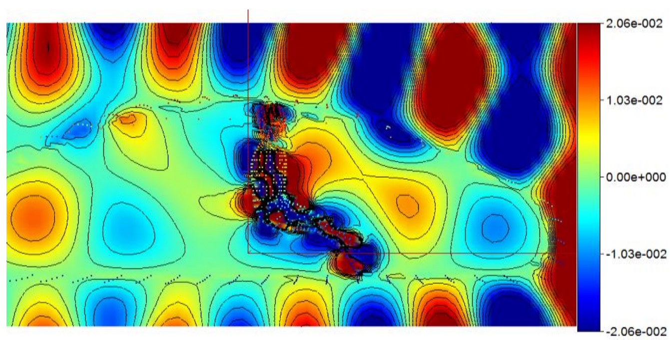


b) c)

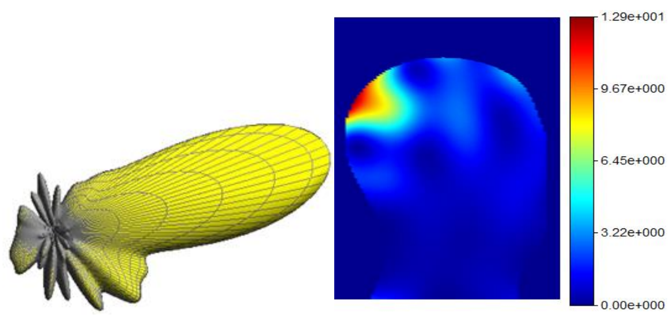
Figure 3. Near field distribution in the car (a) and far field pattern (b), SAR distribution inside of human body (c) at 450 MHz (source is inside the car).

The results show that the resonant field is generated inside the car for both 300 MHz and 450 MHz frequencies, the part of radiated energy is goes through the window and the significant part is absorbed by the human body. At 450 MHz frequency the field value about six times higher than for 300 MHz frequency. As we see from these results at the 450 MHz pick SAR value one order higher than at the 300 MHz frequency.

The near field distribution for the case when the source is the base station antenna is shown of fig.4 a). The far field pattern and SAR distribution inside of human head at the 450 MHz are presented on fig. 4 b) and c) respectively.



a)



b) c)

Figure 4. Near field distribution in the car (a) and far field pattern (b), SAR distribution inside of human head (c) at 300 MHz (source is base station antenna).

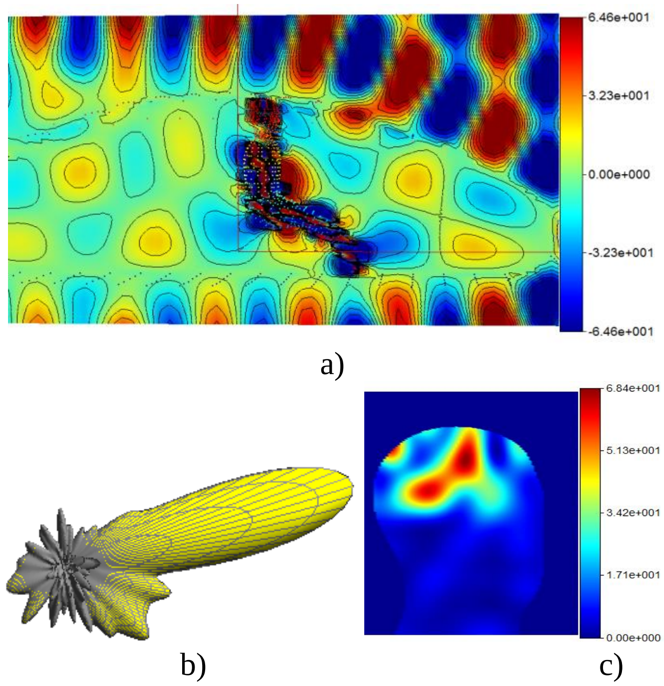


Figure 5. Near field distribution in the car (a) and far field pattern (b), SAR distribution inside of human head (c) at 450 MHz (source is base station antenna).

At the 450 MHz frequency, in case when source is base station antenna, obtained results are presented on the fig.5. The near field distribution for this case is shown on fig.5 a). For far field pattern we got result which is presented on fig.5 b) and SAR distribution inside of human head is shown on fig.5 c).

The EM field reaches inside the car through the window and the most part of this field energy is absorbed by the human body. For both cases the field values are smaller than in case when the EM source is inside the car, because the source is far from the human body. The obtained results show, that in case when EM source is base station antenna, pick SAR value at the 450 MHz is about five times higher than at the 300 MHz frequency. If we compare the obtained results all these considered cases, we see that reactive field and pick SAR values are higher in case when EM source is inside the car.

3. CONCLUSION

In this research we introduce a new approach to use the MAS methodology. There was considering human homogenous model like Mummy. We study far field pattern and near field distribution inside of the human body as well as inside and outside of the car. Also we study SAR distribution inside the homogenous human model head and we see that reactive field and pick SAR values are higher in case when EM source is inside the car, then in case when source is base station antenna.

Based on the obtained results we can make the following safety recommendation: It is not desirable speak on phone for a long time if user is located inside the car. The calculations, conducted with the created program package, showed the presence of resonance and reactive fields in several big scenarios, which could be dangerous for a human. It is important to note, that we study electromagnetic exposure problem for one human model, in some cases the results will not be applicable for other models. Every human is unique and differs in form, dimensions, weight and so more studies may be needed to make a firm conclusion.

ACKNOWLEDGEMENT

This study is supported by Shota Rustaveli National Science Foundation grant: YS15_2.12_56.

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