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TeraSpectra Validation via Absorbance Spectroscopy

In this communication we describe a few measurements with an aim to compare data obtained from ARP's TeraSpectra system with those published in contemporary literature or elsewhere.

Absorption by water vapor

Terahertz radiation is strongly absorbed by both liquid water and water vapor. As such water provides a means of calibrating spectral measurements. However, most terahertz spectrometers, be it commercial or laboratory setup, are sensitive to the moisture present in the air at ordinary conditions. This is an unwanted feature, because moisture level is not always constant, it varies depending on weather conditions and locations. Therefore, it desirable to design a spectrometer that will measure only the specimen properties independent of the ambient conditions. Nevertheless, water absorption spectrum is of interest for validation of the measurements.

In what follows, spectra acquired for liquid water is compared with a few published spectra in different terahertz regions. It has been observed by others that both water and water vapor exhibit two absorption peaks in the low frequency regions [1–4]. This is compared in Fig. 1; absorption peaks at ~18.5 cm^{-1} and 25 cm^{-1} match closely with that reported by the NIST [1]. Danylov [2] has measured the absorbance spectra at different relative humidity conditions. Fig. 2 compares the findings ref. 2 with TeraSpectra measurements. A number of peaks match very closely between the two measurements. However, there are many peaks reported in refs. 2 & 3 that was not reproduced by TeraSpectra. This is presumably for the reasons that refs. 2 & 3 dealt with water vapor while TeraSpectra measurements were conducted on liquid water.

In view of the close match of a number of absorbance peaks produced by TeraSpectra and those reported in the literature, it may be inferred that the measurements conducted by TeraSpectra are valid within the experimental error.

In addition, TeraSpectra exhibits very high sensitivity that can be exploited to detect and identify important molecular events such as characterization of non-ionic detergents in biopharmaceuticals [5], transdermal drug delivery [6], single nucleotide polymorphism [7], and DNA hybridization [8].

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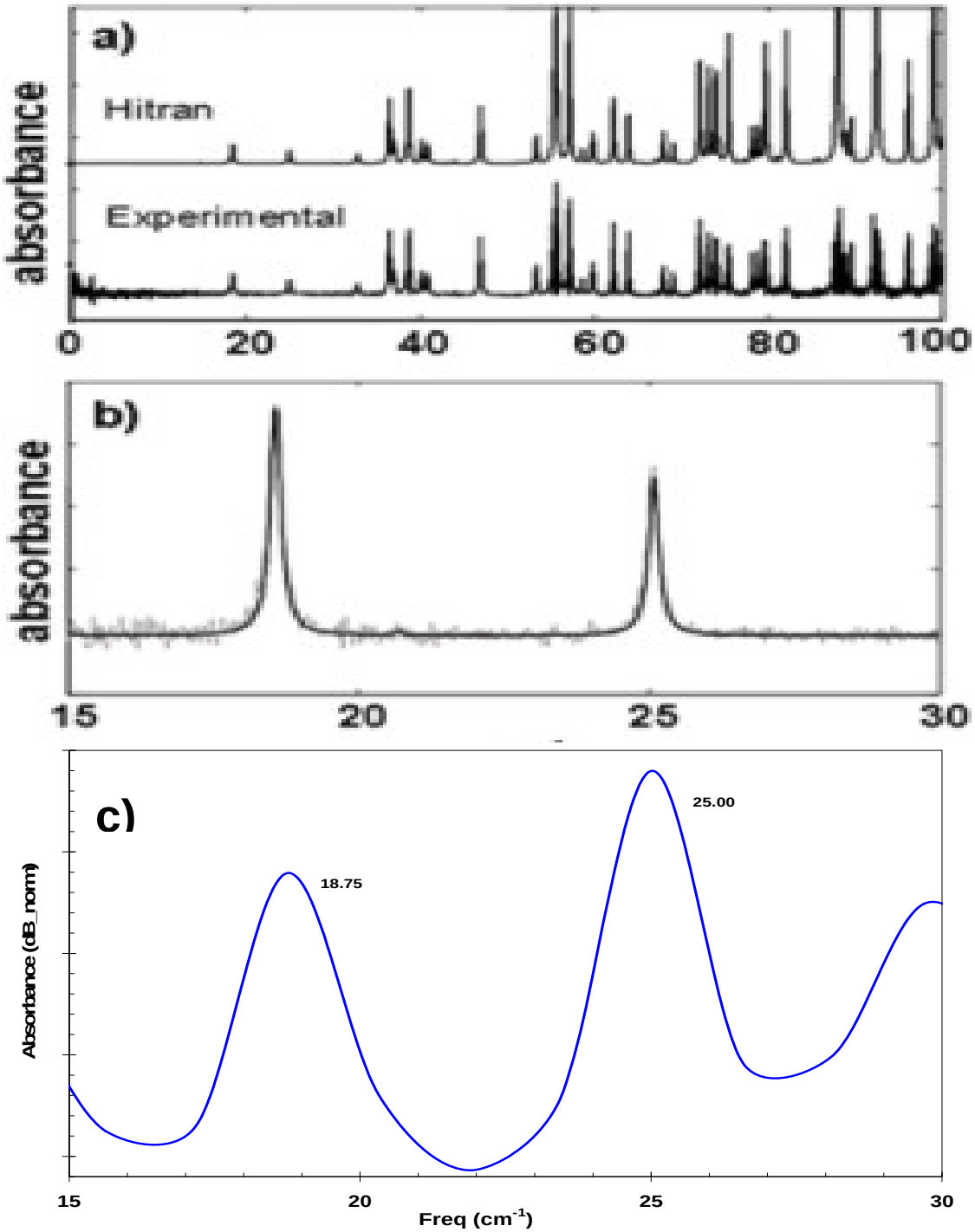

Fig. 1. (a): water vapor absorption spectrum [1] obtained using the THz spectrometer compared to that calculated using the HITRAN database. An expanded portion in the panel (b) containing pressure broadened water lines ($\Delta\nu_{FWHM} \approx 0.2$ cm^{-1}) illustrates the resolving power. (c): Expanded view of vapor absorption lines obtained from ARP's TeraSpectra (see Fig. 5). Low frequency peaks match well with those reported by the NIST [1].

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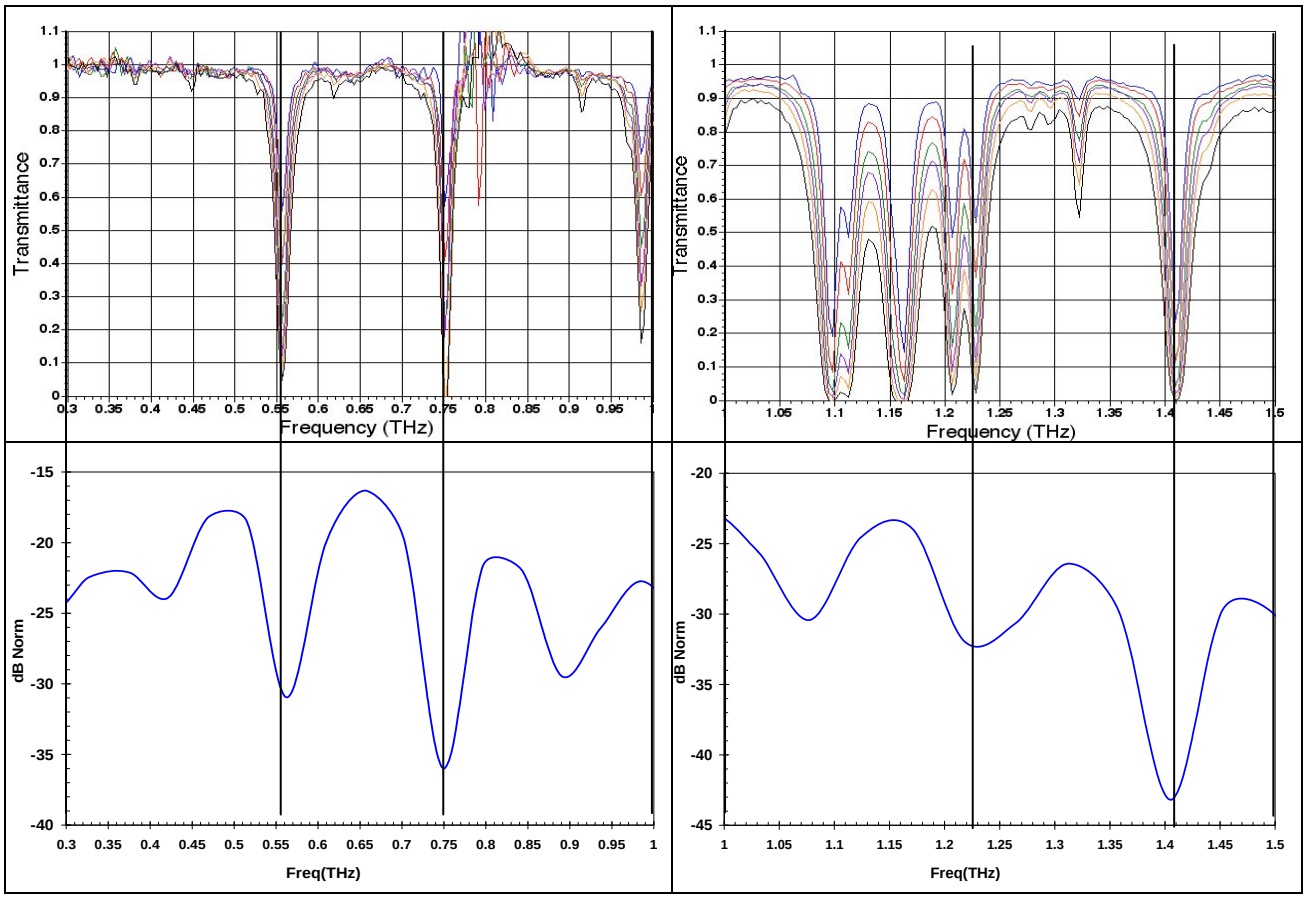

Fig. 2. Absorption peaks reported by ref. 2 (top) in the low frequency region is reproduced by TeraSpectra (bottom). Some peaks match very well, however, some mismatch is also present. Vertical lines at the selected peaks indicate degree of mismatch.

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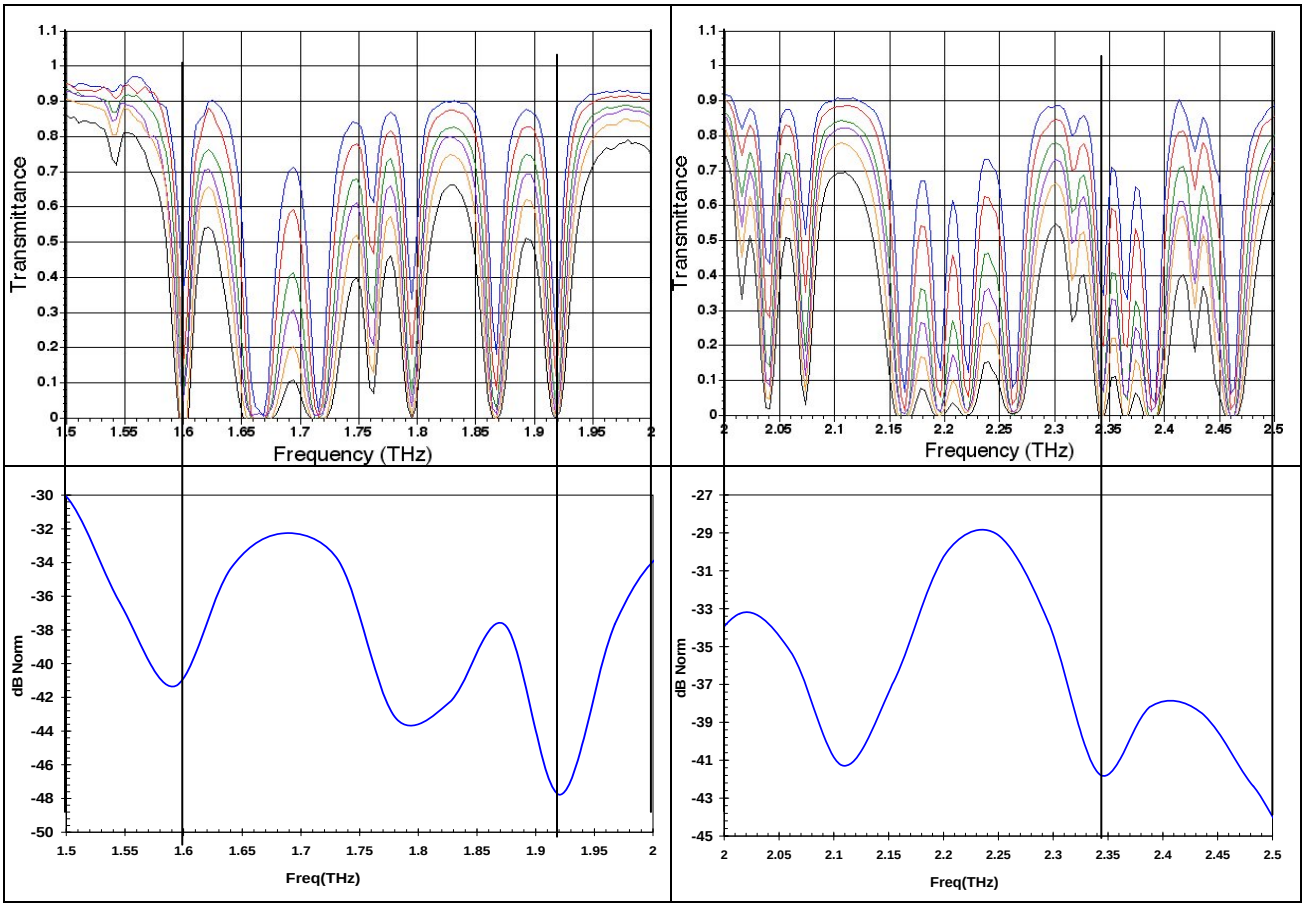

Fig. 2. (Contd.) Absorption peaks reported by ref. 2 (top) in the low frequency region is reproduced by TeraSpectra (bottom). Some peaks match very well, however, some mismatch is also present. Vertical lines at the selected peaks indicate degree of mismatch.

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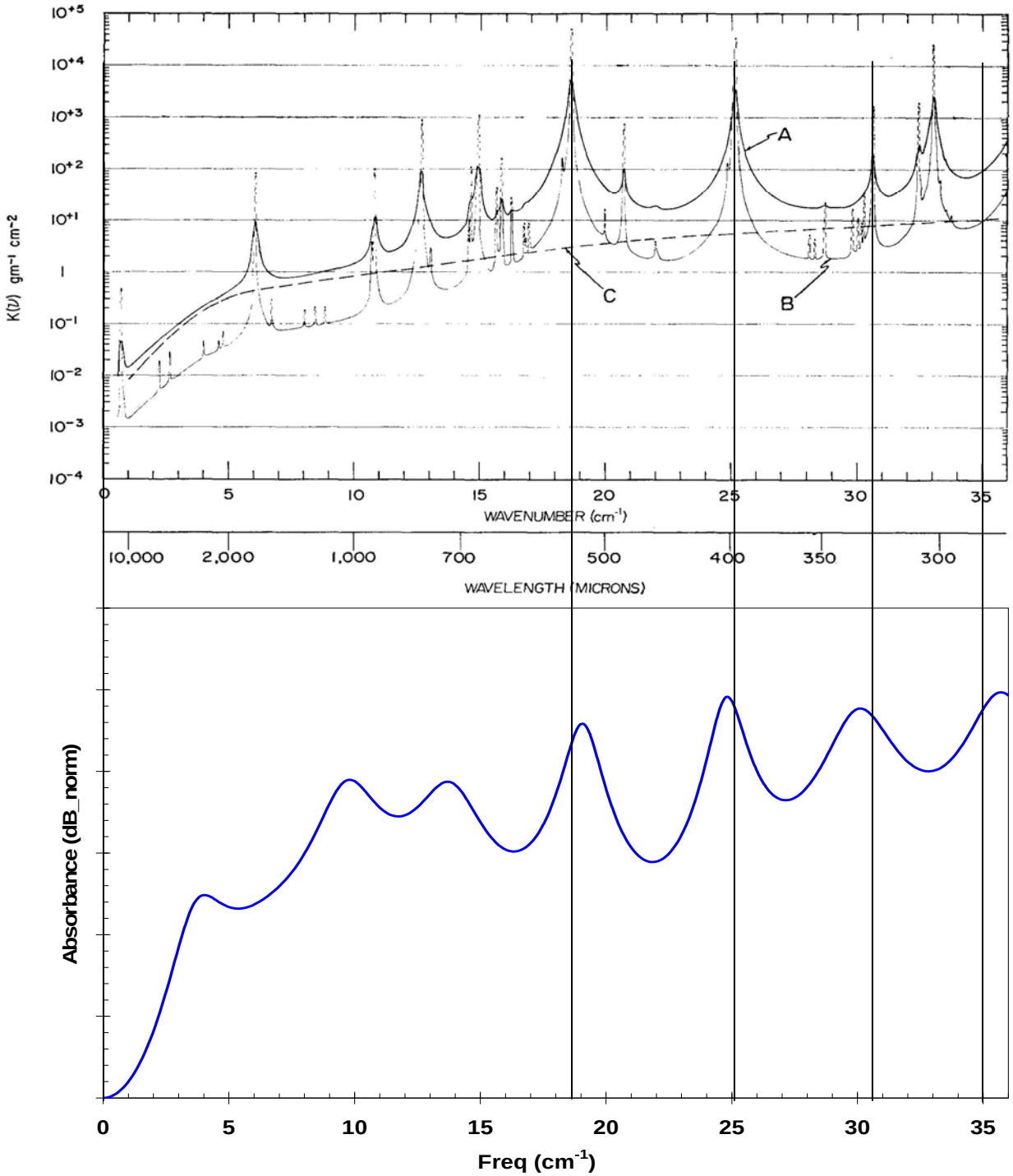

Fig. 4. Comparison of ref. [3] (top) with TeraSpectra (bottom). Several peaks are match with some shift presumably due to their N_2 broadened H_2O lines of ref. 3. Vertical lines at the selected peaks indicate degree of mismatch.

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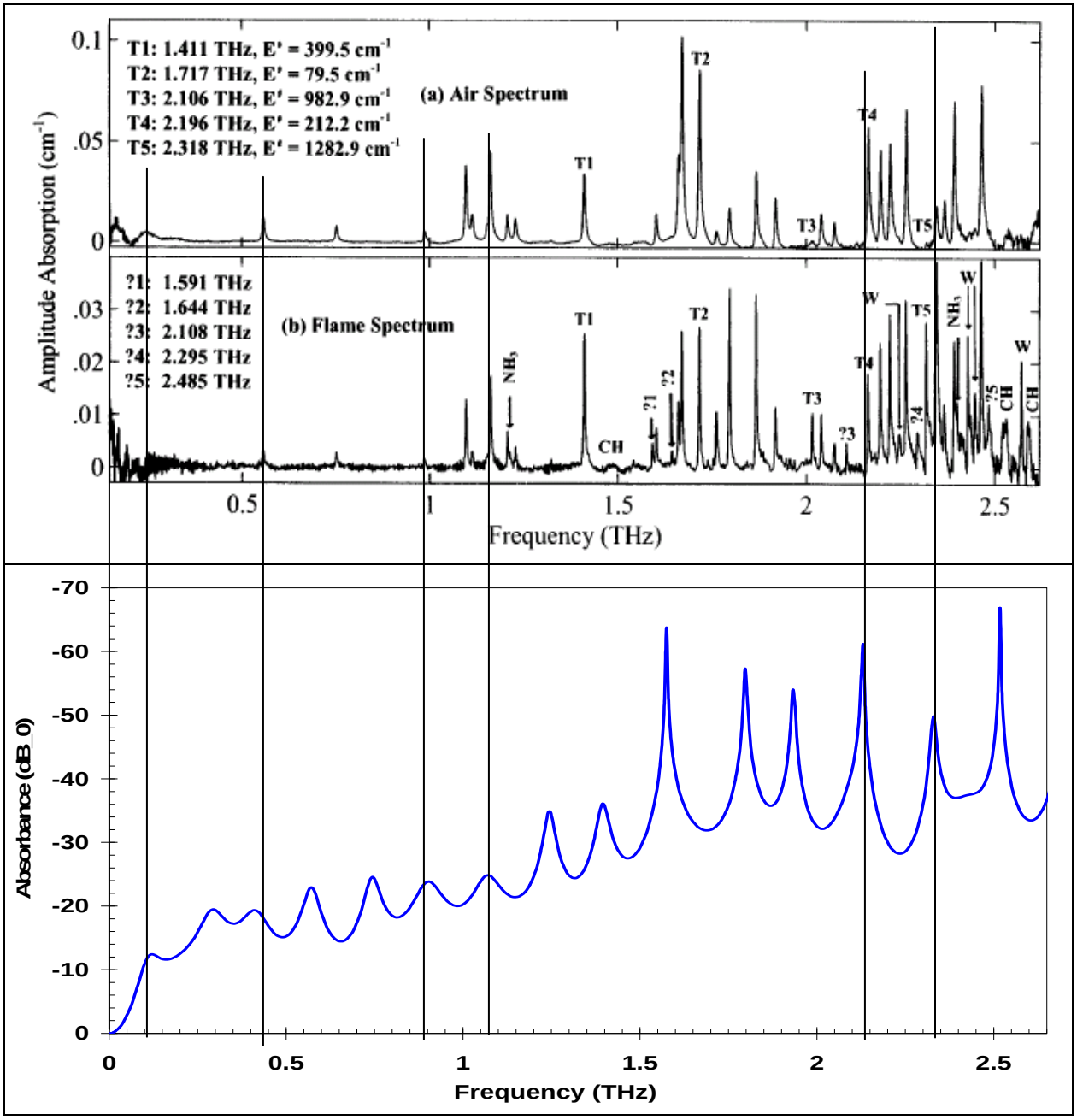

Fig. 5. Comparison of ref. [4] (top) with TeraSpectra (bottom). Several peaks match with slight shifts. Vertical lines at the selected peaks indicate degree of mismatch.

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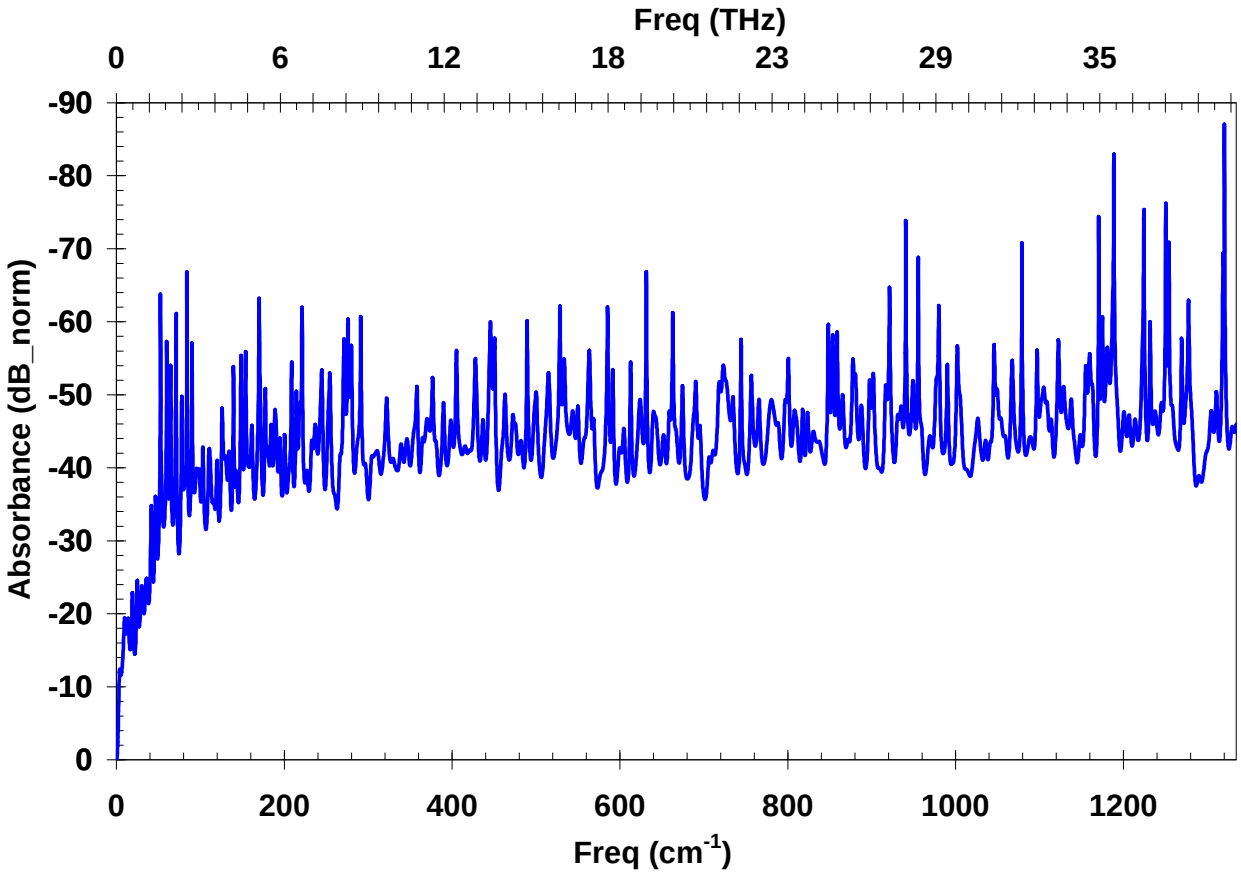

Fig. 6. Absorbance spectrum of liquid water measured by TeraSpectra. Comparisons in Fig. 1–5 are the expanded view of different segments of this spectrum.

References

[1] Ref: http://physics.nist.gov/Divisions/Div844/facilities/thz/Images/Fig2.png

[2] Andriy Danylov, "THz Laboratory Measurements of Atmospheric Absorption Between 6% and 52% Relative Humidity," Submillimeter-Wave Technology Laboratory University of Massachusetts Lowell, 175 Cabot Street, Suite 130, Lowell, MA 01854, http://stl.uml.edu, September 2006

[3] Darrell Burch, "Absorption of Infrared Radiant Energy by CO_2 and H_2O. III. Absorption by H_2O between 0.5 and 36 cm^{-1} (278 u-2 cm)," Journal of the Optical Society of America, **58** (#10), 1383, 1968.

[4] R. A. Cheville and D. Grischkowsky, "Far-infrared terahertz time-domain spectroscopy of flames," OPTICS LETTERS, Vol. 20, No. 15, p. 1646, 1995.

[5] Trevor L. Broadt and Anis Rahman, "Applications of terahertz spectrometry in biopharmaceutical reagent quantification and characterization," Abstracts of the ACS 41st Middle Atlantic Regional Meeting, April 10–13, Wilmington, DE, page: 188, 2010

[6] Aunik K Rahman, Anis Rahman, Diksha Kaushik, and Bozena Michniak-Kohn, "Terahertz study of transdermal drug delivery," Abstracts of the ACS 41st Middle Atlantic Regional Meeting, April 10–13, Wilmington, DE, page: 189, 2010

[7] Gulshan Ara, Aunik K Rahman, Bruce A Stanley, and Anis Rahman[1], "Terahertz spectral analysis of FCGR3A genotypes," Abstracts of the ACS 41st Middle Atlantic Regional Meeting, April 10–13, Wilmington, DE, page: 188, 2010

[8] Anis Rahman, Bruce Stanley, Aunik K. Rahman, "Ultrasensitive label-free detection and quantitation of DNA hybridization via terahertz spectrometry," Proceedings Vol. 7568, Imaging, Manipulation, and Analysis of Biomolecules, Cells, and Tissues VIII, Daniel L. Farkas; Dan V. Nicolau; Robert C. Leif, Editors, 756810 Date: 24 February 2010.