SEARCH FOR COMPLEX ORGANIC MATTER AND SOUNDING OF EUROPA’ SURFACE AND NEAR-SURFACE ATMOSPHERE BY MEANS OF FAR IR & TERAHERTZ SPECTROSCOPY

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**background:**

THz spectroscopy is a quickly developing area related to detection of organic matter. This spectral range corresponds to vibration modes of large molecules and intermolecular bonds in solids and liquids.

![THz spectra of a sucrose crystal](image1)

THz spectra of a sucrose crystal for different angles between its $b$-axis and THz polarization. From R. Rungsawang, Y. Ueno, I. Tomita, and K. Ajito, *Opt. Express*, **2006**, *14*, 5765., Fig. 2.

![THz spectra of polypeptide powder of glycine](image2)

Sustaining demand on commercial security equipment focused on complex organic species, along with biotech industry, drives dramatic boost in terahertz area for last 5 years

Cheap and reliable sources and detectors to be brought to the market within few years

proposer’s team has 20+year heritage of space instrument building
A far-IR & THz channel is proposed for TDLAS instrument
Goals: search for organic matter of biogenic origin, comprehensive analysis of abiogenic organics (tholin-like polymers, PAHs etc), measurement of water spin-isomers.

Method:
(i) gas phase spectroscopy
(ii) ice sample transmission spectroscopy
(iii) reflection spectroscopy on selective adsorption filter

Sensitivity – ppm level in raw ice sample
Wavelengths:
(i) 7-12 μm - search for simple organic volatiles (gas phase transmission)
(ii) 15-25 μm - search for condensed organics in filter (solid-state reflection)
(iii) 70-90 μm - search for condensed organics in ice; trapper ions; ice inner structure (solid-state transmission)
               - spin-isomer analysis of evaporated water ice (gas phase transmission)
Far-IR & THz passive sounding from Europa orbiter:

**Goals:**
(i) Surface and subsurface thermal structure  
(ii) Ice and regolith microphysical structure  
(iii) Search for traces of PAH, tholin and other organic matter on the surface

**Method** – homodyne detection with He-cooled 80 nm-size antenna

**Sensitivity** – relative absorption at $10^{-8}$ level
Spectral properties of Europa’s regolith in THz range

- Discrete Dipole Approximation for near-field interactions
- Non-coherent radiative transfer for far-field
- Mixture of water ice and organics
- Fractal aggregates with variable monomer size
Porous ice

Monomer radius:
- Black – 1 μm
- Red – 7.5 μm
- Green – 60 μm
- Blue – 475 μm

Volume extinction

Relative absorption
Surface thermal emission

Ice, $T = 100$ K, $\nabla T = 0.2$ K/cm

Monomer radius:

- Black – 1 $\mu$m
- Red – 7.5 $\mu$m
- Green – 60 $\mu$m
- Blue – 475 $\mu$m
Naphthalene: a simple PAH

Relative absorption

Monomer radius:
- **Black** – 1 μm
- **Red** – 7.5 μm
- **Green** – 60 μm
- **Blue** – 475 μm
Conclusions

• Far-IR and terahertz spectroscopy is an encouraging method for exploring Europa
• The only remote method that allows to discriminate between common extraterrestrial organic matter from potential life markers
• Experimental techniques allow for both remote and \textit{in vitro} analyses
• Quickly developing and demanded area of technology – hope for cheap and reliable solutions