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

A.V.Rodin[1,2], G.N. Goltsman[3], N.A.Evdokimova[1], M.V.Gerasimov[1], I.I.Vinogradov[1], and A.A.Fedorova[1]

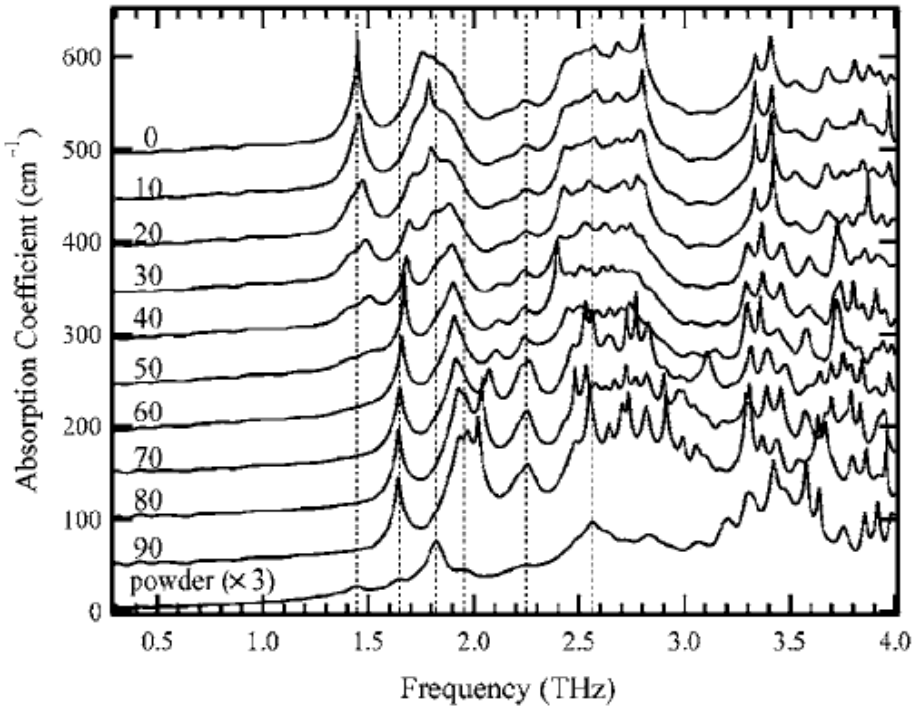
[1]Space Research Institute

[2]Moscow Institute of Physics and Technology

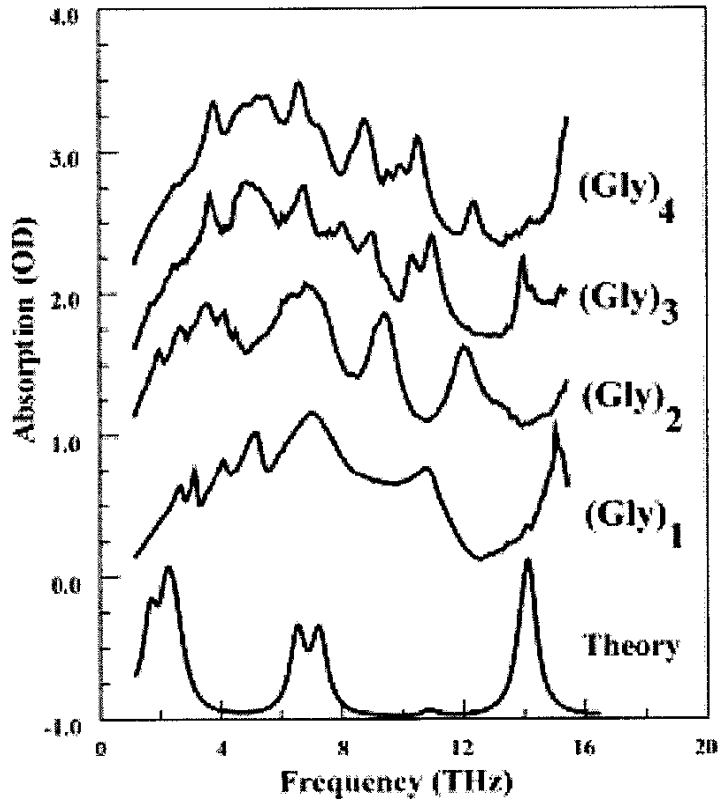
[3]Moscow Teaching University

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 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.

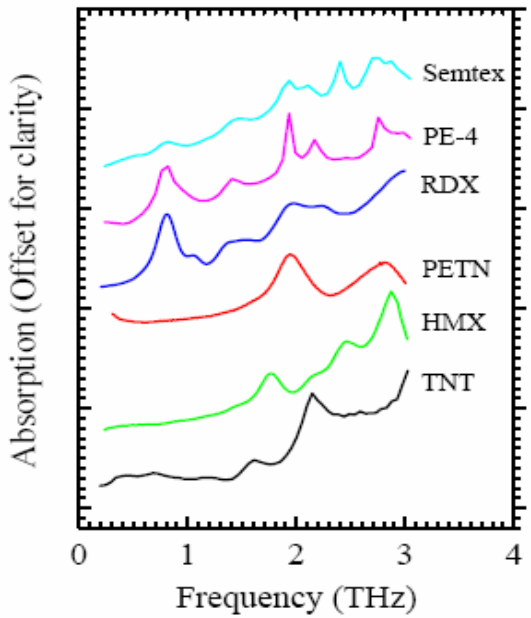


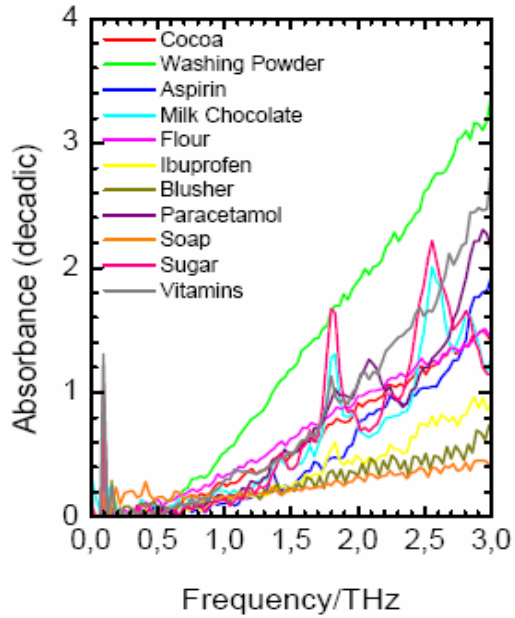
THz spectra of polypeptide powder of glycine, (Gly)n (*n* = 1 – 4). As the chain length increases, distinct and new absorption features were produced. From M. R. Kutteruf, C. M. Brown, L. K. Iwaki, M. B. Campbell, T. M. Korter, and E. J. Heilweil, *Chem. Phys. Lett.*, **2003**, *375*, 337

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 analysys 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

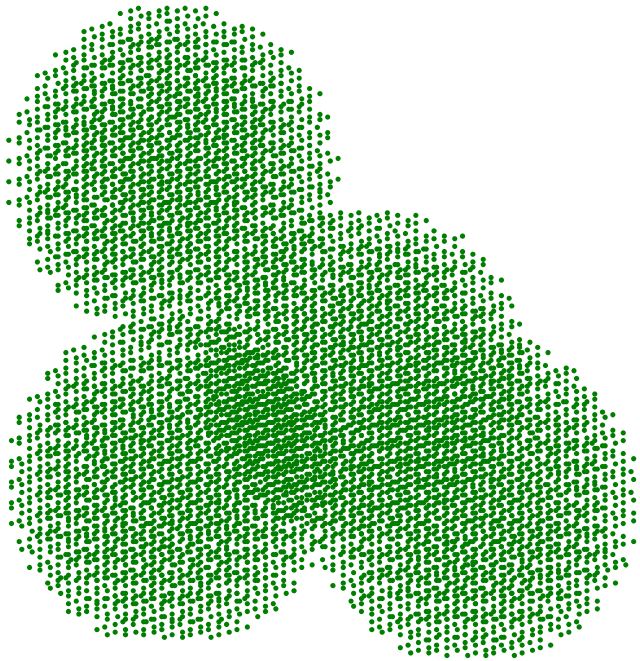
(iii) Search for traces of PAH, tholin and other organic matter on the surface

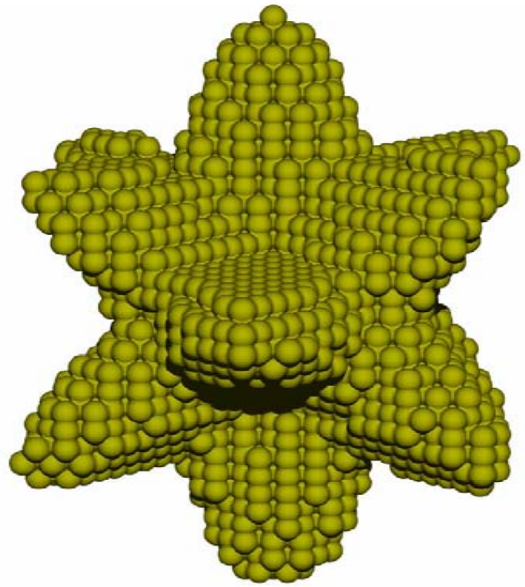
Method – homodyne detection with He-cooled 80 nm-size antenna

Sensitivity –relative absorption at 10^{-8} level

Spectral properties of Europa' 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

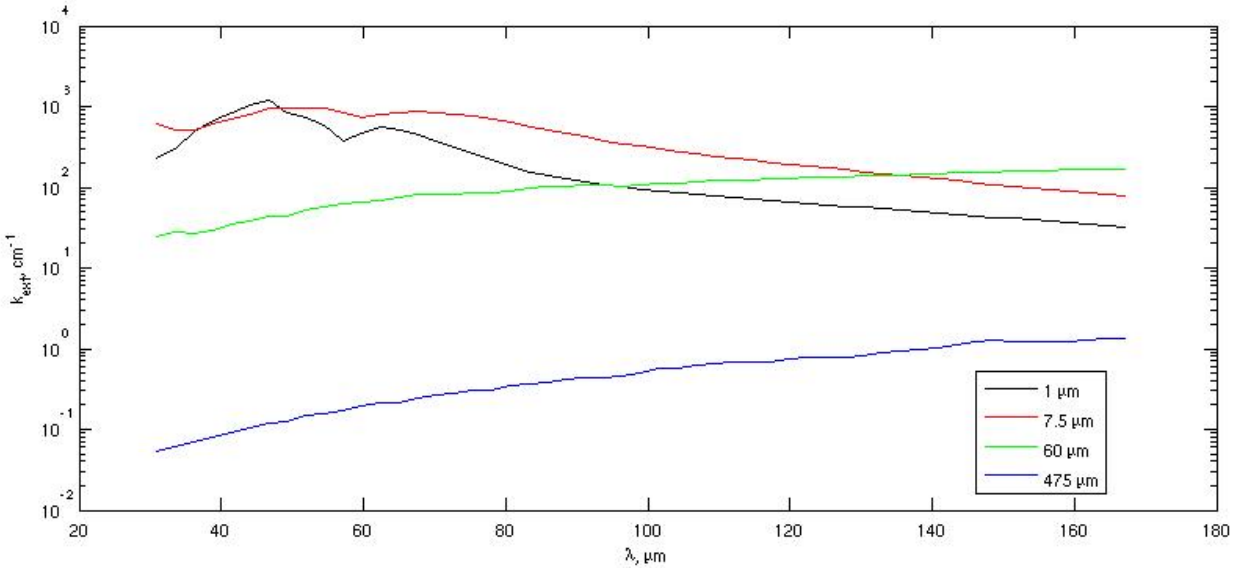




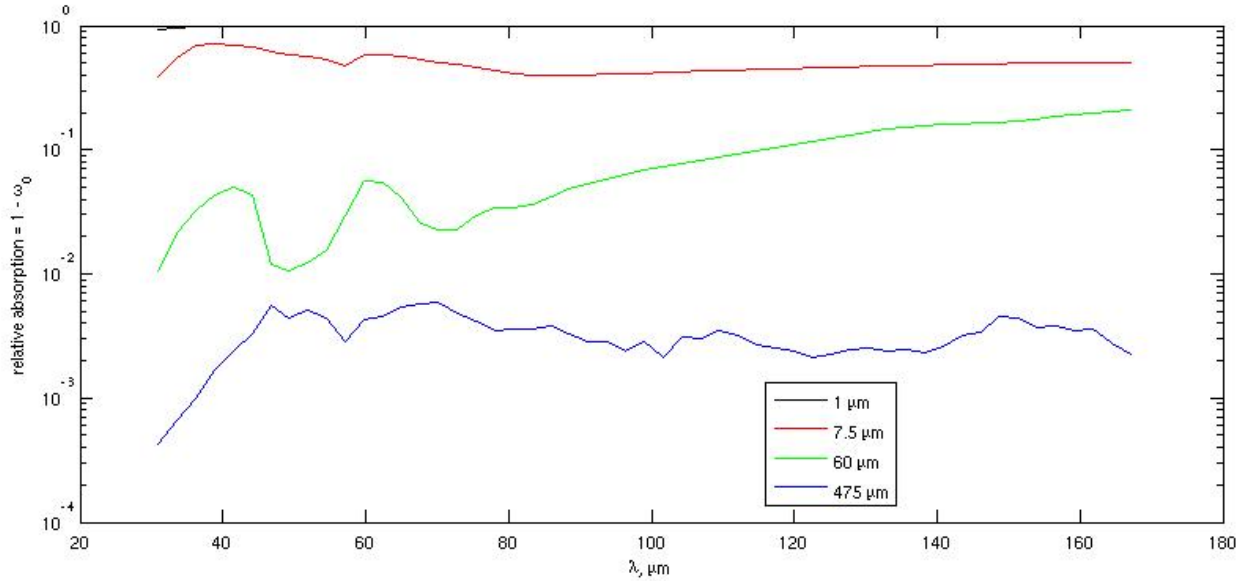
Porous ice

Monomer radius:

Black – 1 μm
Red – 7.5 μm
Green – 60 μm
Blue – 475 μm



Volume extinction



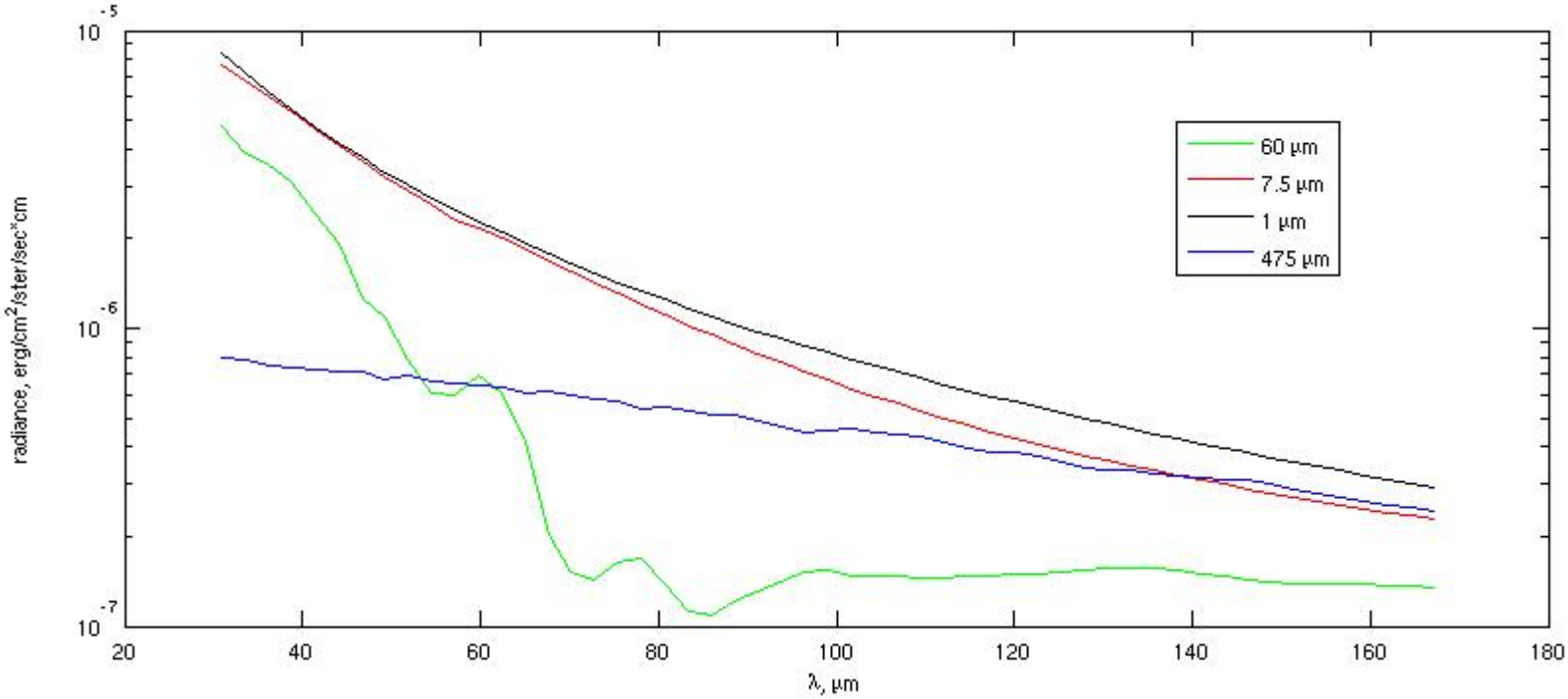
Relative absorption

Surface thermal emission

Ice, T = 100 K, ∇T = 0.2 K/cm

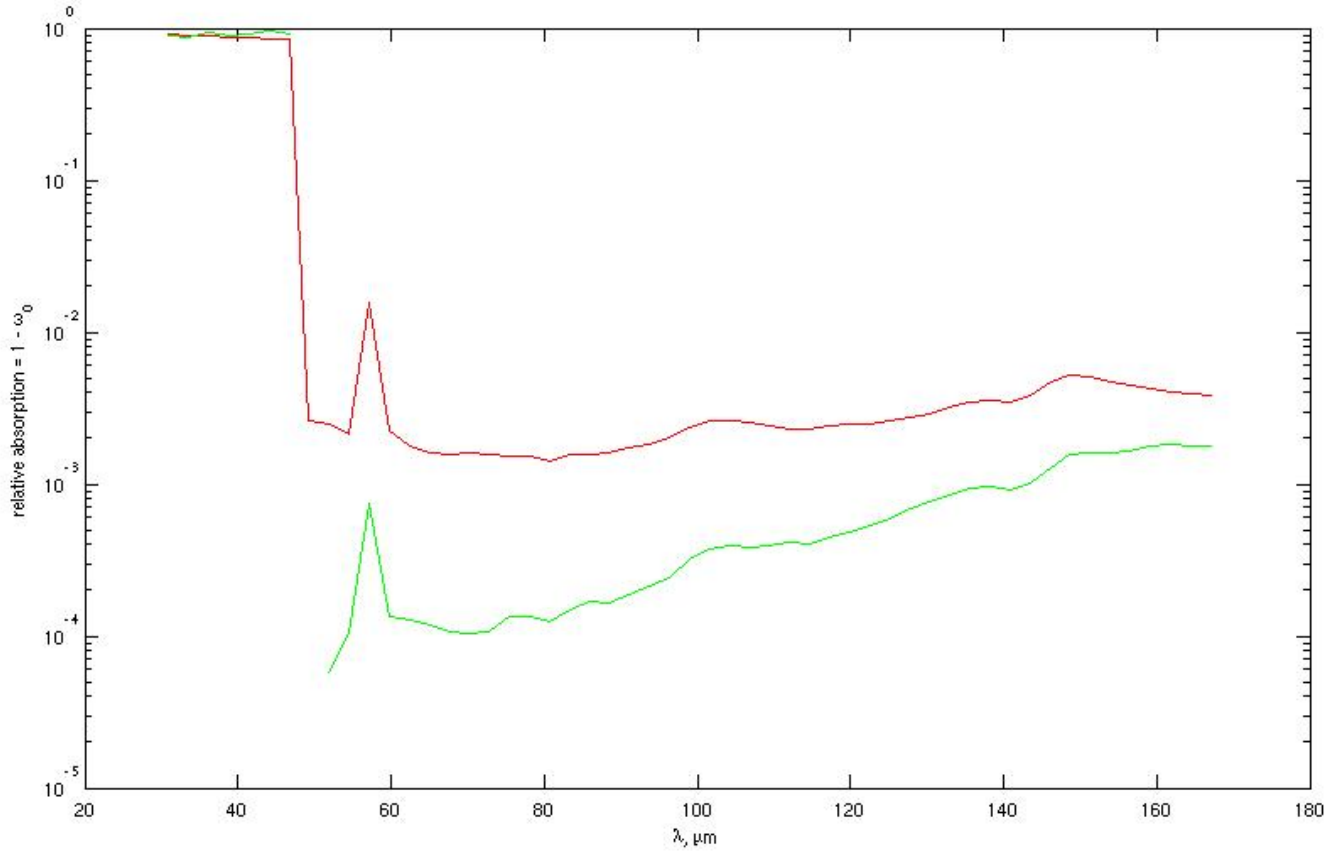
Monomer radius:

Black – 1 μm
Red – 7.5 μm
Green – 60 μm
Blue – 475 μm



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 *in vitro* analyses
- Quickly developing and demanded area of technology – hope for cheap and reliable solutions