Department of Electromagnetic Field

Space Research

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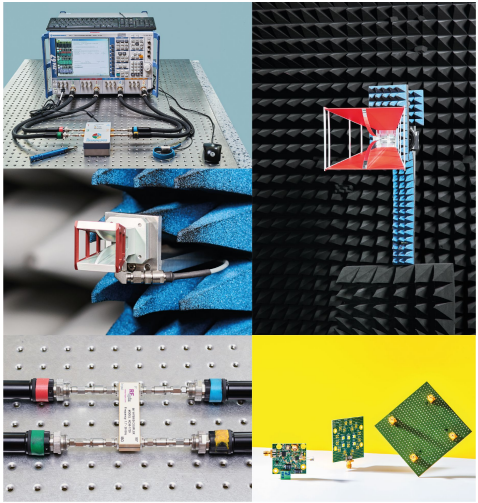
June 23-24
Colloquium

Outline



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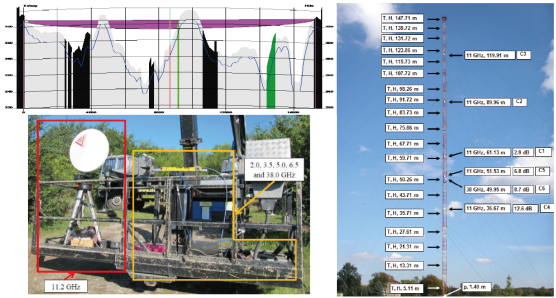
Radiowave Propagation

Modeling for Interference and Frequency Coordination Analysis[1]

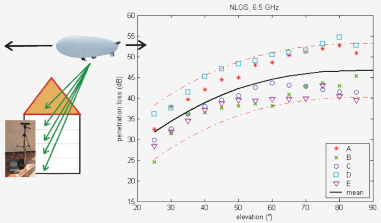
- Short- and long-term experiments,
- modeling/simulations,
- international collaboration (ESA, Joanneum Research, Univ. Of Vigo),
- participation in ITU-R SG3 work towards relevant recommendations.



[1]Propagation Models for Interference and Frequency Coordination Analysis (ESA Artes Contract No. 4000105298/12/NL/CLP, 2012–14).
Reference Procedure for Adoption of Software Tools and Digital Products as ITU-R Recommendations (ESA Artes Contract No. 4000115277/16/UK/AD, 2017–20).
Development and Verification of Earth-Space Statistical Clutter Loss Model (ESA Contract No. 4000133665/20/NL/AS, 2021–22).

Building Penetration Measurement and Modelling for Satellite Communications[2]

- Empirical models providing the penetration loss as a function of elevation angle, frequency, LOS/NLOS case.



[2]Building Penetration Measurement and Modelling for Satellite Communications at L, S and C-Band (ESA PECS project No. 98069, 2099–10).
Kvicera, M., Pechac, P., Building Penetration Loss for Satellite Services at L-, S- And C-Band: Measurement and Modeling, IEEE Trans. Antennas Propag., vol. 59, no. 8, pp. 3013—3021, 2011.

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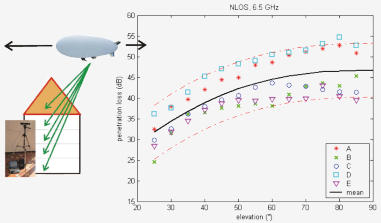
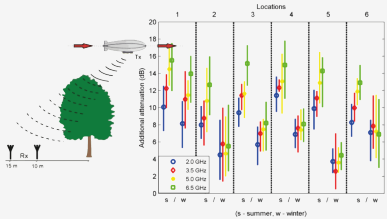


Propag. Modeling of Shadowing by Vegetation for Mobile Satcom & Satnav Systems[3]

- Empirical models for high elevation angle links with a nomadic ground terminal shadowed by vegetation (L-/S-/C-bands).



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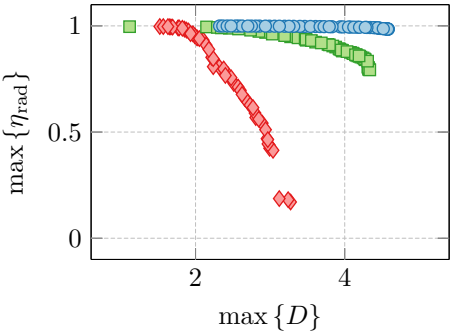
[3]Horak, P., Pechac, P.: Excess Loss for High Elevation Angle Links Shadowed by a Single Tree: Measurements and Modeling, IEEE Trans. Antennas Propag., vol. 60, no. 7, pp. 3541–3545, 2021.

Optimal Performance of Electromagnetic Devices

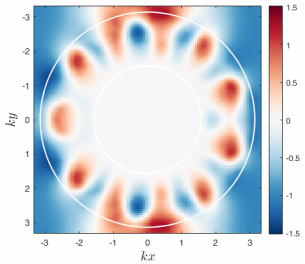
*What are **the fundamental bounds** on performance in various EM metrics and what is **their feasibility** with realizable designs?*[4]

- Radars, antennas, sensors, lenses, etc. can be significantly improved by investigating the bounds on the performance.
- New paradigm: Investigation of fundamental bounds & approaching the bounds with the inverse design.



[4]See GACR Junior Star project 21-19025M "Optimal Electromagnetic Design Based on Exact Reanalysis".

EM Devices Operating Close to Optimum...



Optimal cloaking for sensors[5]

[5] Jelinek, L., Gustafsson, M., Capek, M., Schab, K.: Fundamental Bounds on the Performance of Monochromatic Passive Cloaks, vol. 29, no. 15, Optics Express, pp. 24068–24082, 2021.

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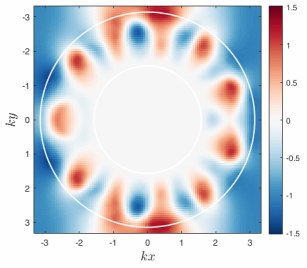

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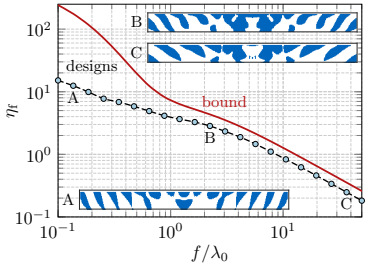

Optimal lenses for detectors

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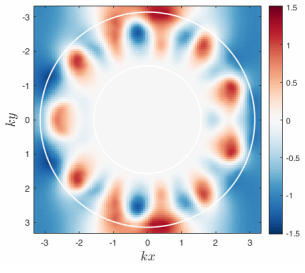

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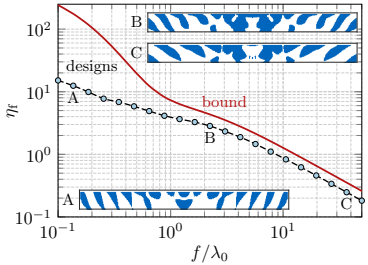

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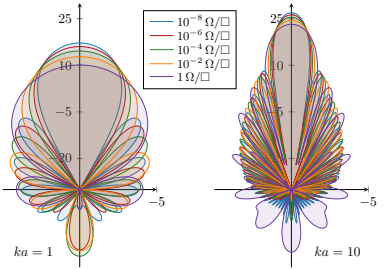


Maximal antenna gain for arrays[6]

[5] Jelinek, L., Gustafsson, M., Capek, M., Schab, K.: Fundamental Bounds on the Performance of Monochromatic Passive Cloaks, vol. 29, no. 15, Optics Express, pp. 24068–24082, 2021.

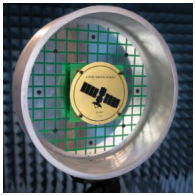
[6] Gustafsson, M., Capek, M.: Maximum Gain, Effective Area, and Directivity, IEEE Transactions on Antennas and Propagation, vol. 67, no. 8, pp. 5282–5293, Aug. 2019.

Antennas for Space Applications

Years of knowledge in designing space antennas[7]:

- design of reflector feeds for multiple bands,
- microwave waveguide structures,
- modeling of electrically small (feed) and very large (feed & reflector) structures,
- synthesis and analysis of antenna arrays.

Low-noise LHC/RHC feeds, 10 GHz.



LHC/RHC metas. ant., gain 15 dBi.

Shared-Aperture 24-28 GHz array.

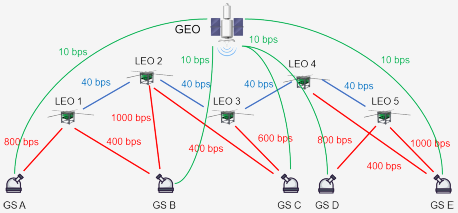
20 dBi, Ka band, orthom. transduc.

[7] Hazdra, P., Kracek, J., *et al.*: Shared-Aperture 24-28 GHz Waveguide Antenna Array, Electronics, vol. 10, no. 23, p. 2976, 2021.
Galuscak, R., Crauwels, W., *et al.*: Deep Reflector Prime Focus Feed for Space Communication, IET J. of Engineering, pp. 496-499, 2021.
Galuscak, R., Mazanek, M., Hazdra, P., Kabourek, V.: A Dual-Band Reflector Feed in Coaxial Configuration for Satellite Communication, IEEE Antennas and Propag. Mag., vol. 60, no. 5, pp. 89–94, 2018.

Optics

Resource Management in a Network of Ground-To-Sat and Sat-To-Sat FSO links[8]

- Used to distribute secret keys in a global scale.



[8]Participation in European Network on Future Generation Optical Wireless Communication Technologies, COST CA19111 project (2020-2024).

[9]CESNET project, cooperation with DLR.

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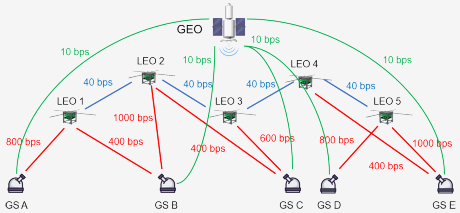
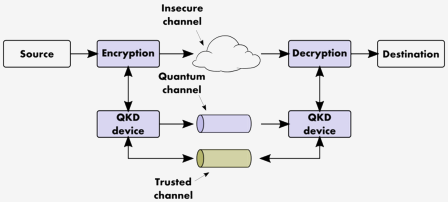


Quantum Key Distribution Using Polarization Entanglement[9]

- Experiments of QKD based on polarization entangled photons for free space optics.



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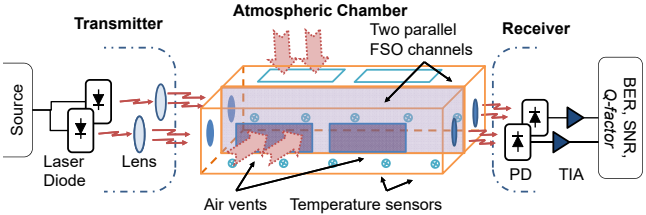
Optics: Route Diversity Measurement Campaign[10]



[10] Perez, J., Zvanovec, S., Ghassemlooy, Z., Popoola, W. O.: Experimental Characterization and Mitigation of Turbulence Induced Signal Fades Within an Ad-Hoc FSO Network, Optics Express, vol. 22, no. 3, pp. 3208–3218, 2014.
Libich, J., Perez, J., *et al.*: Combined Effect of Turbulence and Urban Aerosol on Free Space Optical Links, Applied Optics, vol. 56, issue 2, pp. 336–341, 2017.

Antenna Laboratory

Anechoic chamber:

- special equipment for antenna measurements and EMC radiated emissions testing,
- from 200 MHz to 110 GHz, test ranges 1 m to 4.5 m.

Open area test site

- Outdoor test range (60 m) on the roof for far-field measurement of large antennas.

Key equipment:

- Far-field antenna measurement system NSI 800F-30,
- vector network analyzer Rohde & Schwarz ZVA40,
- test receiver Rohde & Schwarz ESRP,
- Anritsu Sitemaster S400A and S820,
- broadband/narrowband antennas (from 200 MHz to 110 GHz).

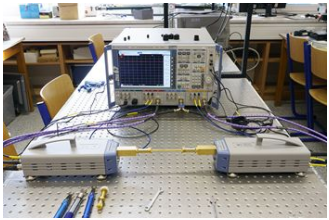
Laboratory of Millimeter-waves

Microwave techniques such as

- scalar and vector measurements of passive and active microwave circuits,
- scalar measurement from 3 Hz to 40 GHz,
- power measurement from 9 kHz to 50 GHz,
- vector measurement from 300 kHz to 110 GHz.

Key equipment

- Vector network analyzers Rohde & Schwarz ZVA67, Agilent PNA E8364A, HP 8970A, Agilent E4440A, and Maury Microwave Automated Tuner MT983A01,
- millimetre-Wave converters Rohde & Schwarz ZVA-Z110,
- spectrum analyzers, power meters, ...



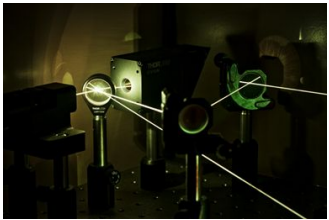
Laboratory of Free-Space and Fiber Optics

Measurement of

- free-space optics, atmospheric effects, turbulence analysis,
- visible light and optical camera communication using LED,
- microwave photonics and radio over fiber systems,
- specialty optical and hollow-core fibers, interferometry.

Key equipment

- Supercontinuum source NKT EXR-15, 400-2400 nm, 6 W,
- fusion station Fujikura LZM-100,
- optical spectral analyzers, FTIR spectrometer 2000-6000 nm,
- oscilloscopes, photodetectors, modulators, amplifiers.



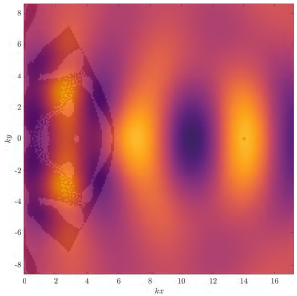
Software Equipment and Simulation Capabilities

Powerful commercial packages:

Dassault CST Studio Suite (FEM, FDTD, MoM)	AWR (MoM, Spice, Harmonic balance)	Optiwave Optisystem (FDTD, BPM, Spice)	Comsol Multiphysics (FEM, MoM)	Altair FEKO (MoM, FEM, ACA, MLFMA)	RSoft BeamProp (BPM)

Unique in-house codes:

- Antenna Toolbox for MATLAB (antennatoolbox.com).
- Topology optimization routines (adjoint, binary, heuristic).



Space-related expertise we offer

- competences in electromagnetism, numerical methods, antennas, RF propagation, optics,
- laboratory facilities for antenna and high frequency measurements up to 110 GHz,
- laboratory facilities for fiber and free-space optics,
- powerful software tools and knowledge of their usage.

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Propagation

Pavel Pechač
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Computational EM

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Questions?

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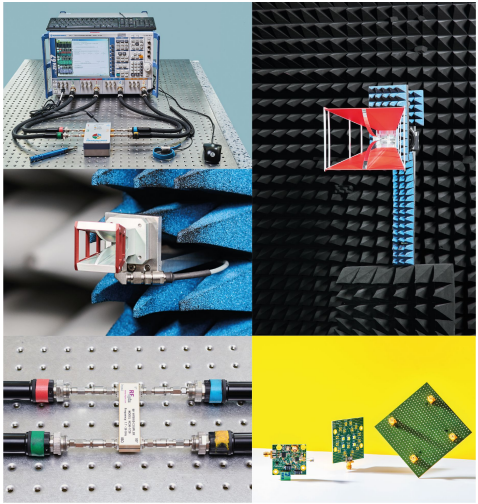

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