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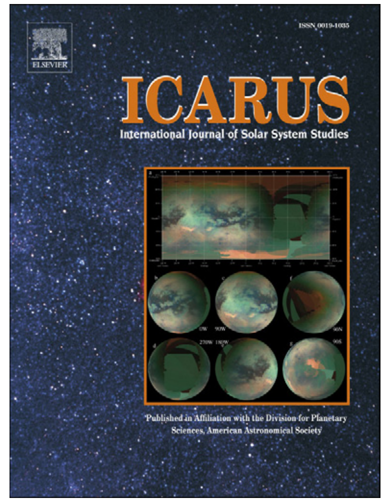

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Comment on *"Evidence of electrical activity on Titan drawn from the Schumann resonances sent by Huygens probe"* by J.A. Morente, J.A. Portí, A. Salinas, E.A. Navarro

[doi: 10.1016/j.icarus.2008.02.004]

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ABSTRACT

Morente et al. [J.A. Morente, J.A. Portí, A. Salinas, E.A. Navarro, 2008. Icarus, doi: 10.1016/j.icarus.2008.02.004] have recently presented a new analysis of the Permittivity, Wave and Altimetry (PWA) measurements made during the descent of the Huygens Probe through the atmosphere of Titan. They claimed the identification of several Schumann resonance harmonics and concluded in favor of a lightning activity on Titan. We report here several reasons for not endorsing this paper.

Key Words: Titan; Lightning; Ionospheres; Instrumentation

1. Introduction

The investigators of the Permittivity, Wave and Altimetry (PWA) instrument on the Huygens Probe have reported a first analysis of the Extremely Low Frequency (ELF) signals recorded by their instrument on the Huygens Probe, in Grard et al. (2006), Béghin et al. (2007), and Simões et al. (2007). They suggest that a narrow-band signal at 36 Hz is probably an emission similar to the Schumann resonance observed at Earth, but they have not yet entirely excluded that it might be the signature of an unlikely - but possible - artefact, such as a mechanical vibration.

The PWA data are archived in the Planetary Science Archive (PSA) of ESA, and are at the disposal of the scientific community. Morente and his co-workers have procured the archived data. They analyse the measurements without any reference to the extensive documentation on the instrument (Grard et al., 1995; Fulchignoni et al., 2002; Falkner, 2004; ftp://psa.esac.esa.int/pub/mirror/CASSINI-HUYGENS/HASI). They claim that several harmonics of the resonance are visible, in concordance with their model for Titan's ionospheric cavity. They discard definitively any artefact.

The PWA investigators have never been consulted by Morente or his co-workers, and do not endorse the conclusions of their paper, whose title is misleading in many ways. (a) No clear evidence of lightning activity in the atmosphere of Titan has been observed in the electric and acoustic waveforms recorded during the descent. (b) The power contained in the 36 Hz emission, clearly visible in the original spectra published by the PWA Team, is too high to be explained by lightning; only an interaction between Titan and the magnetosphere of Saturn could generate such a strong signal.

2. First Recorded Spectrum

The first recorded PWA-SH (Schumann) spectrum is shown in Fig. 1. The level of the line at 36 Hz is close to the noise, as shown in Fig. 2 that represents the profile of this line between approximately 140 and 60 km.

[Figure 1, Figure 2]

Falkner (2004) and Falkner and Jernej (2005) give more information about the PWA operation modes. The amplitude of each of the 16 lines that are transmitted to Earth (full circles) is that of the equivalent sinusoidal signal with the same power (Fig. 1). The scale on the left-hand-side measures the spectral level. The open squares give the average signal observed during the interplanetary cruise, when the antenna is stowed between the heat shield and the back cover. The fact that the first spectrum lies below the noise, at 18 and 42 Hz for example, is of low significance, due to the random nature of the measurement when the signal-to-noise ratio is very small. The thin continuous line in Fig. 1 represents the raw data, reported by Morente et al. in *"Fig. 5a"*. They measure the amplitude in arbitrary units along the scale shown on the right-hand-side, and do not specify why they have not calibrated or even decompressed the data that they analyze. It is clear that, in spite of a similarity, there is no linear relationship between the raw and real spectra. Any further analysis of a data set that is neither calibrated nor decompressed is necessarily tainted with doubt and suspicion.

The *"important pulse at the early time"* seen in *"Fig. 5b"* carries no information whatsoever about the number and times of occurrence of the causal events. It is therefore presumptuous, for convenience, to dress this feature up as the signature of a lightning discharge or that of a static electric field.

The separation between the harmonics in *"Fig. 5c"*, about 12 Hz, is somewhat suspicious because it is close to the inverse of the length of the sample series, 32×0.0026 s = 0.0832 s (see *"Section 3.3, first paragraph"* and *"Fig. 5b"*). The 36 Hz emission, the only one reported by the PWA Team, is not even the most prominent.

3. Statistical Approach

The first PWA-SH spectrum is not the most representative one, because the electric field level is extremely low at the beginning of the descent (Fig. 2). We shall therefore focus our attention on the data collected during the time interval defined by the two markers, between 900 and 1630 s, when the strength of the signal lies well above the noise level. The power is averaged in 3 Hz-wide bands centred on each of the 16 frequencies and the equivalent field amplitudes are plotted in Fig. 3.

[Figure 3]

This statistical analysis reveals that a single resonance is detected at around 36 Hz. The duration of the rectangular sampling window is 333 ms, and is responsible for an artificial broadening of this narrow-band emission; the amplitude of the 42 Hz line, for example, can be enhanced by an amount of up to ~20% of the 36 Hz level. Additional resonances can therefore be identified only if the corresponding peaks are significantly larger than the enhancements associated with the width of the sampling window. The relatively high level of the other neighbouring line, at 30 Hz, might result from the fact that the observed resonance frequency is slightly less than 36 Hz. In conclusion, Fig. 3 contains no evidence for multiple resonances. The shape of this spectrum is compatible with the wave propagation simulations of Simões et al. (2007), and the width of the 36 Hz emission, with due consideration for the constraints introduced by the time window, leads to a Q-factor of at least ~3.

The rigorous analyses of Béghin et al. (2007) and Simões et al. (2007) take into account laboratory calibrations and possible effects of the instrumental noise observed during the cruise. The feat of Morente et al. who extract up to 6 resonances from only 16 spectral lines results from the application of inappropriate procedures.

The PWA co-investigators have already published several arguments in favor of a natural resonance, based on field polarization and distribution in altitude and latitude, but potential artifacts, though unlikely, are still under scrutiny. Morente et al. should therefore refrain, without any in-depth knowledge of the instrument, from asserting that an interference of *"mechanical origin is completely discarded"*. The definite ruling out of a possible mechanical artefact is awaiting the delivery of the spare model of the PWA Deployable Boom System, presently integrated with the spare model of the Huygens Atmospheric Structure Instrument (HASI) in Italy, for complementary tests in a cryogenic chamber at ESTEC (The Netherlands).

4. Conclusion

We refute the conclusions of Morente et al. on the following grounds:

(a) Their effort fails from the beginning because they do not seem to apprehend correctly the format of the data that they plot in arbitrary units.

(b) The late-time signal analysis necessarily shows a peak at time zero, but cannot display any signal whose amplitude is less than that of the less significant bit. Concluding that *"the pulse could be associated with an electrical discharge or, more likely, related to a high level of DC signal generated by a set of electrical discharges non-localized in time, since it appears in all the data series sent by the Huygens probe"* is wishful thinking. The truth is probably more prosaic; the *"pulse"* is simply associated with digitization and shot noise generated by the instrument itself.

(c) Adding zeroes to a time series should be done with caution, especially if one knows little about the waveform. Contrary to increasing the sampling frequency, this process does not contribute any new information. Second, it distorts the spectrum, especially when the original signal is noisy, not band-limited, nor properly calibrated or decompressed. Applying the same treatment to the signal recorded during the interplanetary transit would probably yield the same result and confirm that the harmonics are generated by the analysis procedure itself.

Subjective wording like *"clear proof"*, *"irrefutable proof"*, *"completely discarded"*, and "*extremely unlikely*" should always be used with moderation.

We recommend rejecting the evidence in favor of an electrical activity in Titan's atmosphere claimed by Morente et al.

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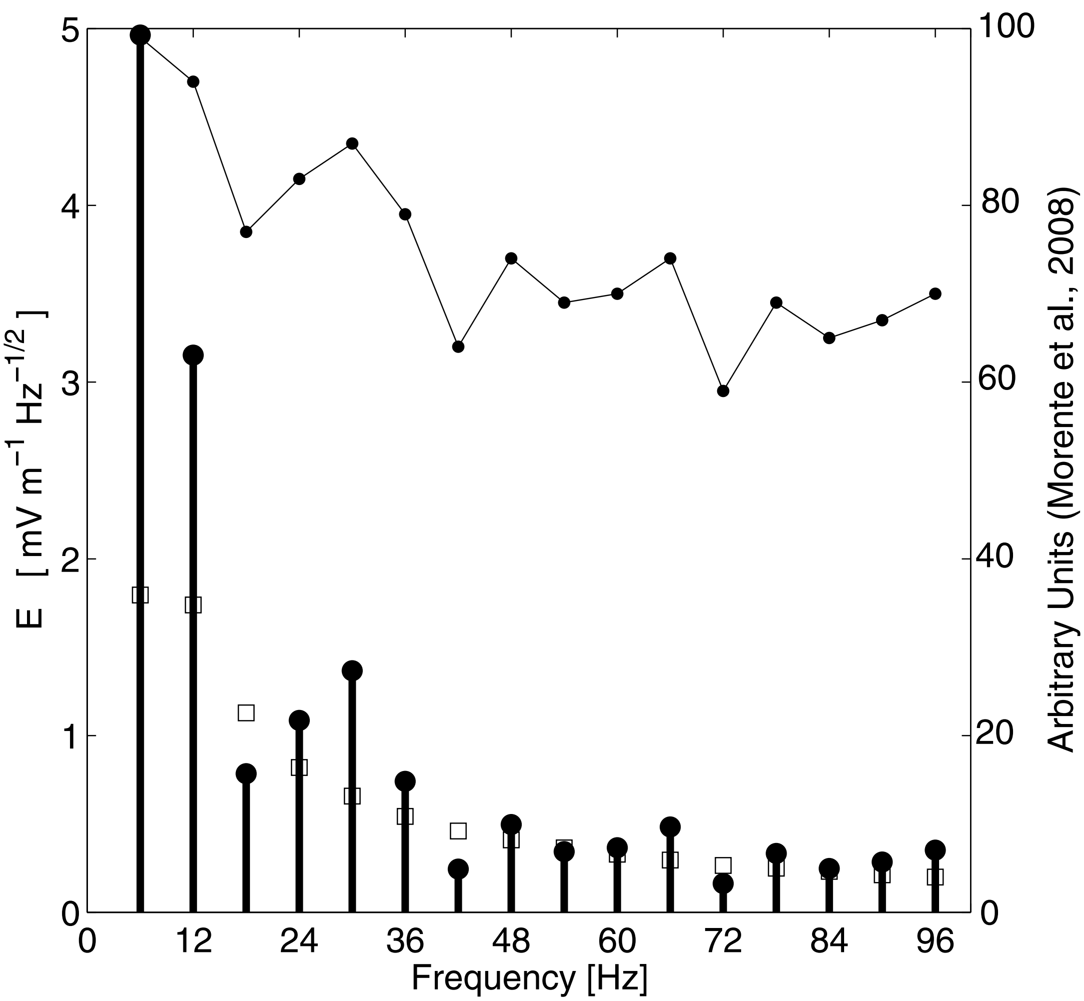
Figure Captions

Figure 1. Comparing spectra. The scales on the left- and right-hand-sides apply to the calibrated and raw data, respectively. (a) Full circles: first spectrum recorded at altitude 141.5 km and time 156.375 s. (b) Open squares: average noise spectrum observed during the interplanetary cruise. (c) Continuous line: raw data used by Morente et al.

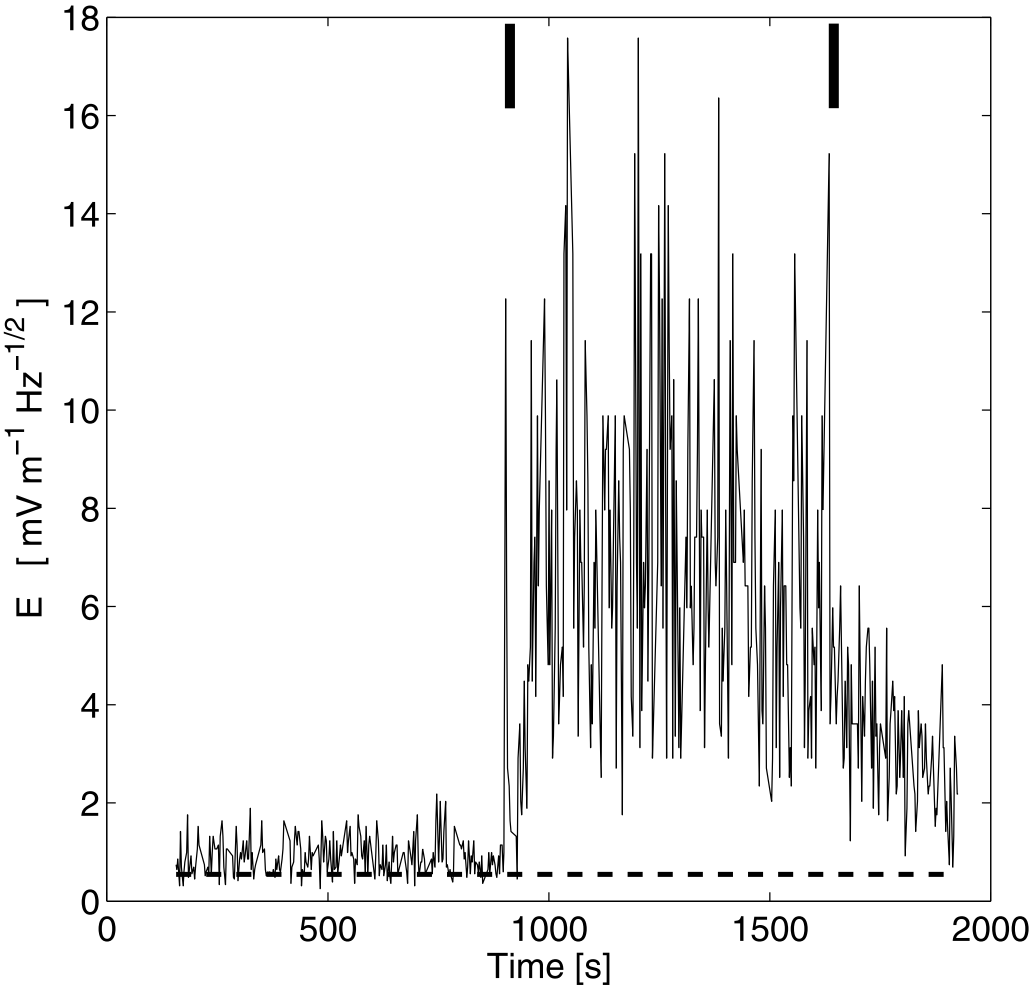
Figure 2. Amplitude profile of the electric field measured in a 3 Hz window centred on 36 Hz. The dotted line gives the cruise level, for reference. The very first point, close to the background noise, corresponds to the 36 Hz level in Figure 1. The average amplitude between 900 and 1630 s is the level at 36 Hz in Figure 3.

Figure 3. Spectrum averaged in the interval 900-1630 s. Symbols as in Figure 1.



5
4
3
2
1
0
E [mV m−1 Hz−1/2]
100
80
60
40
20
0
Arbitrary Units (Morente et al., 2008)
0
12
24
36
48
60
72
84
96
Frequency [Hz]

I10563_Fig1



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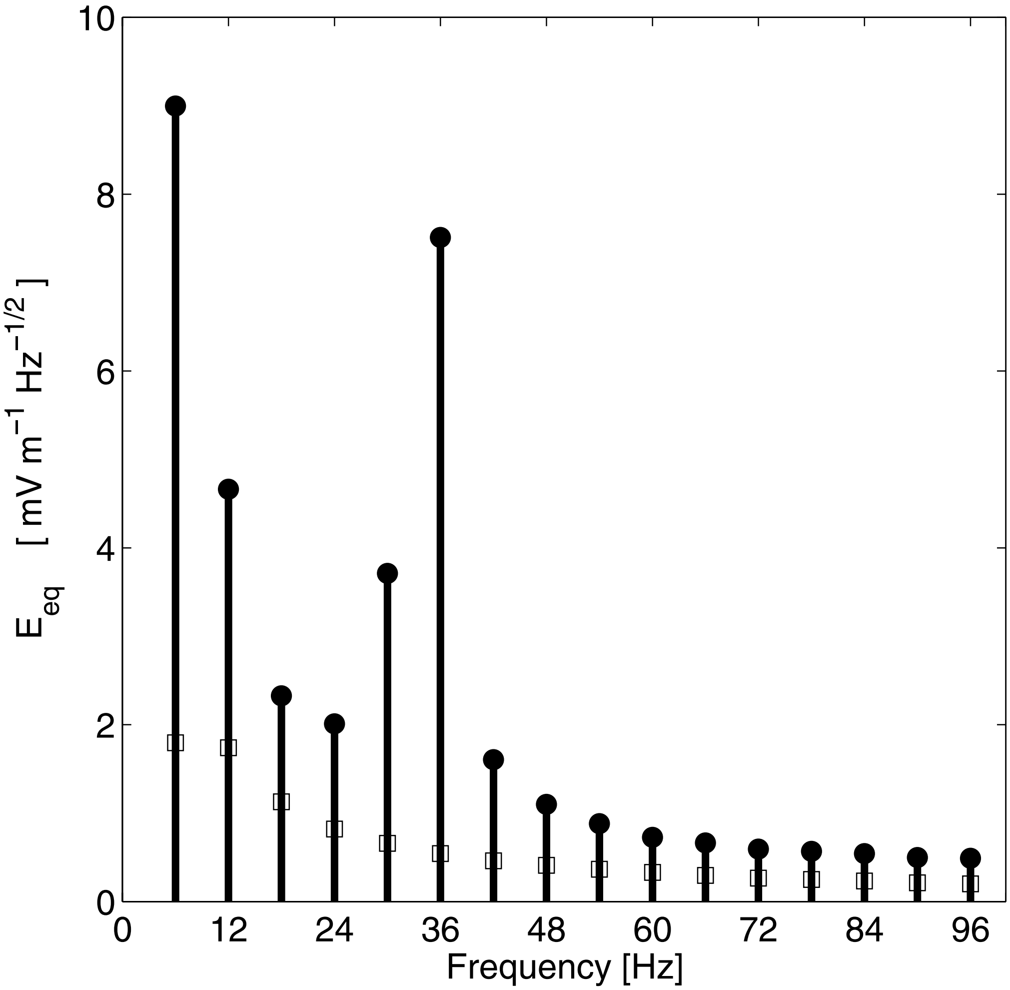

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