First results of the analysis of data of the SAS2 e.m. wave analyzer on board of Compass-2 satellite

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Abstract

During the operation of the Compass-2 satellite launched in 2006, the SAS2 advanced electromagnetic wave analyzer worked properly. Among the recorded ELF-VLF events we found some interesting phenomena. Whistler doublets, reported earlier as detected by SAS wave analyzer on IK-24, appeared at the Compass-2. Spiky whistlers (SpW), reported as detected by Demeter, were recorded by the SAS2-K2. First time was possible to detect and identify whistlers propagating between two layers in the magnetosphere ("onion-skin"-like structure) in higher (third) guided mode form in perfect correlation with the theoretical results of the UWB signal propagation in wave guides filled with magnetized plasmas.

1. Advanced SAS-type e.m. wave analyzer on board of Compass-2

The main goals of the Compass and the planned Volcano mission are the research of the (e.m.) precursors of the earthquakes, the investigation of the electromagnetic environment of the Earth and the space weather. The Compass mission was the first step, the technological test of the instruments and scientific ideas.

The Compass-1 was launched in 10th December 2001, however, it went out of operation just after a successful launch. The Compass-2 (Fig.1) launched in 26th May 2006 and started the operation on the planned orbit. (The general sketch of the Compass-2 is presented in Fig.2.

![Figure 1. The Compass-2 during the final tests](image1)

![Figure 2. The sketch of the Compass-2](image2)

During the first tests of the satellite serious power supply problems appeared which were partly repaired to the beginning of November 2006. From that time some more scientific measurements sessions were made with the perfect operation of the onboard scientific instruments.
An important element of the onboard instrumentation was the SAS2 Signal Analyzer and Sampler, an advanced ULF-VLF e.m. wave analyzer (made by BL Electronics and Eötvös University, Hungary – Fig.3) with electric (1 pair spheric sensors) and magnetic (search coil) sensors (made by Lviv Centre of Space Research, Ukraine [1]).

Figure 3. The SAS2-K1 and -K2 e.m. wave analyzers, the main electronic units without the sensors

The SAS2 produced high quality data with low inner noise and high sensitivity in both channels and worked perfectly during the active life time of the Compass-2.

2. Examples of VLF e.m. events recorded by SAS2

a) Whistler doublets:
Earlier whistler doublets were reported in [2], which were recorded by the first SAS on board of IK-24 (Active) satellite (Fig.4). The SAS2 recorded whistler doublets also, see e.g. in Fig.5. However, the orbit of the Compass-2 is a circular low Earth orbit (i~79°, h~400km). Therefore we must exclude of the possibility that the second traces of the doublets are signals reflected below the satellite, the travel time values exclude this interpretation. The possibility that the parts of the doublets propagated in very close (narrow) ducts is also questionable because these whistlers have no signs of ducted modes (see in point c).

Figure 4: Whistler doublets from SAS on board of IK-24, 14.12.1990.
Figure 5: An example of whistler doublets from SAS2 on board of Compass-2, 27.01.2007.

Therefore we started a revision of the interpretation of whistler doublets.

b) Spiky Whistlers (SpW):
It was reported and interpreted the SpW phenomena based on Demeter data [3] – Fig.6. On board of Compass-2 the SAS2 recorded SpWs also and the parameters, e.g. the asymptotic frequencies of the propagating modes, confirm the earlier results.
Figure 6. The structure of the propagation model, the time functions and FFTs of an SpW recorded by the Demeter and the computed full-wave UWB signal excited by a Dirac-delta current density in the model [3].

c) Evidence of ducted mode propagation of a whistler group:
As we know, first time was identified whistlers propagating in higher order ducted mode. Using the full-wave UWB modeling of signals propagating in wave-guides filled with magnetized plasmas – the theory was shortly presented in [4] – it can verified that the members of the whistler-group recorded by the SAS2 (28.02.2007) propagated between two layers through the magnetosphere along the magnetic field (“onion-skin” type structure of the inhomogeneous plasma). The FFT of the computed (modeled) and measured signals are presented in Fig.8.

Figure 7. An SpW group recorded by the SAS2 on board of Compass-, 16.03.2007.

Figure 8. Computed (modeled) whistlers and measured on board of Compass-2 by SAS2. (Modeling parameters: path=30000km; mode number=1,2,3; $\omega_b=900\text{krad/s}$; $\omega_p=2.5\text{Mrad/s}$; distance of the wave-guiding layers=6km,)
Comparing the measured and the computed signals we can identify that the measured signals are propagating in the mode number=3 form. (The applied theoretical model is valid for duct and layered guiding structures, too.)

3. Conclusion

The SAS2 hardware and software worked perfectly in space environment.
The revision of the generation mechanism of the whistler doublet phenomena is necessary.
The interpretation of the SpW phenomenon identified in Demeter data was verified by the Compass-2 data.
First time whistlers were identified propagating in a higher order guided mode. The existence of an “onion-skin”-like structure in the plasmasphere was confirmed, however, no evidence was found of ducts or narrow ducts.

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5. References


