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Non detection of lightning signature in the Huygens ELF-VLF wave data

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Abstract

Long before Huygens landed on Titan, none of the two Voyager flybys had revealed any impulsive electromagnetic emission from Titan and the question of a possible lightning activity and related biochemistry reactions remained open. However, the modelling of the ionospheric altitude profile predicted the existence of multiple layers. The upper ones, induced by photons and precipitated energetic electrons were crossed by Cassini during its closest flybys, whereas the lower ionosphere, produced by galactic cosmic rays, was detected in situ during the descent of the Huygens probe. One of the main objectives of the Permittivity, Waves and Altimetry (PWA) experiment, a part of the Huygens Atmospheric Structure Instrument (HASI), was to measure in situ the electron and ion densities in the lower ionosphere with two different and overlapping techniques, a mutual impedance probe (MIP) and a relaxation probe (RP). MIP consists of a transmitting dipole that injects a known sinusoidal current in the medium and of a receiving dipole that measures the induced potential. The latter also measured the natural electromagnetic waves confined within the ionospheric cavity that could not be detected by the Voyager spacecraft, nor by Cassini. The two relevant frequency domains are the ELF range (~10-100 Hz), for the global Schumann resonance and its harmonics, and the VLF range (1-10 kHz), for the transverse resonances (tweeks). Average energy spectra were computed on board and telemetered to ground.

The wideband electric receiver revealed the steady presence of an intense emission at 36 Hz throughout the descent, shown in fig. 1 that was reminiscent of a Schumann resonance [3,10]. The 36 Hz emission and its production mechanism was the subject of numerous investigations by the PWA team (see [1] and a companion presentation by Béghin et al., in GP3 Session ESPC-DPS2011-194). No particular emission was observed in the VLF range.

Another team of scientists led by J. Morente revisited the PWA data set and expressed a somewhat different opinion (see [5-7] for ELF and [4.8.9] for VLF). They claimed that these measurements carried the indication of a multitude of resonances and harmonics, thus irrefutably proving the existence of lightning activity on Titan. It can however be demonstrated that their interpretation is based on artefacts generated by an improper analysis of the data.

1. The PWA ELF-VLF instrument

The instrument is composed of an analog part (preamplifiers connected to the electrodes followed by bandpass filters) and a digital signal processor (DSP) for onboard analysis and formatting. The same amplifiers and filters were used for high gain ELF and VLF and the trade-off was to let the ELF channel without an anti-aliasing filter well adapted to the sampling frequency. For ELF the analog filters have a global 3 dB bandwidth 12.6 – 3550 Hz. This is not well suited with a ~3 kHz sampling rate and aliasing effects could occur for signal components > ~1500 Hz, but this range was in principle monitored in the VLF channel, and only the ELF part (< 100 Hz) of the spectrum was sent into the telemetry.

2. An example: the ELF case

An example of the results derived from the ELF data by Morente et al. [6] using the so-called “late-time system response” is shown in fig. 2 (left panel). Their spectrum displays 6 resonances with a claimed frequency resolution of 0.4 Hz, but is extracted from an original energy spectrum that contains only 16 lines, shown in the middle panel (only half of the 32 transmitted lines are present due to the loss of one of the two TM links, thus causing the loss of every other lines. Similar pseudo-resonances are duplicated if Morente et al.'s

"late time" procedure is applied to the cruise checkout data collected during the cruise, when the antenna is still folded under the heat shield[1,4,5]

3. Conclusion

With the exception of a continuous emission at 36 Hz, we conclude that Huygens did not return any evidence of lightning activity in the ELF and VLF ranges, which is corroborated by the observations performed on the Cassini orbiter during the flybys of Titan [2].

4. Figures

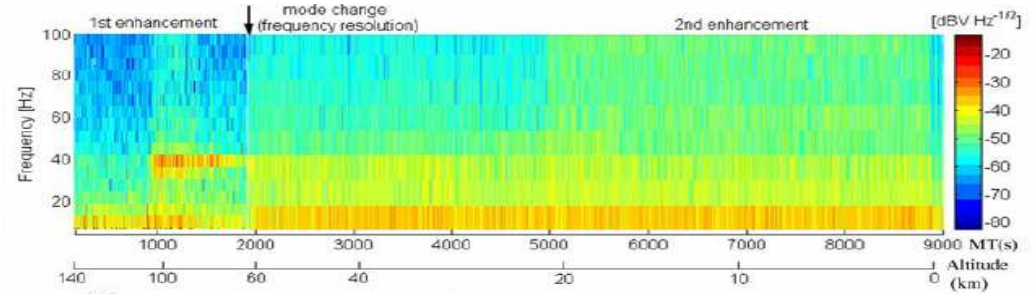

Figure 1. PWA ELF spectrogram recorded by PWA during the descent of the Huygens probe through the atmosphere of Titan..

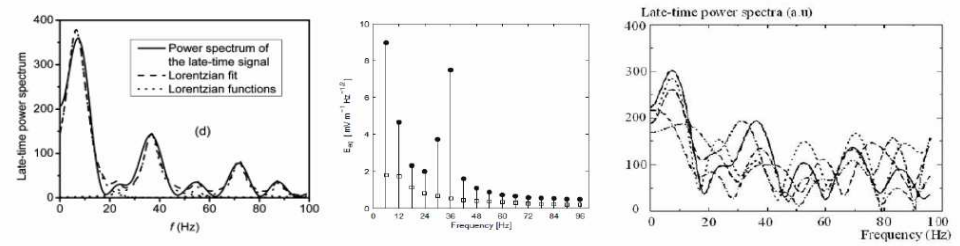

Figure 2. Output of Morente et al.'s procedure applied to the first spectrum recorded during the descent (left panel) [6], vs. the original energy spectrum measured with PWA (middle panel) [5]. The right panel displays the results obtained when the "late time" technique is applied to the checkout data recorded during the cruise [1], which does not markedly differs from the left panel.

Acknowledgements

The PWA instrument has been designed and built by: RSSD-ESTEC: Deployable Boom System; LPCE, Orléans: Preamplifiers (HASI-I); IAA, Granada: Analog board (PWA-A); IWF, Graz: Digital board (PWA-D). The data were transmitted through HASI and CASSINI-HUYGENS systems.

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