IWMTS INTERNATIONAL WORKSHOP ON MOBILE THZ SYSTEMS

July 3-5, 2023
Kameha Grand, Bonn, Germany
Please register on www.iwmts.org/registration

PROGRAM

Day 3 – Wednesday, July 5th

Session 5 - Terahertz Systems and Applications (2)
Room: Kameha Spirit
Session Chair: Mohammed El-Absi

09:00 – 09:30 Ultra Wide Band FMCW Transceiver Modules for Milimeter Wave Spectrum Analysis
K. Kother, J. Altholz, I. Rolfes, J. Barowski

09:30 – 10:00 Pulsed Free Space Photonic Vector Network Analyzers for Broadband Operation
F. Rushd Faridi, S. Preu

10:00 – 10:30 Multistatic 250 GHz Imaging Radar With 12x64 Elements
M. Kahl, R. Hussung, A. Keil, F. Friederich, P. Haring Bolívar

Session 6 - Insect and Plant Monitoring
Room: Kameha Green
Session Chairs: Daniel Erni, Fawad Sheikh

09:00 – 10:00 **Tutorial Talk: Numerical Modeling of Interactions of Radiofrequency Fields with Insects**
P. De Boose, E. De Borre, H. Herssens, F. O. Ribas, D. T. Carvajal, **A. Thielens**

10:00 – 10:30 Terahertz-Based Heavy Metal Detection in Plants - A First Approach
L. Kreuzer, F. Brix, P. Düchting, C. Brenner, M. Deumer, R. Kohlhaas, U. Krämer, M. Hofmann

10:30 – 11:00 Coffee Break

Session 5 (continued)

11:00 – 11:30 Phase-Based Breathing Rate Monitoring in Patient Rooms Using 6G Terahertz Technology
S. Häger, A. Najjar, C. Bektas, D. Lessy, M. El-Absi, F. Sheikh, S. Böcker, T. Kaiser, C. Wietfeld

11:30 – 12:00 Acceleration of 2D SAR Imaging on FPGA by Reducing Off-Chip Memory Accesses
E. Aliagha, A. Kamaleldin, A. Batra, T. Nalapat, M. Wiemeler, T. Kaiser, D. Göhringer

12:00 – 12:30 A Look Through Artificial Human Tissues at Ka-Band and D-Band
A. Prokscha, F. Sheikh, M. Jalali, Y. Zantah, B. Sievert, M. Al-Hasan, D. Erni, T. Kaiser

12:30 – 13:00 Experimental Analysis of VNA-based Measurement Errors in Mobile THz Applications
Y. Zantah, A. Batra, A. Prokscha, F. Sheikh, M. Haidar, A. A. Abbas, N. Zarifeh and T. Kaiser

Session 6 (continued)

11:00 – 11:20 Experimental RCS Determination and Imaging of Honey Bees with THz Time-Domain Spectroscopy
T. Kubiczek, J. Balzer

11:20 – 11:30 Tracking of Honey Bees Inside the Hive Using THz Harmonic Radar
K. Kolpatzeck, J. Balzer

11:30 – 11:50 THz Interaction with Western Honey Bees
M. Jalali, J. T. Svejda, D. Erni

11:50 – 12:10 Miniaturized THz Chips For Water Content Monitoring
P. Alibeigloo, C. Preuss, E. Mutlu, R. Kress, S. Clochiatti, N. Weimann

12:10 – 12:30 Plant Stem Imaging by Combining RCS-Measurements and Semi-Analytical T-Matrix Based Field Calculation
B. Sievert, M. Degen, F. Brix, U. Krämer, D. Erni, A. Rennings

Save the Date: 7th Annual IWMTS, July 2nd – July 4th 2024

THz interaction with western honey bees

Mandana Jalali, Jan Taro Svejda, Daniel Erni
General and Theoretical Electrical Engineering (ATE),
Faculty of Engineering, and CENIDE – Center for Nanointegration Duisburg-Essen,
University of Duisburg-Essen, D-47048 Duisburg, Germany

https://www.uni-due.de/ate-bioemcenter

Introduction

Motivation

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- Insects are vital entities of our ecosystem, whose populations are dramatically diminished due to excessive and uncontrolled use of pesticides and chemicals as well as the decline of available habitats.
- In this regard, **bees** due to their vital ecological role as pollinates are particularly important, specially since their number of colonies dropped by the turn of millennium.
- Accordingly real time monitoring of bees is key, in particular of European honey bees as invaluable pollinators

Introduction

Motivation

ATE-BioEM Center

- Emission problem, do bees/insects have larger relative energy intake than estimated by the anthropocentric ICNIRP limiting values?
- Using radar imaging to track kinetics of social behavior of insects in their habitats and in the environment in order to detect stress (insect as environmental monitor) or for observation according to research questions posed mainly by our collaborating entomologists.
- What is the electric field penetration depth within bees/insects?

Introduction

Objective

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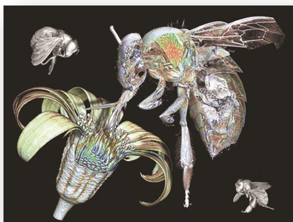
- Investigating the interaction of electromagnetic radiation with European honey bees at frequencies in the range of 1–500 GHz.
- The first goal of the study aims at multiscale electromagnetic virtual dosimetry of bees, using particularly tailored digital twins.



A-T. Javier, et al. J. Microsc., 2019.

Modelling

Building the geometry

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The bee model is acquired as an shell mesh with .STL format	The file is imported within the COMSOL as a mesh file and fixed so an volumetric mesh file can be created	The volumetric mesh is then converted into a solid geometry and then fixed
		

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Modelling

Material characterization

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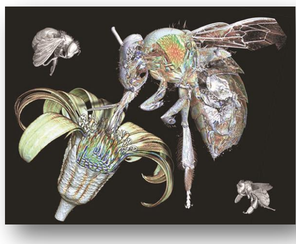
- Bees are complex creatures consisting of various part and organs, and hence modelling a detailed bee is not computationally tractable.
- In this regard and at first stage a bee, specifically European honey bee (Apis mellifera), is considered as a uniform material with a given frequency-dependent permittivity and conductivity.
- However, the available data on permittivity and conductivity of honey bees is few and only in low frequency bands.

	0.6GHz	1.2GHz	2GHz	3GHz	6GHz	12GHz	24GHz	60GHz	120GHz
ε_r	45.6	44.2	39.9	38.8	38.0	28.6	14.9	7.018	5.46
$\sigma\left({}^{S}/_{m}\right)$	0.688	0.924	1.35	2.05	5.05	12.0	21.1	27.9	29.2

A. Thielens, et al. Sci. Rep., 2020.



A-T. Javier, et al. J. Microsc., 2019.

Modelling

Material characterization

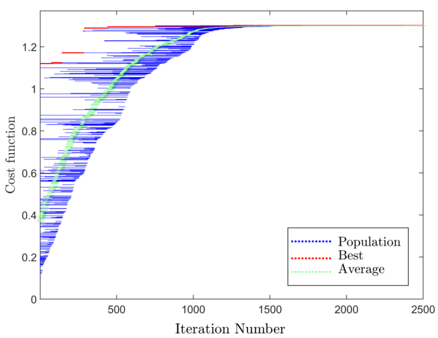
- The data are then fitted to the multi-pole Debye model, keeping the first four terms in the summation based on the nonlinear least square method.

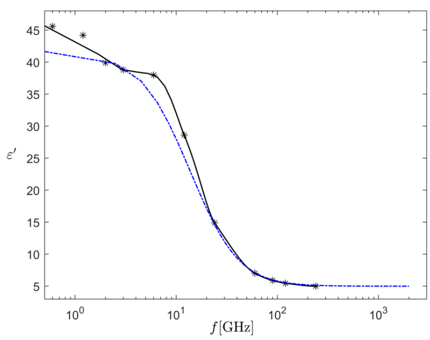
$$\varepsilon = \varepsilon_\infty + \sum_{i=1}^{n} \frac{\Delta\varepsilon_i}{1+j\omega\tau_i} + \frac{\sigma_s}{j\omega\varepsilon_0}$$

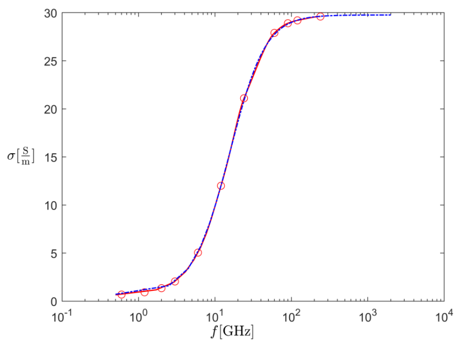
- As the fitting requires simultaneous fitting of 10 parameters, the fitting is optimized based on the genetic algorithm, using the sum of the squared difference between the measured data and the multi-pole Debye model.

Modelling

Optimized permittivity and conductivity







ε_∞	$\Delta\varepsilon_1$	$\Delta\varepsilon_2$	$\Delta\varepsilon_3$	$\Delta\varepsilon_4$
5.0	19.0	17.7	8.6	8.6
τ_1(ps)	τ_2(ps)	τ_3(ps)	τ_4(ps)	σ_s (S/m)
84.2	1854	16.8	16.8	0.6

Modelling

Simulation

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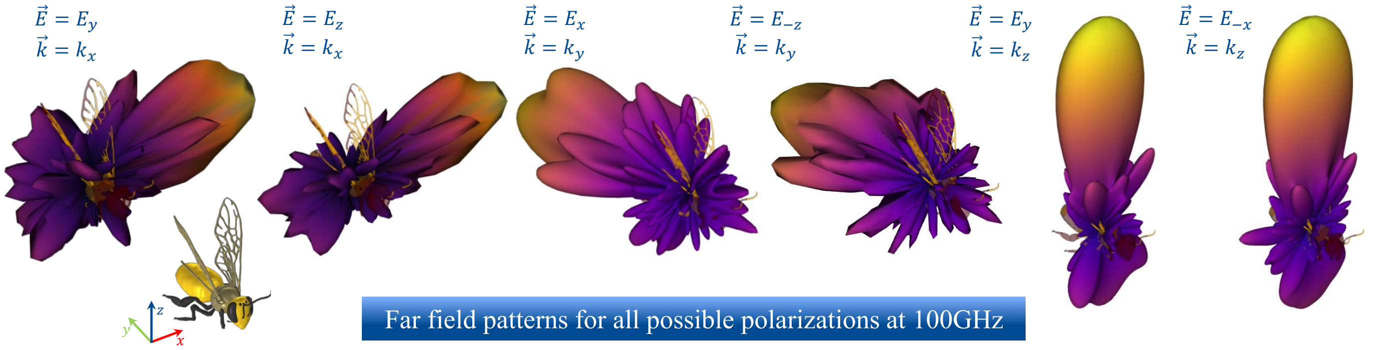
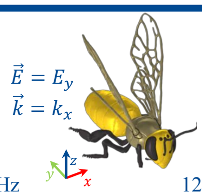
- The geometry is imported within the EMPIRE XPU, which is a FDTD based software, and the optimized Debye model is introduced as the material properties for the bee. The electric field, radar cross section (RCS), and far field of the bee is determined under plane wave illumination from 1GHz-500GHz.



Far field patterns for all possible polarizations at 100GHz

Results

Far field pattern evolution



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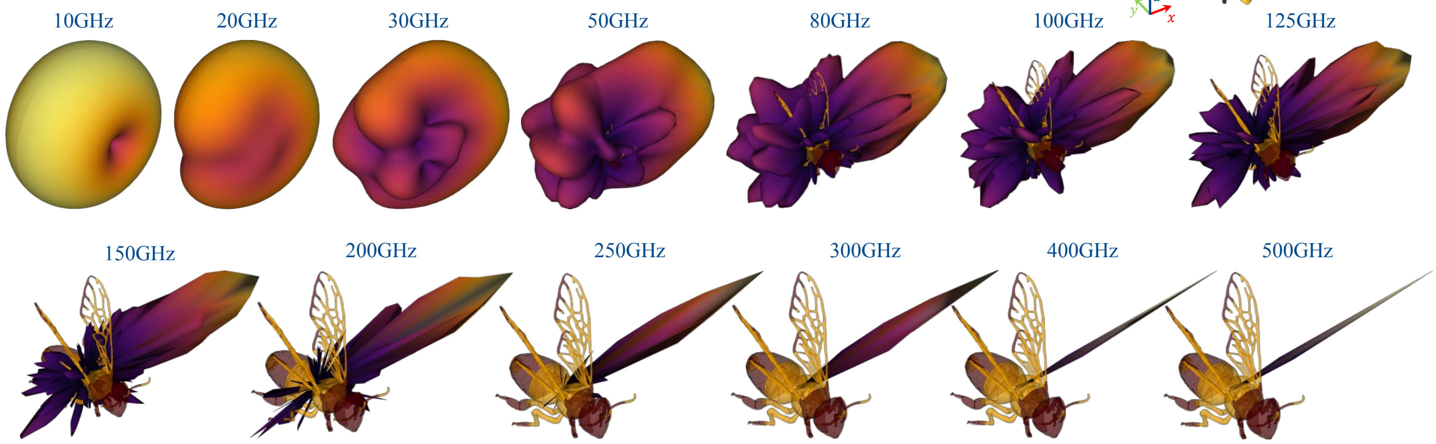

Results

Electric field distribution

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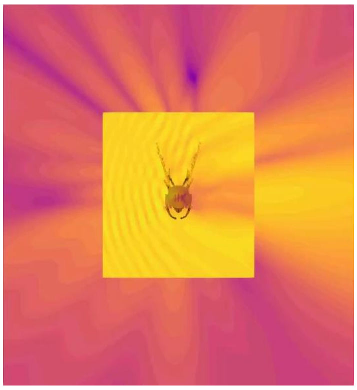
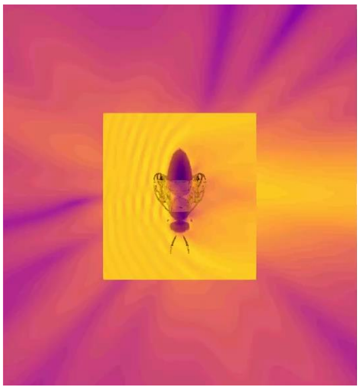
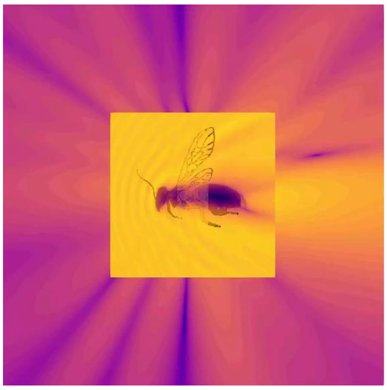


$\vec{E} = E_y$
$\vec{k} = k_x$



$\vec{E} = E_z$
$\vec{k} = k_x$



$\vec{E} = E_x$
$\vec{k} = k_y$

Material characterization

A heterogenous bee model

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- Considering an insect as a homogenous material leads to a loss of valuable information, including the following aspects:
  - **Wings**: The wings of insects are transparent, suggesting that they should exhibit lower permittivity compared to other parts.
  - **Exoskeleton**: The outer shell of the bee, known as the exo-skeleton or Cuticula, is harder, implying that it should have a higher permittivity or may possibly provide a shielding effect.
- Dead honey bees are dissected in various parts namely, wings, exoskeleton, and the inner parts.

Material characterization

A heterogenous bee model

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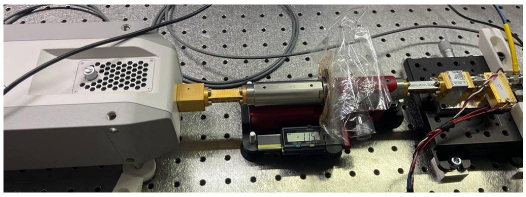
- Using the SWISSto12 material characterization kits (MCK) for the two dedicated frequency ranges (i.e. 25-40 GHz and 110-170 GHz) the material properties of each section are measured – partly for the first time!
- Since, it's seen that the material characteristics namely permittivity and loss tangent determined by the SWISSto 12 software are not accurate enough, specially the calculated loss tangent, only the measured s-parameters are saved.

SWISSto 12 – WR-28+ (25-40GHz)

SWISSto 12 – WR-6.5 (110-170GHz)



Material characterization

A heterogenous bee model

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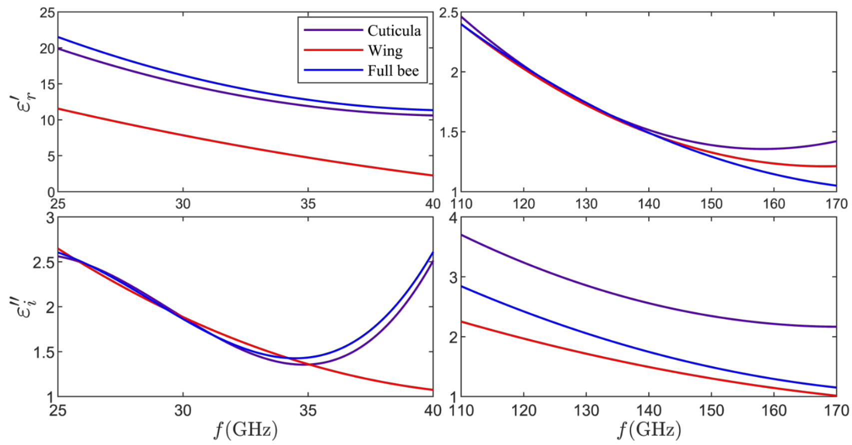
- The saved s-parameters are normalized and time gated.
- Based on such normalized and time gated s-parameters, the complex permittivity of each dissect in each frequency range is calculated based on three methods of Nicholson-Ross-Weir Conversion (NRW-Method), the National Institute of Standards and Technology (NIST) iterative method, and Baker-Jarvis method.
- NIST iterative method proved to be the most robust technique in our case and hence is the method chosen for determining the complex permittivity.

Material characterization

A heterogenous bee model



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Material characterization

Fitting to a given material characterization model

- A 5-pole Debye model is considered, meaning that 12 parameters have to be fitted.
- An evolutionary genetic algorithm optimization method is chosen as the optimization method.
- The cost function is defined as:

$$C = \sum_{n=1}^{f_{num}} \frac{1}{f_{num}} \left(\frac{|\varepsilon'_{mes} - \varepsilon'_{deb}|^2}{{\varepsilon'_{mes}}^2} - \frac{|\varepsilon''_{mes} - \varepsilon''_{deb}|^2}{{\varepsilon''_{mes}}^2} \right)$$

- In which the f_{num} is the number of frequency points, the ε'_{mes} is the measured real part of the permittivity, the ε'_{deb} is the real part of the fitted 5-pole Debye permittivity, the ε''_{mes} is the measured imaginary part of the permittivity, the ε''_{deb} is the imaginary part of the fitted 5-pole Debye permittivity.

Material characterization

Full bee

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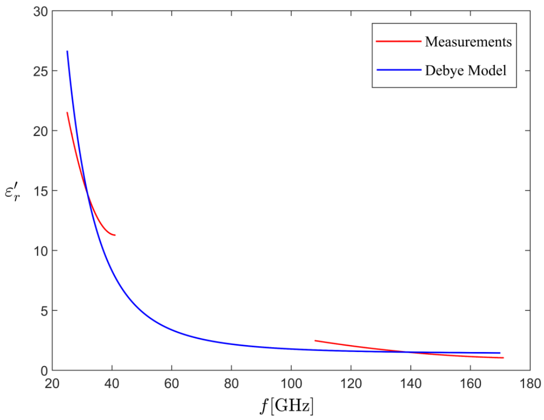

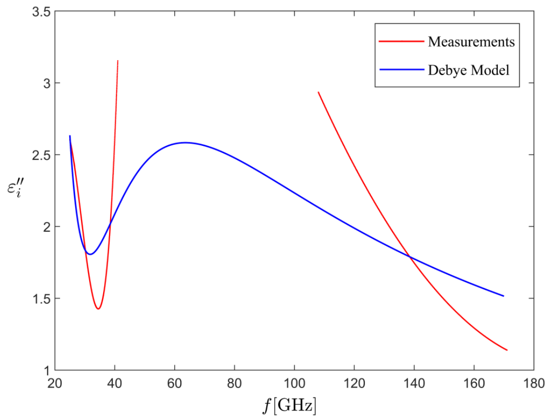

Material characterization

Cuticulla

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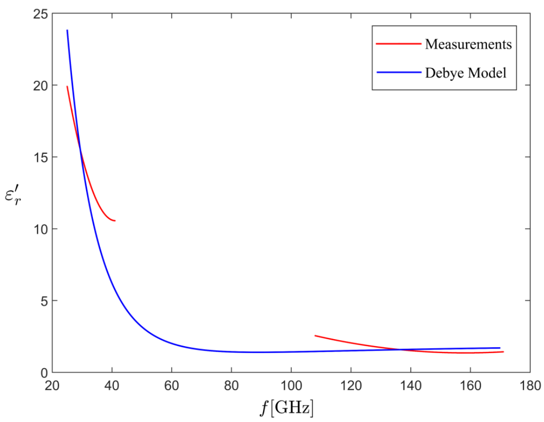

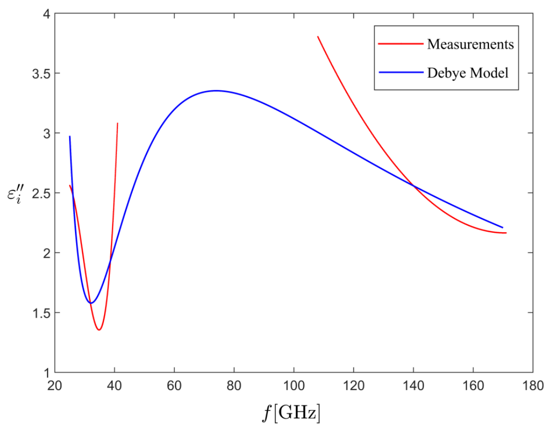

Material characterization

Wing

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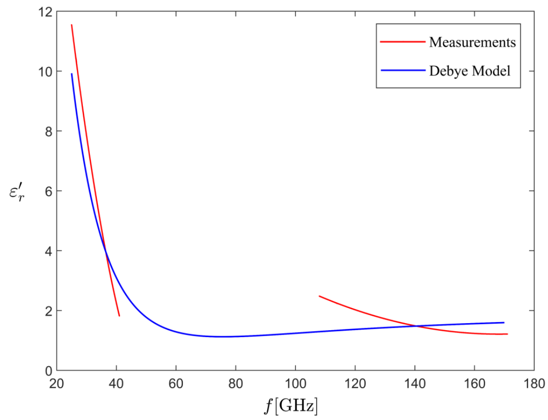

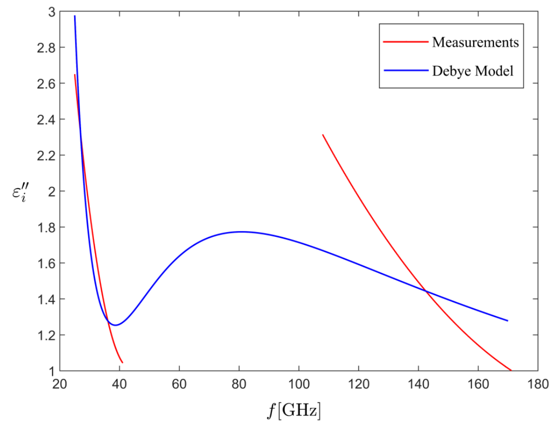

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Thanks for your attentions

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6GEM terahertz.NRW FSM - Forschungsstiftung Strom und Mobilkommunikation FSM – Swiss Research Foundation for Electricity and Mobile Communication Marie SFB/TRR 196 DFG Deutsche Forschungsgemeinschaft

IWMTS INTERNATIONAL WORKSHOP ON MOBILE THZ SYSTEMS

Sixth International Workshop on Mobile Terahertz Systems (IWMTS), 3 - 5 July 2023, 5* Kameha Grand Hotel Bonn, Germany

The 2023 Sixth International Workshop on Mobile Terahertz Systems (IWMTS) will be held at 5* Kameha Grand Hotel, Bonn, Germany, on 3 - 5 July 2023.

IWMTS sets itself apart from well-known THz conferences by focusing on "Mobile THz Technology and corresponding THz Systems" since the organizing committee believes that "Mobility" will ultimately push THz solutions to mass markets. Of course, progress reports on traditional technological advances for THz components and theoretical studies on THz wave propagation as well as related topics are also highly welcome.

The topics of the workshop include, but are not limited to, the following areas focusing on THz frequencies (>100 GHz) and mobility:

- Devices and systems
- Antennas and propagation
- Measurements, simulations and modeling
- Electronic and photonic transceivers
- Prototypes and testbeds
- Material characterization
- Spectroscopy
- Signal processing
- Communications (in particular 6G)
- Localization
- Identification
- Imaging and remote sensing
- Beamforming and -management
- Data and sensor fusion
- Applications

Confirmed Keynote Speakers

- Emma MacPherson, "Advances in THz *in vivo* imaging of skin"
- Daniel Mittleman, "Conformal Antennas for THz wireless Links"
- Ullrich Pfeiffer, "THz Light-Field Imaging"

Apply for the IWMTS "TalentTravel" Program

Travel grants are available in the "TalentTravel" Program. For more information please visit www.iwmts.org.
Application deadline: March 31, 2023

Special Issue in IEEE Transactions on Microwave Theory and Techniques

Authors of all papers presented at IWMTS 2023 are invited to submit an extended version of their papers to a Mini-Special Issue of IEEE Transactions on Microwave Theory and Techniques. Every paper will be reviewed in the same manner as all other regular submissions. Further information can be found on www.iwmts.org

Join the Panel Session:
Is "Miniaturization" the Destiny of THz?

Important Dates

Full Paper Submission Deadline:
February 28, 2023

Proposals for Special Sessions:
February 28, 2023

Acceptance Notification:
April 24, 2023

Camera-ready Submission:
May 15, 2023

IWMTS Organizing Committee

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Papers are invited to be uploaded on the EDAS system: https://edas.info/newPaper.php?c=30226. The manuscript should follow the IEEE two column format with single spaced, 10 pt font in the text. MS or LaTex templates can be downloaded from https://www.ieee.org/conferences/publishing/templates.html. The manuscript length should be three to five pages, including all figures, tables, references, and so on. All papers which meet IEEE quality standards and presented by one of the authors will be submitted to IEEE Xplore for indexing. More details about the workshop can be found on www.iwmts.org.