

WP4.8: 6G.Bioelectromagnetics Interactions

A bioelectromagnetics center for exposure analyses of biological organisms at 6G frequencies

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We are setting up a BioEM center, in which we pool all the knowledge and expertise in the field of BioEM at mm-wave and THz frequencies that has been acquired in our joint THz research projects. The center will be equipped with the state-of-the-art THz measurement set ups.

We are looking at electromagnetic exposure regarding biological material but in particular European honey bees, investigating if the bees have larger relative energy intake than estimated by the anthropocentric ICNIRP limiting values. This is based on a virtual microdosimetry using realistic structural models.

ATE-BioEM Center

1. ATE-BioEM Center

■ The ATE-BioEM Center at the lab for General and Theoretical Electrical Engineering (ATE), Faculty of Engineering, University of Duisburg-Essen, is a research center focused on investigating the interaction of electromagnetic fields with biological organisms in a broad frequency range for different applications.

■ At the moment 5 projects are active within the center, namely **6GEM**, *MicroBioEM*, *QDMBiosensor*, *insighTHz*, and *terahertz.NRW*, each dealing with the interaction of electromagnetic radiation with biological material and organisms. Diverse aspects of such interactions are investigated from determining the exposure limits under given radiation to environmental monitoring of plants and insects as well as developing new concepts for ultra-sensitive biosensors.



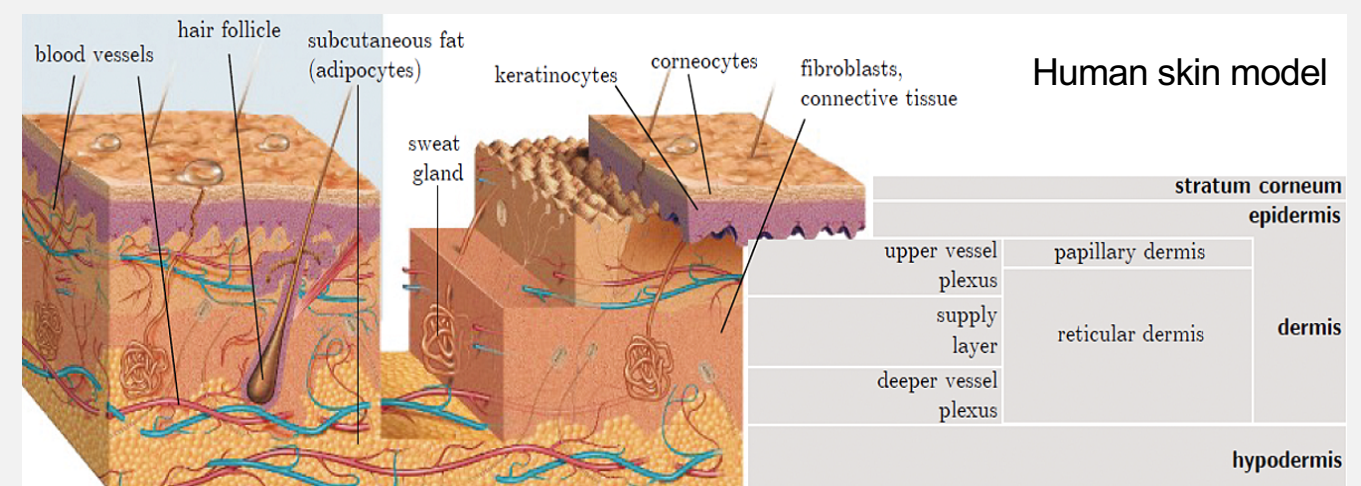
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ATE-BioEM Center



2. ATE-BioEM Center Mission

■ The ATE-BioEM center has been established as research group with the mission of providing better understanding of electromagnetic fields interaction with biological tissue and biological organisms. We are amongst the first research centers to study the interaction of electromagnetic fields specially in 5G, **6G**, and THz ranges with biological organisms other than humans such as insects and plants.



3. Vision of the ATE-BioEM Center

■ The center intends to pool all the knowledge and expertise in the field of BioEM at mm-wave and THz frequencies that has been acquired in **6GEM** and our other joint THz research projects.

■ Additionally, the center intends to foster research activities between biologists, physicians and electrical engineers in terms of establishing new interdisciplinary research fields applicable in e.g. electromagnetic microdosimetry, biosensing, biomedical engineering, behavioral entomology, environmental sensing, and plant monitoring.

Insect microdosimetry

4. European honey bee material characterization

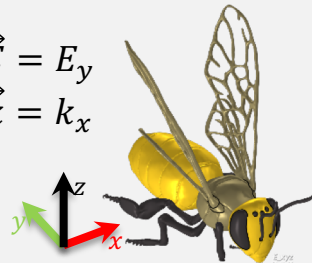
■ Bees are complex creatures consisting of various part and organs, and hence modelling a detailed bee is not computationally tractable. In this regard and at first stage a bee, specifically European honey bee (*Apis mellifera*), is considered as a uniform material with a given frequency-dependent permittivity and conductivity.

■ The data are then fitted to the multi-pole Debye model (keeping the first four terms in the summation) based on the nonlinear least square method.

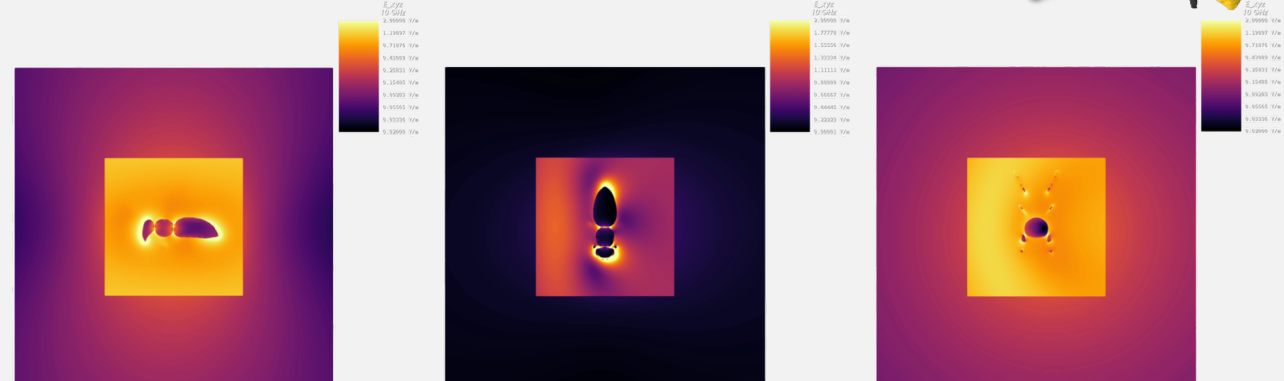
$$\epsilon = \epsilon_{\infty} + \sum_{i=1}^n \frac{\Delta\epsilon_i}{1+j\omega\tau_i} + \frac{\sigma_s}{j\omega\epsilon_0}$$

$$\vec{E} = E_y$$

$$\vec{k} = k_x$$



5. EM microdosimetry



4. Far field pattern



5. Measurements

■ The European honey bees are analyzed first as mixed powder (using effective medium theory), and as whole structure with wings, cuticula layers, which will be characterized using our SWISSto12 material characterization set up.

■ Local SAR and RCS of European honey bees will then be determined, as useful figure of merits for environmental monitoring.

