PCG31-P01 Room:Convention Hall Time:May 27 18:15-19:30

Potential for seismic investigation of Europa using meteorite impacts

TSUJI, Daisuke[1*] ; TEANBY, Nicholas[2]

[1]Graduate School of Environmental Studies, Nagoya University, Japan, [2]School of Earth Sciences, University of Bristol, UK

Europa, one of the Galilean satellites of Jupiter, has an icy outer shell, beneath which there is probably liquid water in contact with a rocky core [1]. Europa, may thus provide an example of a sub-surface habitable environment so is an attractive object for future missions to explore. In fact, the Jupiter Icy Moon Explorer (JUICE) mission has been selected for the L1 launch slot of ESA's Cosmic Vision science programme with the aim of launching in 2022 to explore Jupiter and its potentially habitable icy moons.

In order to improve our understanding of the internal structure, a seismic investigation would provide powerful constraints. The Apollo seismic experiment detected numerous seismic events on the Moon, and has revolutionized our knowledge of the lunar interior. On Mars, unmanned establishment of the Viking seismometer was carried out despite the fact that it was not able to capture any detectable events due to the poor coupling to the ground. The deficiency will be addressed by NASA's 2016 InSight Mars lander.

In this study, we investigate the detectability of seismic waves on Europa's surface caused by meteorite impacts. Internal fracturing and cracking of the icy crust could be the largest source of seismic waves, but in general multiple well-dispersed seismometers are necessary to locate the seismic source. However, meteorite impact sites could potentially be located using other methods such as surface imaging. The internal structure could then be estimated using a single seismometer. Recently, the seismic detectability on Mars using a single seismic station has been studied [2]. Motivated by this work, we estimate the number of detectable meteorite impacts per year on Europa by the process mentioned below.

1) We derive a relation between the crater diameter and the impactor's kinetic energy based on observational data compiled from impact tests, controlled explosions, and simulations.
2) Impact frequency on Europa is estimated by the distribution of observed crater sizes.
3) The results of 1) and 2) are combined to give the number of meteorite impacts which can be detected per year.
4) Taking the precision of practical seismic instruments into consideration, we discuss if using a single seismic station could be a reliable way of probing Europa's interior.

Reference

[1] F. Cammarano et al., J. Geophys. Res., 111, E12009 (2006)
[2] N. A. Teanby and J. Wookey, PEPI, 186, 70 (2011)

Keywords: Europa, icy satellites, meteorite induced seismicity, planetary exploration

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PCG31-P02 Room:Convention Hall Time:May 27 18:15-19:30

Development of electric field instrument onboard spacecraft

ISHISAKA, Keigo[1*] ; KOJIMA, Hirotsugu[2] ; KASABA, Yasumasa[3] ; ABE, Takumi[4]

[1]Toyama Prefectural University, [2]RISH, Kyoto University, [3]Tohoku University, [4]ISAS

Measurements of electric fields are one of key elements for various missions. The detection of electric field is useful to identify global plasma dynamics and energetic processes in magnetosphere and ionosphere. The concrete examples are as follows.

- Electric field structure associated with the charged particle precipitation
- Electric field structure associated with the global motion of the ionosphere
- The role of the electric field in the acceleration and heating mechanisms of ions
- Propagation mechanism of the electric field in the auroral ionosphere to the low latitude ionosphere
- Electric field structure in the equatorial ionosphere

Many electric field measurements have been carried out in Japan. And the electric field detector onboard sounding rockets and satellites have been successfully used in the D, E and F regions of the ionosphere and in the magnetosphere.

The double probe technique have been extensively used on sounding rockets in order to measure electric field in the ionosphere. And the passive double probe technique has been proven to be a reliable technique in the high electron density plasmas of the ionosphere. The technique has been extended to the lower density plasmas of the D region of the ionosphere. For electric field measurement, a wire antenna has been used as a sensitive sensor onboard Japanese sounding rocket. And this antenna will be used for several spacecraft in the future mission. However, its extension mechanism is complicated and it is difficult for the sounding rocket to extend a wire antenna in the ionosphere. Accordingly new type antennas are developed in order to measure the electric field by the sounding rocket. Their antennas fulfill the severe requirements to the antenna system, i.e., light mass, enough stiffness, compact storage, safe extension, and reasonable test efforts. Three antennas were newly developed for the electric field measurement. These antennas were loaded on three sounding rocket in Japan (S-310-37, S-520-23, S-520-26). And these new style antennas deployed normally during the flight of a sounding rocket, and succeeded in the electric field observation in the ionosphere.

This paper describes about the basic measurement techniques of the electric field in the ionosphere. In particular it explains about three new type antennas in detail. Then we show the electric field in the ionosphere measured by the new type antenna onboard the Japanese sounding rocket.

Keywords: electric field instrument, electric field sensor, antenna, sounding rocket, small satellite

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PCG31-P03 Room:Convention Hall Time:May 27 18:15-19:30

Developing of a chip for the interface between plasma wave instruments and plasma particle instruments

ONISHI, Keisuke[1*] ; ZUSHI, Takahiro[1] ; KOJIMA, Hirotsugu[2] ; SAITO, Yoshifumi[3]

[1]Graduate School of Engineering, Kyoto University, [2]Research institute for sustainable humanosphere, Kyoto University, [3]Solar System Science Division, Institute of Space and Astronautical Science, Japan Aerospace Explora

Since space plasmas are essentially collisionless, kinetic energies of plasma particles are exchanged through the plasma waves. These interactions among the space plasmas and the plasma waves are called the wave-particle interactions. The wave-particle interactions are very important in analyzing electromagnetic phenomena occurring in space.

The Wave-Particle Interaction Analyzer (WPIA) is proposed in order to analyze the wave-particle interactions quantitatively and directly, and it will be installed in the next satellite mission ERG of Japan. The WPIA needs to measure the timing of the each particles at the same accuracy as the sampling frequency of the plasma wave. In the case of the ERG, the relative time accuracy is guaranteed by using the time information from the plasma wave instrument. The most precise method is using the same clock for the particle detection as the sampling clock of the plasma wave. Developing the circuit which interface the particle observation pulse with the plasma wave instruments removes the complicated procedure of time setting and enables more simply observation with high accuracy. In this study, we develop the interface circuit which input each pulses derived from the particle to the plasma wave instrument. The circuit composed of discrete components is large scale because the number of outputs from the plasma particle instruments increases according to the number of view divisions. Using the application specific integrated circuit (ASIC), we design the new dedicated chip which takes signals from the plasma particle instruments to the plasma wave instruments.

The interface circuit consists of two stages. The pre-stage converts electric charge to voltage, and the post-stage detects the arrival of a plasma particle from the voltage of the pre-stage. We use a voltage follower circuit as the pre-stage and a comparator circuit as the post-stage. We have designed the pre-stage circuit. The waveform input to the pre-stage circuit is estimated a current pulse at the frequency of several GHz. In order to convert current pulse to voltage with small delay and distortion, we have designed an operational amplifier which is capable of operating at a high speed, and have requested to manufacture a chip. In the present paper, details of the interface circuit and measurement results of the manufactured chip will be focus on.

Keywords: Wave-particle interaction, Interface, ASIC

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PCG31-P04 Room:Convention Hall Time:May 27 18:15-19:30

Improvement of dynamic range of ASIC waveform receiver for plasma wave observations

KOJI, Hiroki[1*] ; OZAKI, Mitsunori[1] ; YAGITANI, Satoshi[1] ; KOJIMA, Hirotsugu[2] ; ZUSHI, Takahiro[2] ; YOSHIDA, Akira[1]

[1]Graduate School of Natural Science and Technology, Kanazawa University, [2]Research Institute for Sustainable Humanosphere, Kyoto University

Further reductions in mass, volume, and power of analog circuits are important in developing scientific instruments of plasma wave observations. Typical plasma wave receiver is roughly divided into two types: one is a waveform receiver and the other is a spectrum one. The waveform receiver provides a waveform with a high time resolution and phase information of a plasma wave. On the other hand, the spectrum receiver provides a frequency spectrum with a high frequency resolution and a high signal-to-noise ratio in comparison with waveform receivers.

We have been developing a plasma waveform receiver using Application Specific Integrated Circuit (ASIC) technology. Previous ASIC waveform receiver consists of a differential Gm-C Low-Path Filter (LPF), a main amplifier for the gain adjustment, a switched capacitor LPF for anti-aliasing with the cutoff frequency of 100 kHz, and a Gm-C LPF for reducing the clock pulse noise of the switched capacitor LPF. The previous ASIC receiver shows a sufficient low noise performance (210 nV/sqrt(Hz) at 10 kHz) and low power consumption (60 mW). However, the dynamic range of output voltage is not sufficient due to using operational transconductance amplifiers (OTAs) of Gm-C LPFs. In order to improve the dynamic range of the ASIC receiver, we have redesigned the ASIC receiver to exclude OTAs. In this study, we used active LPFs consisting of operational amplifiers (OPAs) instead of Gm-C LPFs using OTAs. As a result, the dynamic range increased by 80%. Moreover, the layout area decreased by 18%, and the number of transistors decreased by 60% in comparison with the previous ASIC receiver.

In this presentation, we will present the design principles of our ASIC receiver for plasma wave observations and discuss its electrical performances in detail.

Keywords: Analog ASICs, Plasma waveform receiver

Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

PCG31-P05 Room:Convention Hall Time:May 27 18:15-19:30

A model calculation of MIA sensor characteristics on board MMO

MIYAZAKI, Shoichi[1*] ; MIYAKE, Wataru[2] ; SAITO, Yoshifumi[3] ; YOKOTA, Shoichiro[3]

[1]Graduate School of Engineering, Tokai University, [2]School of Engineering, Tokai University, [3]ISAS

MIA is an electrostatic analyzer, on board MMO. The objectives are studies of plasma environment around Mercury. According to the result of ground test, it has performance almost as designed. This analyzer design is axial symmetric. However, the characteristics are depending on angle of ions' incidence. Assuming that the dependence is caused by slight unexpected shift of cylindrical 3 parts; inner and outer plates, top-hat plate. In this paper, first of all, we calculate two-dimensional and three-dimensional sensor models with axial symmetry, and compare the results with the data of ground test. Then we simulate three-dimensional model with asymmetry. The study will lead to designing electrostatic analyzers with high accuracy.

Keywords: MIA, MMO

PCG31-P06 Room:Convention Hall Time:May 27 18:15-19:30

Laboratory experiment simulating Martian surface observation with submillimeter-wave polarimetric radiometry

ARIMURA, Taketo[1*] ; OCHIAI, Satoshi[2] ; KASAI, Yasuko[2] ; KIKUCHI, Kenichi[2] ; KITA, Kazuyuki[3]

[1]Graduate School of Science and Engineering, Ibaraki University, [2]National Institute of Information and Communications Technology, [3]Faculty of Science, Ibaraki University

Energy and materials exchange between the ground and atmosphere on Mars is deeply related to Martian water cycle. It is worthwhile to observe the spatial and temporal variability of physical temperatures and material compositions in the Martian subsurface from orbiter. Millimeter/submillimeter radiometer is expected to achieve continuously monitoring the Martian subsurface. However, such measurement has never been conducted in planetary explorations. We assess the effectiveness of this observation method by laboratory experiment.

By observing millimeter/submillimeter emission from the Martian subsurface in several incident angles and two polarizations, we can derive physical temperatures and permittivity of the subsurface. In order to estimate those properties from observed emissions, we need to know relationship between emissivity or/and reflectivity and the properties of surface in millimeter/submillimeter wave region. To discuss feasibility of this observation, it is necessary to experimentally demonstrate such estimation from the millimeter/submillimeter observation. It is also important to study the effective skin depth of the material surface in the observation.

We developed an experiment system to examine millimeter/submillimeter wave scattering and emission characteristics of the simulated Martian surface in a chamber. The chamber is designed to measure both emission from simulated surface using a receiver and reflection of the surface using a transmitter and a receiver. We can measure arbitrary-polarized emissions with arbitrary incident angles by moving mirrors in the experiment system. The experiment system is designed to set up the incident angles to an accuracy of 1 degree and measure the brightness temperatures to an accuracy of 2K.

Reflectivity measurements were made first, because emission characteristic is basically predictable from the precise reflection measurements. In experiment, we measured the reflectivity of 2 specimens at 230 GHz frequency range, 13 incident angles (from 20 to 80 per degrees in units of 5 degrees) and 2 polarizations (V and H polarized waves). We examined if we can distinguish two different samples from the reflectivity. Samples we measured are glass and PET plates. An electric property of glass is similar to the main component of Martian rocks and a PET has a permittivity similar to water ice in 230 GHz frequency range. The result of this experiment shows that it is distinguishable the glass plate from the PET plate with reflectivity at 20-70 degree angles in V polarized wave. Then, we measured reflectivity of samples of two layers consisting of the PET and the glass plates at the same conditions (frequency, incident angle and polarization) as the previous experiment. We determined the upper limit of the thickness of the glass plate that we can detect the signal of the PET plate which is placed under the glass plate from the reflectivity measurement at incident angles 65 and 70 degrees in V polarization. The glass thickness of the result was 3.0 mm. The effective skin depth of the glass plate was found to be about twice of the measurement wavelength. From these experiment results, it is estimated that water ice or temperature subsurface is detectable in the depth up to twice wavelength of millimeter/submillimeter by observing radiation from the Martian subsurface. We plan to examine whether able to distinguish between a glass and a PET by emission measurement. Furthermore, it is necessary to confirm the relationship between an effective skin depth and a permittivity of surface in future research.

Keywords: Mars, surface observation, submillimeter-wave