EPSC Abstracts
Vol. 11, EPSC2017-607, 2017
European Planetary Science Congress 2017

The Jovian Neutral Atoms Analyser onboard JUICE/PEP: Performance and Calibration Measurement Results

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Abstract

The Jovian Neutral Atoms Analyser (JNA) is one of the sensors of the Particle Environment Package (PEP) onboard the JUICE spacecraft. One of the main JNA science objectives is the investigation of the plasma dynamics in the Ganymede magnetosphere using energetic neutral atom imaging. We will show the results from laboratory testing of the JNA prototype with particular focus on the angular resolution, the mass resolution and the detection efficiency.

1. Introduction

Instruments for energetic neutral atom (ENA) imaging were flown on numerous space missions to different planetary bodies. The measurements of these ENA imaging instruments have greatly helped to answer questions on the different interaction processes of the solar wind with the planetary surfaces, the resulting space weathering processes and interaction of ions and neutrals with the space plasma [1].

The JUICE mission will be launched in 2022 and reach Jupiter and the Jovian system 8 years later. The JNA onboard the JUICE spacecraft will measure energetic neutral atoms in an energy range from 10eV to 3keV with an angular resolution 11°x7° resolving hydrogen and heavy atoms throughout the mission [2].
Special importance is attached to the mission phase of the JUICE spacecraft orbiting Ganymede. The Jovian moon possesses an intrinsic magnetic field. As a result, certain terrains on the surface of the Jovian moon are protected against space weathering processes while others are not. As the interaction of plasma ions with the icy surface of Ganymede result via different processes in ENAs, mapping the ENAs is a direct means of mapping the plasma interaction processes with the surface. JNA onboard the JUICE mission will provide the scientific data to quantify ENA fluxes from Ganymede and to create ENA maps of the surface, hence offer valuable clues to the plasma environment of Ganymede and the space weathering effects in the Jovian system [2].

2. Technical

The JNA instrument is built at IRF Kiruna with heritage from the CENA sensor, which was one instrument of the SARA (Sub-keV Atom Reflecting Analyser) experiment onboard Chandrayaan-1 [1], and the ENA sensor, one of the instruments of the MPPE (Mercury Plasma Particle Environment), which will be launched onboard BepiColombo [4]. Shape and dimension of the JNA will be similar to the ENA instrument, which is shown in Fig. 1.

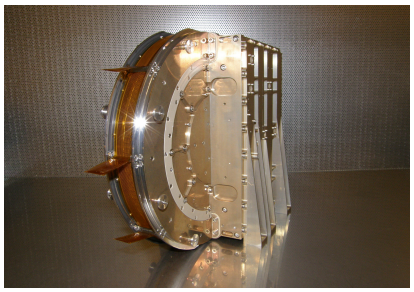

Figure 1: The flight model of the ENA instrument for BepiColombo, image credit: IRF

In comparison to the instruments mentioned above, the JNA instrument is designed for being operated in the harsh radiation environment of Jupiter. Thus, the design includes radiation shielding and minimization of penetrating background radiation by a reduced time of flight (TOF) and the use of channel electron multipliers instead of micro channel plates. Additionally, it is considered to apply a diamond coating to the surface, which triggers the start of the

TOF measurement. Synthetic diamond has yielded promising results regarding its ionisation efficiency and angular scattering properties [3]. In addition, the chemical inertness of diamond would be advantageous regarding radiation hardness.

3. Experimental

We operated a prototype of the JNA instrument as well as the test model in the calibration facility at IRF Kiruna. We carried out numerous measurements with different particle species, different energies and different angles of incidence to analyse the detection efficiency, to proof the required mass and energy resolution as well as the angular resolution. As an example, Fig. 2 shows the TOF spectrum of 1.3 keV H, measured with the JNA prototype.

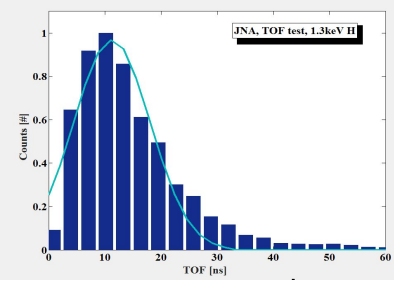

Figure 2: TOF spectrum of 1.3 keV hydrogen, measured with the JNA prototype

Furthermore, we tested the instrument with the start surface being coated with synthetic diamond. We will report on the analysis and results of the test measurements and show the JNA performance meeting all mission requirements.

4. Summary and Conclusions

Numerous models and former space missions have shown that the detection of neutral atoms in the vicinity of a planetary body is a measurement, which yields the data for answering key scientific questions. ENA measurements onboard space missions, e.g. Chandrayaan-1, offer valuable clues about the interaction of the space plasma with the planetary body and the different processes that are alterating the planetary surface.

The PEP/JNA instrument will measure the fluxes of neutral atoms at Jupiter and the Jovian icy moons on the JUICE mission. JNA measurements at Ganymede will help to understand the complex interactions of the Jovian plasma environment with the icy surface of the moon. We present the JNA instrument, the different performance evaluations that were carried out and the results from the test campaign. We will show that the JNA is a high performance instrument to significantly contribute to our understanding of the Jovian system.

Acknowledgements

This work is supported by the Swiss National Science Foundation (SNF) Early PostDoc Mobility Grant No.168708 and the Swedish National Space Board (SNSB).

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