Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)


PPS02-01 Room:301A Time:May 24 13:45-14:00

# Giant Planets: Formation, Atmospheric Evolution, and Future Exploration

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The giant planets are key to the mystery of the origin and evolution of the solar system and, by extension, extrasolar systems. Amongst prevailing hypotheses of their formation ? core accretion and gravitational instability ? the former is generally favored. At the heart of the classic core accretion model is the formation of a solid core of a critical mass of 10-15 Earth masses, followed by gravitational collapse of surrounding protoplanetary nebula that completes the formation of the planet. The core forms from agglomeration of grains of dust, refractory material, metals and ice and the gases they trap. The most volatile of the gases, hydrogen, helium and neon are captured gravitationally during the collapse phase. The atmosphere results from these gases and the volatiles initially trapped in and subsequently released from the core during accretional heating. The above scenario demonstrates that the core is critical to the formation of the giant planets, and that the well-mixed atmosphere is expected to reflect its composition. Since heavy elements comprise much of the core mass, their determination is crucial to any model of the giant planet formation. The core accretion model predicts solar abundances of the heavy elements (>4He), all relative to H. The Galileo probe measurements at Jupiter in 1995 changed all that. The probe revealed that the heavy noble gases, argon, krypton and xenon, were each enriched relative to solar by roughly a factor of two, whereas the enrichment factor was 4-6 for carbon and nitrogen and about 2.5 for sulfur. Thus, these heavy elements were found to be enriched relative to solar by a factor of 4(+/-2), not solar, and the enrichment factor is non-uniform. One missing element is oxygen, which is crucial since water – the principal reservoir of oxygen in Jupiter – was presumably the original carrier of the core-forming heavy elements and could make up half of the core mass or greater. The Galileo probe entered a five-micron hotspot ? the Sahara Desert of Jupiter ? where water vapor was severely depleted. O/H was measured to be 0.4x solar in this site. It is unknown whether water is depleted everywhere on Jupiter or enriched like the other heavy elements. The Juno microwave radiometers will measure and map water to deep tropospheric levels in Jupiter in July 2016. It is only then one could assess whether Jupiter is indeed oxygen poor and carbon rich like the exoplanet hot Jupiter WASP-12b, or not. Even after the inventory of key heavy elements has been completed for Jupiter, comparison with the other gas giant, Saturn, is essential. However, with the exception of carbon, no reliable data exist on other heavy elements for this planet or, for that matter, the icy giant planets, Uranus and Neptune. Considering the fundamental importance of this science, which only entry probes can deliver, the US NRC Planetary Decadal Survey has recommended a Saturn probe as one of four candidate missions in the New Frontiers class and a Uranus orbiter and probe as one of four candidate missions in the flagship class for the 2013-2023 decade. Relevant publications may be downloaded from www.umich.edu/˜atreya for personal use.

Keywords: Solar System, Giant Planets, Jupiter, Saturn, Uranus, Neptune, Formation, Origin and Evolution

PPS02-02 Room:301A Time:May 24 14:00-14:15

# Formation of The Jovian and Saturnian Satellite Systems

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The Jovian satellite system mainly consists of four Galilean satellites, where the inner two satellites are rocky and outer two are icy, and only the outermost one is compositionally undifferentiated. They have similar masses and are trapped in mutual mean motion resonances. On the other hand, the Saturnian satellite system has only one big icy body, Titan, and the other satellites have masses that are two orders of magnitude smaller. Since both satellite systems would have been produced in similar circum-planetary proto-satellite disks, the origin of the diversity has been a long-standing question. Here we explain the origin of the diversity by simulating growth and orbital evolution of proto-satellites in an accreting proto-satellite disk model that is combined with the idea of different termination timescales of gas infall between Jupiter and Saturn based on a planet formation model. We show that in the case of the Jovian system, a few similar-mass satellites are likely to remain in mean motion resonances, the configuration of which is formed by type I migration, temporal stopping of the migration near the disk inner edge, and quick truncation of gas infall by gap opening in the Solar nebula. The Saturnian system tends to end up with one dominant body in the outer regions caused by the slower decay of gas infall associated with global depletion of the Solar nebula. The compositional zoning of the predicted satellite systems is consistent with the observed satellite systems. Our results indicate that the diversity of the satellite systems is closely related to how the final masses of gas giant planets are determined, which is a big debate in the context of the mass distribution and multiplicity of extrasolar gas giants. The architecture of the Galilean satellites may be fossil evidence that Jupiter opened up a clear gap in the circum-stellar proto-planetary disk to terminate its growth.

Keywords: satellites, Galilean satellites, Titan, rings, satellite formation, planetary formation

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PPS02-03 Room:301A Time:May 24 14:15-14:30

# Dehydration of primordial hydrous rock in Ganymede: formation of the conductive core and the grooved terrain

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From gravity data, it has been found that Ganymede has a small value of the moment of inertia (MoI) factor (0.3115), which suggests a highly differentiated interior. Combined with its mean density (1,942 kg $m^{-3}$), a three-layered structure (an outermost $H_2O$ layer, a rocky mantle, and a metallic core) is most consistent with the gravity data. Also, existence of the intrinsic magnetic field strongly supports the existence of a (at least partially) liquid, iron core. However, process of the internal differentiation including the core formation is highly unclear, and the size of Ganymede implies that only accretional heat is insufficient to segregate the water, rock, and metallic materials completely. On the other hand, Callisto has similar size to Ganymede but show larger value of the MoI (0.355) implying incomplete differentiation. Although many hypotheses to explain this contrasting characteristic between two moons have proposed, but none of these theories has been sufficiently convinced. Here we suggest another hypothesis for the internal evolution in early stage and focus on a dehydration process of primordial rock-metal-mixed core.

Dehydration of hydrous rock and associated rheological change might be a key to create the dichotomy but its possible influence to the thermal histories of these satellites has never been explored. During the stage of accretion, rocky component is possibly hydrated because of the chemical reaction with liquid water generated by accretional heating. The similarity in reflectance spectra among hydrated carbonaceous chondrites and asteroids near Jovian orbit also implies that the constituent material of the icy moons has already been hydrated prior to their incorporation into circum-Jovian nebula in which the regular satellites accreted. After the end of accretion (and after initial upwelling segregation of excess water due to the accretional heating), hydrous rock-metal-mixed core starts to warm due to the decay of long-lived radioactive elements. The thermal convection occurs efficiently in such mixed core because of low viscosity of hydrated minerals. However, once the temperature within the mixed core reaches the dehydration point then the viscosity would significantly increase and the efficiency of heat transport would decrease. As a result, thermal run-away would occur, that is, the core temperature would increase higher and the dehydration of rock would further proceed. Consequently, the temperature would exceed the melting point of the metallic component, and thereby metal segregation from rocky material could occur, although in mainly depends on the amount of the heat sources. If the trigger of thermal runaway needs sufficient rocky mass near that of Ganymede, it could explain the dichotomy in differentiation state between the two satellites and the metallic core formation of Ganymede.

To test above idea, we performed numerical simulations for the internal thermal evolution taking into account the reaction heat due to dehydration. In a reasonable range of viscosity is assumed for hydrated rocky core, models for Ganymede experience the dehydration of the pristine mixed-core and possibly the metallic component could segregates from the rocky materials in case of the high silicate content and/or higher viscosity of hydrous rock. On the other hand, Callisto does not undergo dehydration because of the smaller amount of radiogenic heat. The difference of radiogenic heat and the dehydration process have potential to create the dichotomy between two moons. Moreover, this may also explain the geological records on Ganymede showing the occurrence of global extension after the period of heavy bombardment. Global mapping with high spatial resolution in future mission on giant icy moons and improvement of accuracy in cratering chronology (e.g., current estimate on Ganymede's bright grooved terrain has uncertainty of an order of Gyr) are needed to examine our hypothesis.

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PPS02-04 Room:301A Time:May 24 14:30-14:45

# Tidal Distortion of Outer Planet satellites: Implications for Interior Structure and Thermal State

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In the giant planet systems many satellites are subject to significant tidal distortion. Most prominent examples are Io, where the volcanism is driven by tidal friction, and Europa, where tidal heating may play an essential role to sustain a subsurface ocean over long time. However, even for other satellites, e.g. Ganymede, Enceladus, and Titan, tidal distortion is not negligible.

Measuring tidal amplitudes, the tidal potentials, and in some cases the thermal activity of the moons are key factors to understand the present states with respect to interior structure, rheology and evolution of the satellites.

The implication of tidal interaction of the satellites with their primary planets and the prospects for detecting the signals from orbit or at the surface by future missions will be discussed for several examples in the Jovian and Saturnian systems.

Keywords: satellites, giant planets, tides, interior

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# Ice rheology and tidal heating of Enceladus

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The small Saturnian satellite, Enceladus has an active surface in spite of its small radius (~250 km). Cassini prove observed that Enceladus radiates 6-16 GW of heat from the south polar terrain. One of the effective heat source of Enceladus is tidal heating. However, it is calculated that Enceladus model with Maxwell rheology cannot produce sufficient heat by tidal heating.

In this work we considered Burgers and Andrade model as a ice rheology of Enceladus. Some laboratory experiments have proved that Burgers and Andrade model is more efficient rheology to the stress. We calculated the amount of heat produced by tidal heating by using two rheology models, and found that Burgers and Andrade bodies can produce comparative heat to observed heat flus (~ giga watt).

Keywords: Enceladus, Tidal heating, Ice Rheology

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PPS02-06 Room:301A Time:May 24 15:00-15:15

# Volatile partitioning and formation of core, mantle, and atmosphere on early Titan

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Titan is a complex body with a thick atmosphere composed mainly of N2 and CH4, relatively young surface with lakes of liquid hydrocarbons, ice mantle that holds an interior liquid ocean, and low density core. The core may consist of either a mixture of ice and rock or hydrous silicates, suggesting that Titan's interior would have been much colder than previously thought (Iess et al., 2009; Fortes et al., 2012). However, such a view of a cold interior seems to be inconsistent with evidence for extensive geological activities near the surface inferred from the young surface age (Neish and Lorenz, 2012) and presence of radiogenic Ar degassed from the interior (Niemann et al., 2005). In addition, the findings of significant amounts of CO2 in Enceladus plumes (Waite et al., 2009) indicate that the chemical composition of the building blocks of Titan may have also been a comet-like one with a few percents of CO2 content relative to H2O. Nevertheless, the presence of such CO2 in Titan's proto-atmosphere and mantle should have resulted in the formation of large amounts of atmospheric CO in addition to N2 through photolysis (Atreya et al., 1978), shock heating (McKay et al., 1988; Ishimaru et al., 2011), and hypervelocity impacts (Sekine et al., 2011). Although the Cassini spacecraft has provided important clues to understand the origin and evolution of Titan, there is no unified view that accounts for the complex nature of the core, mantle, and atmosphere consistently.

Here we investigate partition and chemical evolution of primordial CO2, NH3 and CH4 in a water magma ocean that is considered to have been formed during Titan's accretion (Kuramoto and Matsui, 1994). On the basis of laboratory experiments, we show that primordial CO2 would have been readily converted to carbonate minerals in the water magma ocean through hydrothermal reactions with primitive minerals, such as olivine. Thus, CO2 would have been partitioned mainly into the core by forming a low density carbonate during accretion. The proto-atmosphere and mantle conversely would have been highly depleted in CO2, preventing the formation of a thick CO atmosphere. On the other hand, our experimental results indicate that NH3 would not have been converted into N2 in the water magma ocean due to the efficient formation of H2 through serpentinization, suggesting that NH3 has been partitioned mainly in the mantle and proto-atmosphere. Given the low solubility of CH4 in the water magma ocean, CH4 is considered to have been partitioned mainly in the proto-atmosphere. Because of the thermodynamical stability of carbonate at high temperatures (e.g., 2000 K) under high pressure conditions corresponding to Titan's core (Isshiki et al., 2004), the carbonate-rich, low density core allows a warm interior of Titan, consistent with the evidence for extensive surface geological activities. Our model provides a new hypothetical starting point for the evolution of interior and atmosphere-surface systems of Titan and other large icy bodies.

Keywords: Titan, partitioning, hydrothermal reactions, icy satellites, core, atmosphere

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PPS02-07 Room:301A Time:May 24 15:30-15:45

# The capture and release of Trojan asteroids by the giant planets during the solar system history

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Trojan objects can be dynamically stable over billions of years, implying that they carry precious information about the history of the solar system. We performed numerical simulations to investigate the origin and long term evolution of Trojans of the four giant planets. The results suggest all giant planets are able to capture and retain a significant population of Trojan objects from the primordial planetesimal disk after planet migration. In general, captured Trojans yielded a wide range of eccentricities and inclinations. The bulk of captured objects decay over Gyr providing an important source of new objects on unstable orbits. Our results suggest the bulk of observed Jovian and Neptunian Trojan populations are the survivors from a larger captured population, but their high-i component (>20~25 deg) remain unexplained so far.

Keywords: Edgeworth-Kuiper belt, Solar system, Giant planets, Orbital resonances, Trojan asteroids, Trans-Neptunian objects (TNOs)

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PPS02-08 Room:301A Time:May 24 15:45-16:00

# Slowing ion by a dust-plasma interaction and ionospheric conductivities in Saturn's plasma disk

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Past observations using the particle detectors on Voyager and Cassini showed that the plasma speeds in the Saturn's inner magnetosphere are close to the ideal co-rotation speed around 5 Rs and gradually become 70?80% of the ideal co-rotation speed at 7 Rs [Bridge et al., 1981, 1982; Richardson, 1986, 1998; Wilson et al., 2008, 2009]. On the other hand, observations using the Langmuir Probe (LP) on board the Cassini spacecraft showed that the ion bulk speeds are close to Keplerian speed in the E ring [Wahlund et al., 2009]. The E ring of Saturn consists of small (micron- and nano- meter sized) dust particles. These dusts are negatively charged inside 7 Rs and expected to contribute to the electro dynamics in the plasma disk [Horanyi et al., 2004; Kempf et al., 2008]. Near Enceladus, which is a major source of the E ring dusts, the electron densities are significantly smaller than the ion densities and the ion speeds are near Keplerian [Morooka et al., 2011]. According to the latest ion modeling, the ions are slowed down due to the interaction with dust through the magetosphere-ionosphere coupling and the ion speeds from the modeling are consistent with LP observations when the thickness of dust distribution is larger than 3 Rs. Moreover, the ion speeds are Keplerian in high density region such as the neighborhood of Enceladus. However, this model is only solved in one dimension, which is the radial component.

We have calculated the ion speeds in the two-dimension expanded in the latitudinal component to investigate the effect of the distributions of density and temperature in latitude on the ion speeds. We have also investigated the effect of the ionospheric conductivities. The ionospheric conductivities are considered a few mho [Cowley and Bunce, 2003; Cowley et al., 2004, 2008; Moore et al., 2009]. Cowley and Bunce [2003] calculated the co-rotation lag due to the ionospheric current in the Saturn's inner magnetosphere. Moore et al. [2009] estimated the latitudinal variations of Pedersen conductivity. However, variations of ion speeds due to the changes of the ionospheric conductivities are not estimated. We have estimated the variations of ion speeds with our model that the effect of dusts is included and extended in two-dimension.

In this presentation, we discuss importance of role to inner magnetosphere played by dusts and the ionosphere through monitoring the ion speeds. We also discuss based on our results that future exploration to Saturn plays very important roles in planetary sciences.

Keywords: Saturn, inner magnetosphere, ionosphere, plasma disk, dust-plasma interaction, dusty plasma

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PPS02-09 Room:301A Time:May 24 16:00-16:15

# On the feasibility of characterizing Jovian auroral electrons via $H_3^+$ infrared line-emission analysis

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Ground based telescopes can monitor Jovian infrared (IR) auroral activities continuously for an extended time interval compared to the more restricted temporal coverage of ultraviolet (UV) observations. Here we investigate the feasibility of characterizing the Jovian auroral electron energy and flux via $H_3^+$ IR line-emission analysis. Since the departure from local thermodynamic equilibrium (LTE) varies with vibrational levels and altitude, measurements of the relative emission line intensities reveal the altitude of emission and hence the electron energy. The combination of three $H_3^+$ line-intensity ratios is required to determine the electron energy and the background temperature. The feasibility issue is evaluated by studying how the observational error propagates into the error of the estimated electron energy. We have found several best sets of $H_3^+$ lines from which the intensity-ratios can be utilized for the present purpose. Using these lines in the observed 2- and 4- micron wavelength ranges, we can estimate the electron energy and the background temperature within errors of a factor of ~3.5 and 3%, respectively, if the observation error is 1%. Since Saturnian $H_3^+$ emissions vary far more substantially according to temperature variations, the method described here is not applicable to observations of Saturn. We introduce the application of our model to observation and future plan.

Keywords: Jupiter, ionosphere/thermosphere, infrared emission, aurora, Saturn

PPS02-10 Room:301A Time:May 24 16:15-16:30

# Mixed time-frequency patterns of Jovian S- and L-bursts at high resolution, wide band, and sensitivity

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Jovian decametric (DAM) S-bursts are powerful pulses of radio emission presumably generated within the magnetic field flux tube connecting Jupiter with its innermost satellite Io. In the time-frequency plane, the S-burst patterns are distinguished from much slower L-type ones by both the characteristic time scale of a narrow band receiver output signal (milliseconds compared to seconds in the case of L-emission) and mostly negative frequency drift across a frequency band of several MHz. It should be however noted that the classification of Jovian DAM spectral patterns into two types only appears to be a very rough approximation to versatile morphology observed during typical noise storms. Very often S- and L-type emissions are interweaved in spectrograms (see, Fig.1) that makes classification into two types difficult, if possible at all, leading many authors to the necessity of suggesting new types of Jovian DAM radiation, such as N-emissions [1], slow- and fast-drift shadow events [2,3], tilted V-patterns [4], modulation lanes [5], trailing edge emissions [6] etc.

Many observational features of the both types of DAM emission can be explained within a model of cyclotron maser pumped by a loss-cone distribution of velocities in the upstream flow of electrons [7]. Many aspects remain however unclear, e.g., why the emissions have a pulsed character and how extremely complicated spectral patterns are formed.

In this paper we report the results of recent analyses of DAM emissions recorded in 2004-2008 at the world most sensitive decameter array UTR-2 equipped with a digital waveform recorder [8] at the back end. The baseband recording enables one to study the spectral patterns with very fine time and frequency resolutions thus providing means for analyzing S-bursts of arbitrary complexity. On the other hand, wide operation band (20 MHz) of the receiver and array permit the analysis to be performed simultaneously at different frequencies where various spectral patterns occur. With such powerful tools, we could study the amplitude fluctuations down to the time scales of microseconds as well as develop new methods of detecting coherent segments in the waveforms corresponding to S- and L-emissions of various spectral shapes. Depending on the instantaneous bandwidth and morphology of the frequency drifting S-burst patterns, we identified two general classes of S-burst events that could be called wide- and narrow-band S-bursts. The bursts of the former type could be attributed to trains of Alfven waves [9,10] triggering those of the latter type having a narrower instantaneous bandwidth and slower frequency drift rate.

The analysis is then focused on the coherent properties of subpulses detected at microsecond time scale resolution that had been initially attributed to the latter class of events only [11]. Finally we demonstrate that at microsecond-scale resolution there is now difference between emissions of different types demonstrating signatures of cyclotron maser amplification. Despite the fact that most of the observed spectral patterns could be generated by a maser amplifier, the reason for their discrete pulsed character at the millisecond time scale still remains to be found.

[1] T.D. Carr, et al. in A.J. Dessler (ed.), Physics of the Jovian Magnetosphere, Camb. Univ. Press, 1983.
[2] T. Koshida, et al., J. Geophys. Res. 115, A01202 (2010)
[3] J. J. Riihimaa, et al., Icarus 48, 298 (1981)
[4] J. J. Riihimaa and T.D. Carr, The Moon and the Planets 25, 373 (1981)
[5] G. Litvinenko, et al., A&A 493, 651 (2009)
[6] M. Oya, et al., Earth, Moon and Planets 88, 187 (2002)
[7] P. Zarka, J. Geophys. Res. 103, 20159 (1998)
[8] V.B. Ryabov et al., A&A 510, A16 (2010)
[9] R. E. Ergun et al., J. Geophys. Res. 111, A06212 (2006)
[10] S. Hess, et al., J. Geophys. Res. 112, A11212 (2007)
[11] V. B. Ryabov, et al. J. Geophys. Res. 112, A09206 (2007)

Keywords: Jupiter L- and S-bursts, waveform, coherence, cyclotron maser, Alfven waves

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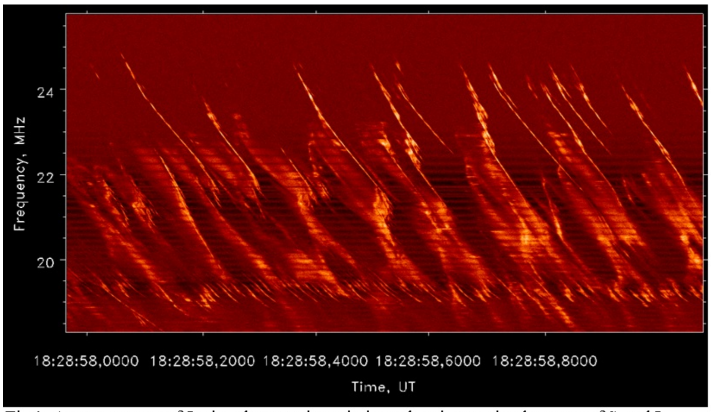


Fig.1. A spectrogram of Jovian decametric emissions showing a mixed pattern of S-and L-bursts. Observed at UTR-2 array on March 13, 2004

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# Study of the Jupiter X-ray imaging spectrometer on Jupiter Magnetospheric Orbiter

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In 2000's, the new generation X-ray observatories (Chandra, XMM-Newton and Suzaku) have revealed various new X-ray phenomena in the Jupiter system. The detected objects include Jupiter's aurorae, disk (middle and low-latitude emission), Io, Europa, the Io Plasma Torus, and radiation belts. For example, Jupiter's aurorae emit time variable X-rays via bremsstrahlung by keV electrons and charge exchange by MeV ions (Gladstone et al. 2002 Nature). A diffuse X-ray emission associated with the Jupiter's radiation belts suggests an inverse Compton scattering of tens MeV electrons (Ezoe et al. 2010 ApJ). Hence, the X-ray emission can be a unique diagnostic tool to investigate key fundamental problems on the Jupiter system such as the relativistic particle acceleration and the Jupiter-satellite interaction. However, since these observations have been done with the X-ray astronomy satellites orbiting the Earth, the photon statistics of X-ray spectra and light curves, and the angular resolution of X-ray images were severely limited. In this context, we have started to study design of an X-ray imaging spectrometer for JMO (Jupiter Magnetospheric Orbiter) which is a Jupiter exploration mission led by JAXA descended from international collaboration with JUICE (JUpiter ICy moon Explorer) mission led by ESA in 2020's. JMO is expected to perform high-latitude (10-30 deg inclination) measurements of the Jupiter system and overview the magnetospheric activities. The in-situ measurements by JMO provide us with an unprecedented opportunity to observe Jupiter with extremely high photon statistics, high time and angular resolution. To realize the in-situ X-ray instrument for JMO, stringent mass and power limitations must be fulfilled. Furthermore, the radiation and the contamination of optical lights and debris must be taken care. The base line is a combination of an original ultra-light weight X-ray telescope with the mass to area ratio of 10 $kg/m^2$ based on the micromachining technologies (Ezoe et al. 2010 Microsystem technologies), and a radiation-hard and low-power DepFET imaging detector (Struder et al. 2010 SPIE). In this presentation, the scientific objectives and current status of instrumental study will be presented.

Keywords: Jupiter, magnetosphere, exploration, X-ray, particle acceleration

PPS02-P01 Room:Convention Hall Time:May 24 17:00-19:00

# The first observation of the altitude distribution of Jovian near-IR auroral emission using SUBARU/IRCS with Adaptive Op

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The altitude emission profile is very important to understand that why the spatial distribution of the IR emission from $H_2$ and $H_3{}^+$ are morphologically different (e.g., Raynaud et al., 2004). The origin of this morphological deference is still unknown. It may be caused by the difference of heating altitude and/or difference of precipitation energy.

Although the altitude distribution of IR auroral emission of $H_2$ and $H_3{}^+$ is well discussed by the theoretical model (e.g., Kim et al., 1990; Grodent et al., 2001), observational study is limited. The observation of vertical distribution of $H_3{}^+$ column density and vibrational-rotational temperature are only reported by Lystrup et al., 2008. And there is no vertical-resolved observation of $H_2$ emission.

Based on the model calculation, it is thought that the difference of IR emission altitude between $H_2$ and $H_3{}^+$ is about 500-1000 km (Grodent et al., 2001). It is impossible to detect this vertical difference by ground-based observation, because the typical seeing of 0.6 arcsec is corresponding to the vertical resolution of about 1800 km at the Jupiter. The recent technique of Adaptive Optics (AO) makes it possible to get the high spatial resolved data about 0.1 arcsec, corresponding to the vertical resolution of about 300 km.

Simultaneous $H_2$ and $H_3{}^+$ observation near 2.1 um took place on 30 Nov. 2011 using the SUBARU/IRCS with AO188 system. The slit is set along rotational axis (vertical to the equator) at northern pole. Using Europa for the guide star for AO system, we succeeded the first limb observation of Jupiter $H_2$ and $H_3{}^+$ IR auroral emissions.

In the polar region, $H_2$ emission lines S1(0), S1(1), and S1(2) at the wavelengths of 2.22, 2.12, 2.03 um and several $H_3{}^+$ emission lines are detected.

We will report the difference in the spatial and vertical distributions of those emissions and temperatures, derived from the observation.

Acknowledgement: Based on data collected at Subaru Telescope, which is operated by the National Astronomical Observatory of Japan.

Keywords: Jupiter, ionosphere, Infrared, spectroscopy, thermosphere, aurora

PPS02-P02 Room:Convention Hall Time:May 24 17:00-19:00

# Modeling micro structure of Jovian S-bursts

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Jupiter is known as the strongest source of decametric (DAM) radio emissions in the Solar system. The emissions occur during events called radio storms lasting from tens of minutes to few hours. The radio storms are well predictable, since their occurrence correlates well with certain range of Jupiter rotation phases and orbital positions of Jovian innermost moon Io. The control of radio emissions from Io can be explained by the combination of such factors as strong Jovian magnetic field, fast rotation of Jupiter (much faster than that of Io's orbital motion) and presence of plasma along Io's orbit sputtered by numerous volcanoes on its surface.

Crossing of Jovian magnetic field lines by Io causes about 400 kV voltage across the moon by electromagnetic induction that leads to acceleration of electrons in its vicinity. The electrons perform cyclotron motion propagating along magnetic field lines towards Jupiter. As they approach Jupiter, some of them are reflected at corresponding mirror points due to increasing value of the magnetic field. However, part of electrons that penetrates deeply into Jovian atmosphere is lost due to collisions that leads to a deficit of certain pitch angles in the electron distribution of the upstream and can pump electromagnetic waves to grow by the cyclotron maser instability (CMI) mechanism.

The above macroscopic picture explains many observational features of DAM emissions, but does not account for complex morphology of time -frequency patterns often present in spectrograms. First, the emissions can be roughly divided into two classes called S- and L-bursts, depending on their characteristic time scales: order of seconds for L(Long) ones and order of milliseconds for S(Short) ones. Furthermore, spectrograms of S-emission events present us with perplexing variety of spectral patterns, from simple linearly drifting in frequency bursts to extremely complicated shapes, which can hardly be interpreted within a framework of a simple CMI model.

An attempt to look at S-bursts with sub-microsecond time resolution had been performed in [1,2] aimed at understanding the very basic details of the emission mechanism. It had been suggested in [2] that two classes of models, of amplifier and generator type, can serve as prototypes of linear wave growth and saturated plasma wave instability, correspondingly. The final conclusion of paper [2] derived from the analysis of several simple linearly drifting bursts stated that only the former mechanism could account for the observed characteristics of S-bursts. It remains, however, unclear whether such type of model can be used for explaining the generation mechanism of other, more complicated bursts, as well as whether linear wave growth is never saturated in simple linearly drifting bursts.

In this work, we perform a more systematic study of the Jupiter radio emission waveforms recorded at world largest DAM array UTR-2 on March 15, 2005, with the purpose of validating the amplifier model for a larger set of S-bursts with different properties. First, we analyze several simple linear S-bursts and search for waveform segments with apparent saturation that could be attributed to generator model (Fig.1). We attempt then to interpret the found segments with amplifier model all the same. For this purpose, we perform a numerical simulation of amplifier-type signals trying to reconstruct the found saturating waveforms. Finally, we interpret such waveform segments in terms of characteristic time of autocorrelation function and fluctuating instantaneous bandwidth in the selected S-bursts. We also present the analysis of several S-bursts displaying a complex pattern in the time-frequency plane checking for its consistency with the amplifier-type model.

References
[1] Carr, T. D., and F. Reyes, JGR 104, 25127 (1999).
[2] V. B. Ryabov et al., JGR 112, A09206 (2007).

Keywords: Jupiter, S-bursts, cyclotron maser, amplifier, generator, filter

PPS02-P02 Room:Convention Hall Time:May 24 17:00-19:00

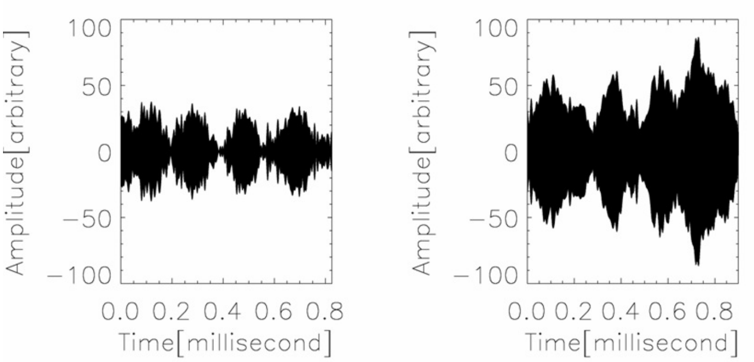


Fig 1. Examples of S-bursts: waveforms of amplifier (left) and generator (right)

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# Titan's degassing history constrained by the isotopic ratio and abundance of Ar in the atmosphere

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The volatile inventory on Titan is a key parameter to reconstruct the evolution of its atmosphere-surface system and climatology. The Cassini spacecraft has revealed the absence of a large liquid $CH_4$ reservoir on the surface and the presence of radiogenic $^{40}$Ar in the atmosphere, suggestive of recent degassing from the interior. However, the timing and magnitude of degassing remain largely unknown. Knowledge on volatile releases from the interior into the atmosphere since its accretion is also essential to understand the thermal history, interior structure, and early evolution of Titan.

Here, we focus on the abundance and isotopic ratio of Ar in the atmosphere to constrain the degassing history of Titan. The abundances and isotopic ratios of Ar in the atmospheres of Earth and Mars have been used to constrain their degassing histories (e.g., Hamano & Ozima, 1978; Tajika & Sasaki, 1996), because of both its inertness and the lack of radiogenic $^{40}$Ar in the early solar system. We have developed a degassing model of Titan's atmosphere based on that of Earth's atmosphere (Ozima, 1975). We calculated the time evolution of the amounts of primordial $^{36}$Ar and radiogenic $^{40}$Ar both in the atmosphere and interior of Titan. In the interior, $^{36}$Ar and $^{40}$Ar were assumed to be homogeneously distributed. We assumed that the initial abundances of $^{40}$K and $^{36}$Ar in Titan's rock component were same as those of the average abundances of CI chondrites ([$^{40}$K] = 0.77 ppm, [$^{36}$Ar] = 1.25 ppb) (Mazor et al., 1970; Lodders, 2003). We also assumed that the ice component was initially free of primordial $^{36}$Ar. We did not consider the escape of atmospheric Ar. The following two extreme cases were considered for the degassing history; (1) continuous degassing through Titan's history and (2) episodic degassing, in which releases of volatiles from the interior occurred episodically in Titan's history (e.g., Tobie et al., 2006).

On the basis of comparison with the observations, we found that the calculated present atmospheric $^{40}$Ar/$^{36}$Ar ratios cannot reproduce the observations ($^{40}$Ar/$^{36}$Ar = 106-295, Niemann et al., 2010) for either continuous or episodic degassing. In the case of continuous degassing, the calculated present atmospheric $^{40}$Ar/$^{36}$Ar ratio reaches only 39. Even in the case of episodic degassing, the $^{40}$Ar/$^{36}$Ar ratios become less than 56, which is the calculated present 40Ar/36Ar ratio in the interior 4.55 billion years after the solar system formation.

There are two possibilities to account for the observed atmospheric $^{40}$Ar/$^{36}$Ar ratio and abundance of $^{40}$Ar in Titan's atmosphere: (1) More than 60% of primordial $^{36}$Ar initially contained in the rock components had escaped in the early history of Titan, or (2) the distribution of $^{40}$K in the interior was heterogeneous, and $^{40}$K was concentrated in cryomagma $>$ 2.6 times that of CI chondrites in the early stage. Either explanation would require a large-scale interior melting and/or consequent formation and loss of proto-atmosphere (Kuramoto & Matsui, 1994). These conclusions suggest that the accretion time of Titan would be much shorter ($< 10^6$ years) than the prediction by the gas-starved model for the circumplanetary subnebula (Canup & Ward, 2006; Barr et al., 2010) and that Titan's interior would have been differentiated (Fortes, 2012), rather than mixtures of ice and rock components (Iess et al., 2010).

Keywords: Titan, degassing, rare gas, icy satellite, evolution of atmosphere