Electromagnetic Simulations for Microwave Radiometer Systems

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Hamburg, 6th February 2015
1 Microwave Physics at the University of Bern

2 Research of the THz-Optics Group

3 What’s next?
University of Bern
University of Bern

- Mathematical Institute
- Space Research & Planetary Sciences
- **Institute of Applied Physics**
  - Biomedical Photonics
  - Laser Physics
  - **Microwave Physics**
- ...
Institute of Applied Physics

Goals:

• Techniques and instruments for atmospheric remote sensing
• Understanding of physical processes in the atmosphere
• Contribution to the research field of climate change
Atmospheric Processes - Klemens Hocke

- Observations and simulations of atmospheric processes
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- Analyses of ozone and water vapor in the middle atmosphere
- Development of millimeter and sub-millimeter wave radiometer systems
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THz Optics - Axel Murk
- Development, simulation, measurement, and application of quasi-optical components
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MIAWARA-C – Stratospheric H$_2$O Measurements at 22 GHz
Institute of Applied Physics - Microwave Group

GROMOS-C – $O_3$ Measurements at 110 GHz
1. Microwave Physics at the University of Bern

2. Research of the THz-Optics Group

3. What’s next?
THz-Optics group: optics, antennas, calibration loads, vacuum windows, receiver testing...

radio telescope

temperature $T_A$
THz-Optics group: optics, antennas, calibration loads, vacuum windows, receiver testing 

incoming field 

mirror 

calibration target

antenna 

receiver 

spectrometer
THz-Optics group: optics, antennas, calibration loads, vacuum windows, receiver testing...
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Numerical Approaches used in THz-Optics

- **Antenna Design**
  - Mode-Matching, MoM, BOR-MoM (CHAMP)
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  - BOR-MoM (GRASP), FEM (HFSS), Ray-Tracing
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- **Vacuum Windows**
  - FEM (HFSS), Analytical
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- **Calibration Loads**
  - BOR-MoM (GRASP), FEM (HFSS), Ray-Tracing
- **Vacuum Windows**
  - FEM (HFSS), Analytical
- **RCS of Aircraft**
  - MoM, PO (HFSS), MoM (CONCEPT-II for validation)
Vacuum Windows

\[ \varepsilon_r \]

(a) No Coating

![Graph showing the reflection in decibels against frequency in gigahertz for vacuum windows. The graph indicates the reflection levels for different frequencies, with a clear dip at specific frequencies.]
Vacuum Windows

(a) No Coating
(b) Simple Coating

Reflection [dB]

Frequency [GHz]
Vacuum Windows

(a) (b) (c)

100 120 140 160 180 200

-60 -50 -40 -30 -20 -10 0

Frequency [GHz]
Reflection [dB]

(a) No Coating
(b) Simple Coating
(c) Linear Coating
1. Microwave Physics at the University of Bern
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3. What’s next?
What’s next? Jupiter Icy Moon Explorer (JUICE)

- ESA L-class mission to the Jupiter system
- Selected 5/2012, launch 2022, Jupiter orbit 2030–2033
What’s next? Jupiter Icy Moon Explorer (JUICE)

Submilimeter Wave (SWI) instrument

- Passive radiometer with two 530 GHz - 630 GHz receivers (optional 600 GHz and 1.2 THz receiver)
- Mapping of temperatures, winds, chemical species (H2O, CH4, CO, ...) in Jupiter’s stratosphere
- Surface properties and atmospheres of the satellites

(source: Grasset et al. JUpiter ICy moons Explorer (JUICE): An ESA mission to orbit Ganymede and to characterise the Jupiter system)
What’s next? Jupiter Icy Moon Explorer (JUICE)
What’s next? Design of calibration targets

The calibration accuracy is limited by:

- Temperature gradients
- Spillover and total scattering (emissivity < 1)
- Coherent reflectivity S11 (standing waves)
What’s next? Design of calibration targets
Thank you for your attention!
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