Portable THz Spectroscopic Device for Biomedical Diagnostics in the Space Environment

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Background

- As NASA moves forward with its plans for human long-term space flights to asteroids, outer planets, and other deep space destinations, the development of reliable, portable biomedical diagnostic systems becomes of paramount importance.

- In long duration flights, reliable biomedical diagnostics approaches should focus not only on maintaining the well being and good health of astronauts but also in enabling early detection of abnormal health conditions in astronauts.

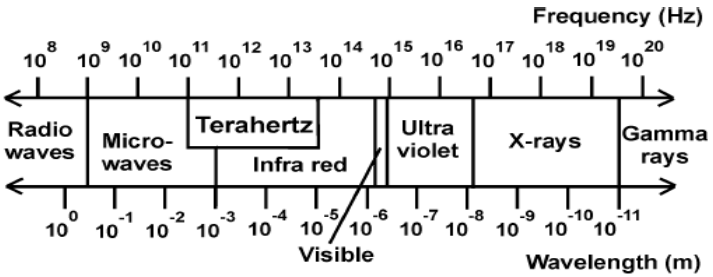
- In this context, the proposers have previously demonstrated wireless radio frequency telemetry systems and BioMEMS sensors for astronauts health monitoring [1, 2].

- Nevertheless, to identify countermeasures, treatments and/or suppression of conditions that can adversely affect astronauts' health, it is desirable to develop diagnostic tools that can probe the pertinent intramolecular behavior in humans ***while posing no ionization hazard for biological tissue.***

[1] "Radio Frequency Telemetry System for Sensors and Actuators," by R. N. Simons and F. A. Miranda, US Patent no. 6,667,725 December 23, 2003.
[2] "Hand Held Device for Wireless Powering and Interrogation of BioMEMS Sensors and Actuators," by F. A. Miranda and R. N. Simons, US Patent no. 7,191,013 March 13, 2007.

Potential Option

- A technology that could be considered for the aforementioned purpose is THz spectroscopy [3].



THz band: Numerically defined as frequencies from ~ 100 GHz to 30 THz [4]

- When interacting with heterogeneous biological tissue, the comparatively long THz wavelengths can penetrate much further than visible light or the near infrared.

- THz spectroscopy has the unique ability to detect intermolecular vibrations in organic/biological molecules. Accordingly, the understanding of intermolecular vibration studies could help elucidate the dynamics of large biomolecules under normal conditions on healthy individuals.

- By knowing the THz spectroscopic signature of the healthy biomolecules, the technique can be used to detect deviations from the healthy dynamics of these molecules that can offer clues associated to the onset of abnormal health conditions.

- Because of the elevated operational frequencies and low power levels, the likelihood of THz spectroscopy to interfere with the frequency spectrum currently used in the International Space Station (ISS) or spacecraft currently under development , e.g., the Multipurpose Crew Exploration Vehicle (MPCEV), will be negligible.

[3] "Cutting-edge terahertz technology," Masayoshi Tonouchi, Nature Photonics, Vol. 1, pp. 97-105, February 2007.
[4] "Medical applications of Terahertz Imaging: a Review of Current Technology and Potential Applications in Biomedical Engineering," K. Humphreys, et al.

Status of THz Technology

- Advances in technology have made possible the production and detection of THz radiation with solid state and vacuum electronic devices operating at room temperature. [5-7]
- THz quanta are far less energetic than those of x-rays and ***pose no ionization hazard*** to biological tissue. While this is also true for microwaves the ***shorter wavelength of THz allow for greater spatial resolution.***
- THz radiation has already been shown to have good tissue differentiating abilities.
- Hence THz technology is well set to provide the next generation of non-invasive biomedical diagnostics.

[5] Proceedings of 14th International Symposium on Space Terahertz Technology, Tucson, Arizona, 2003; Proceedings of 11th International Conference on Terahertz Electronics, Sendai, Japan, 2003.
[6] "A 100 mW, 0.670 THz Power Module," J. C. Tusek, et al., Paper 148, International Vacuum Electronics & Vacuum Electron Sources Conference (IVEC-IVESC 2012) Monterey, California, April 24-26, 2012
[7] "A 0.85 THz Vacuum-Based Power Amplifier," M. A. Basten, et al., Paper 103, International Vacuum Electronics & Vacuum Electron Sources Conference (IVEC-IVESC 2012) Monterey, California, April 24-26, 2012

What is being Proposed?

- While it is conceivable to assemble such a diagnostic capability, the large size (e.g., laboratory bench top scale) of already demonstrated THz devices and systems limits the viability of their practical implementation in the aforementioned space platforms.

- Consequently, this initiative ***seeks to establish collaborative efforts*** to investigate ***portable THz spectroscopic integrated technologies*** that could be used safely for biomedical diagnostics in space platforms (e.g., ISS, MPCEV, etc.) as well as terrestrial applications.