# RECENT RESEARCH ACTIVITIES

## Novel Space Environment Monitor, Instrument, and Space Mission Concepts

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### Space Debris Observation, Modelling, and Mitigation

The space debris problem is tackled from observation (space situational awareness), trajectory evolution, and mitigation points of view. 1) A method to identify the size, shape, and rotation, and to determine the trajectory of known space debris using range Doppler data of MU (Middle and Upper) Radar, RISH, Kyoto Universiry, is investigated with some successful observation results. 2) A study to investigate space debris trajectory evolution focusing on objects smaller than 1 cm has been started to shed light on geomagnetic field effects. 3) Space debris mitigation (orbit control) using Lorentz force by positive charging effect is studied. Lorenz force is based on the interaction between an electro-statically charged debris and the Earth's plasma environment. The orbit control method to decrease the altitude using Lorentz force is studied focusing on decreasing semi-major axis, enlarging eccentricity, and lowering perigee distance. 4) An on-orbit space debris observing system is studied assuming an optical sensor onboard a satellite. The required specifications of optical sensors and ranges of observable space debris are investigated for application to removal sequence.

### Electromagnetic Space Propulsion Systems

Recently, new propulsion systems that utilize electromagnetic forces acting on a charged spacecraft were proposed. The Lorentz force that acts when a charged object goes across the Earth's magnetic field and the Coulomb force that acts on among the charged objects can be employed to control the orbit of charged spacecraft or space debris by controlling the electrostatic potential of the object with charged particle emitters. One of our studies is to evaluate feasibility and performance of such "electromagnetic orbital control" regarding both orbital dynamics and plasma physics by using numerical simulation on the super computer system of Kyoto University. We 1) proposed a new charging model that enables to compute the surface potential fast and precisely by considering a velocity distribution of emitted particles, 2) proposed a new secondary electron emission model for particle simulations that can simulate much like the actual physics than conventional methods, and 3) revealed the thrust performance of an electric solar wind sail, a novel propulsion system which obtains its thrust by deflecting the ions in solar wind with numerous positively charged tethers.

### Miniaturization of plasma wave receiver system

Plasma wave receiver is one of the essential instruments for space environment exploration; however, conventional receiver has a problem in its large weight and size. In order to overcome this problem, we have been miniaturized plasma wave receiver by developing Application-Specific Integrated Circuits (ASIC) for plasma wave receivers. We succeeded in developing miniaturized plasma wave receiver by realizing analog circuit, which is especially large part of the receiver, using ASIC. This miniaturized receiver will be onboard the SS-520-3 sounding rocket, which will launch in the December of this year to resolve the cause of ion outflow phenomena at the cusp region. In addition, we aim to develop a mixed-signal ASIC chip for one-chip plasma wave receiver. The mixed-signal ASIC chip includes all analog and digital circuits for plasma wave receiver. One-chip plasma wave receiver allows to reduce weight and size of the instruments drastically, and it will contribute for increasing opportunities of plasma wave observation.

### Quantitative evaluation of basic properties of nano bubbles in water

The electric and electrochemical performance of nano bubble (NB) in pure water, is reported herein. Recently, NB has found applications in various fields, However, the detailed mechanism underlying the performance of NB is not known, although the relevance of ions (proton and hydroxide ion) in solution has been discussed. Therefore, we investigated NB through electric and electrochemical measurements. First, we conducted a preliminary experiment in an nano bubble generator and a measuring device for the concentration of nano-particles. We also measured the electrical conductivity and found that the amount of flowing gas and the gas species did not influence the NB concentration.