Investigation on rapid variations of Jupiter's inner magnetosphere

H. Misawa and T. Mizuguchi
PPARC, Tohoku University, Sendai 980-8578, Japan
E-mail: misawa@pparc.gp.tohoku.ac.jp

ABSTRACT

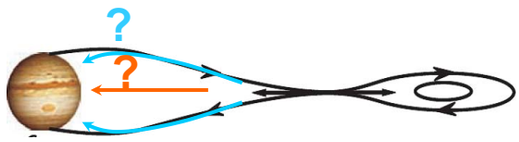
It is known that Jupiter's synchrotron radiation (JSR) has information on dynamics of the deep inner magnetosphere. Our Tohoku University group has made JSR observations at several hundreds MHz for more than a decade, and has showed that JSR at the frequencies generally shows short term variations by more than several tens percent with the time scale of days to weeks (Misawa and Morioka, *ASR*, 2000; Tsuchiya et al., *Adv. Geosci.*, 2011). Furthermore, it is revealed that JSR quite occasionally shows sudden flux variations (SFV) by more than 100% within two days (Nomura et al., *SGEPSS Fall meeting, Nagoya*, 2007). It is quite difficult to explain conventional physical processes for Jupiter's radiation belt electrons because the characteristic time scales for known source and loss processes are much longer than the time scale of the SFV event (Goertz et al., *JGR*, 1978; Hood, *JGR*, 1993; Thorne, in *Phys. Jovian Magnetosphere, Cambridge Univ. Press*, 1983). The SFV phenomena rather recalls the fast particle acceleration and transport in the earth's magnetosphere during substorm events. It is already confirmed that there are substorm like events also in Jupiter's magnetosphere (see Woch et al., *GRL*, 1999; Kronberg et al., *Ann. Geophys.*, 2009), however, it has not been revealed whether the events affect the deep inner region.

In order to reveal unknown physical processes of the SFV events in JSR, we have tried to investigate relationship between the SFV events and electromagnetic phenomena in Jupiter's magenetosphere. We have surveyed in-situ data observed by Galileo and also radio flux data in the hectometer wave range (HOM) using the WIND/ WAVES data. For searching the SFV events, we have used the daily JSR monitoring data at 327MHz observed using the large radio telescopes of STE Lab, Nagoya University. The preliminary analyses show that the SFV events indicate positive correlation with substorm-like events in Jupiter's magnetosphere and also HOM enhancements detected by WIND near the earth to some extent. This result implies that substorm-like events actually lead to rapid enhancement of energetic particles in the deep inner magnetosphere. Although explication for generation process of the energetic particles is deferred in future studies, the correlation between the SFV events and HOM enhancements will give further information from future observations.

Acknowledgement: We would greatly appreciate M. Kaiser, J.-L. Bougeret and the WIND/WAVES team for providing the radio wave data.

Investigation on rapid variations of Jupiter's inner magnetosphere

H. Misawa (PPARC, Tohoku Univ., Sendai Japan)



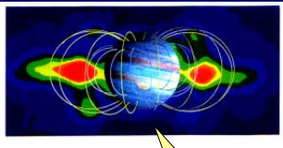
ABSTRACT

It is known that Jupiter's synchrotron radiation (JSR) has information on dynamics of the deep inner magnetosphere. Our Tohoku University group has made JSR observations at several hundreds MHz for more than a decade, and has showed that JSR at the frequencies generally shows short term variations by more than several tens percent with the time scale of days to weeks. Furthermore, it is revealed that JSR (quite) occasionally shows sudden flux variations (SFV) by more than 100% within two day. It is quite difficult to explain its physical process by present theories on particle transport, such as radial diffusion. This phenomena recalls the fast particle acceleration and transport in the earth's magnetosphere during substorm events. It is already confirmed that there are substorm like events also in Jupiter's magnetosphere, however, and it has not been revealed whether the events affect the deep inner region.

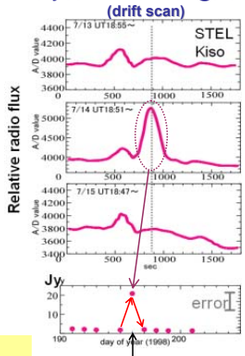
In order to reveal unknown dynamics of the SFV events in JSR, we have tried to investigate relationship between the SFV events and electromagnetic phenomena in Jupiter's magenetosphere. We have surveyed plasma data observed by Galileo and also radio flux data in the hectometer wave range (HOM) using the WIND/WAVES data. For searching the SFV events, we have used the daily JSR monitoring data at 327MHz observed using the large radio telescopes of STE Lab, Nagoya University. In this presentation, we show preliminary results of characteristics of the SFV events and their relation to substorm-like events.

Acknowledgement: We would greatly appreciate M. Kaiser, J.-L. Bougeret and the WIND/WAVES team for providing the radio wave data.

Introduction: Sudden radio Flux Variation (SFV) in Jupiter's inner-magnetosphere



Daily JSR flux variation @325MHz (drift scan)



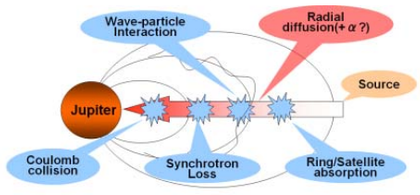
July 14(UT)

(Nomura et al., 2007)

Daily radio flux of Jupiter's syncrotron radiation (JSR) from the radiation belt showed nearly 1000% variation within 1 day! ➔ SFV event.

Introduction: Strangeness of SFV

[Expected causalities of JSR variations (relativistic particle variations in Juputer's radiation belt) and their time scales]



	τ (day)@JSR peak position
Radial diffusion	~1000 days (#1)
Synchrotron Loss	>100 days (#2)
Wave-particle interaction Loss	~10^5 days (#3)
Rings/satellites Loss	>1000 days / 10 days (#2)

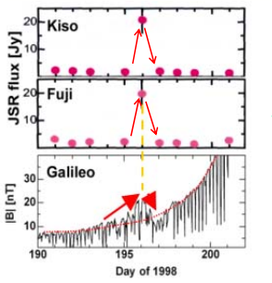
#1: Geoertz et al., 1978 #2: Hood, 1993 #3: Thorne, 1983

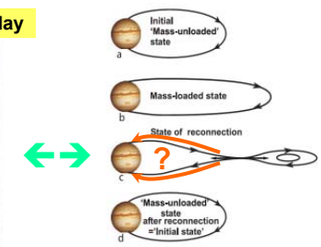
The expected time scales for JSR variations are much longer than the time scale of SFV!

➔ What the causalities??

Introduction: An expected causality of SFV

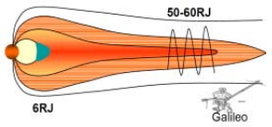
×10 variation within one day





Substorm like event

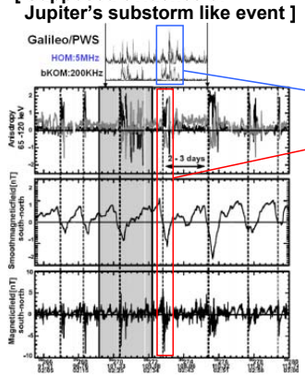
(Kronberg et al., 2007)

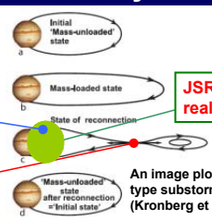


Does substorm like activity originally occurred in the middle-outer magnetosphere activate SFV in the deep inner magnetosphere?

Purpose of this study

[Supposed evidence of Jupiter's substorm like event]





JSR region is really affected??

An image plot of mass-loaded type substorm like event (Kronberg et al., 2007)

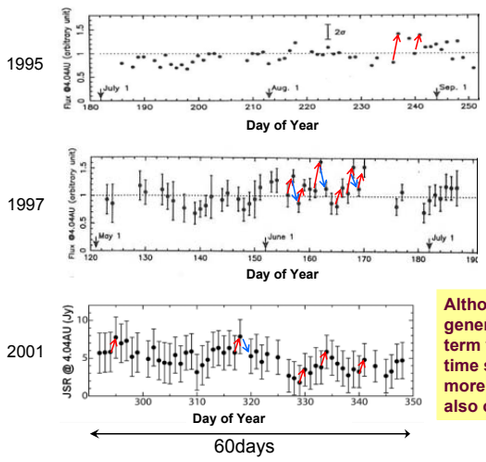
Top : Louarn et al., 1998

Bottom : Kronberg et al., 2005

<<< Purpose >>>

1. Investigation on characteristics of SFV.
2. Assessment of relation between SFV and substorm-like event; i.e. connection of the middle-outer magnetosphere & deep inner magnetosphere.

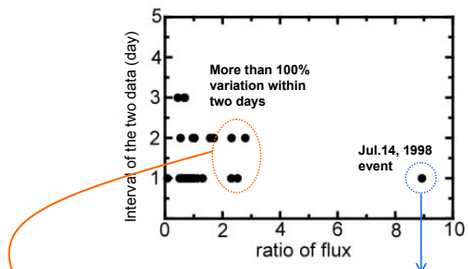
Results: Daily variations of JSR @327MHz



Although JSR@327MHz generally shows short-term variations with the time scale of days-week, more abrupt variations also occur occasionally.

Results: Daily variations of JSR @325MHz

[Daily variation ratio of JSR flux for 1995~1999]



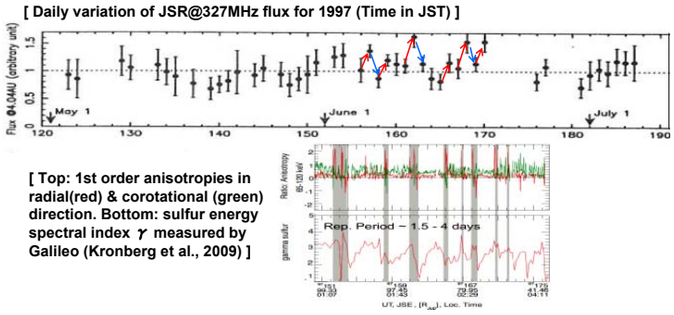
The Jul.14, 1998 event is quite unique: Only one event was identified within 1,200 observation opportunities in 1995-2005.

'SFV event', where its radio flux varies more than 100% within one or two days, is not so rare in JSR@325MHz.

#JSR@325MHz is approximately generated by several MeV electrons around 1.5Rj.

Results: SFV vs. substorm-like event

[Daily variation of JSR@327MHz flux for 1997 (Time in JST)]

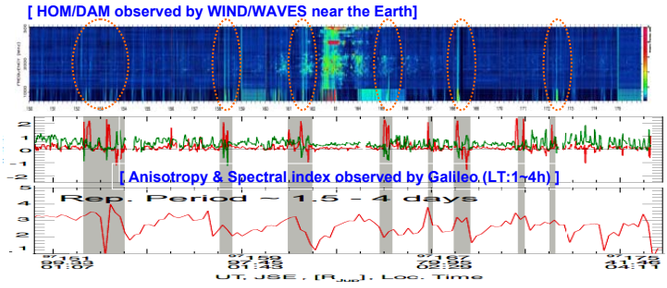


[Top: 1st order anisotropies in radial(red) & corotational (green) direction. Bottom: sulfur energy spectral index γ measured by Galileo (Kronberg et al., 2009)]

Remotely observed JSR 'SFV event' and Galileo detected in-situ 'substorm-like event' shows correlation to some extent.
➔ Magnetic reconfigurations in the middle-outer magnetosphere may really affect the deep inner magnetosphere.
··· now under investigation for other cases ···

Results: substorm-like event vs. HOM/DAM detected near the Earth

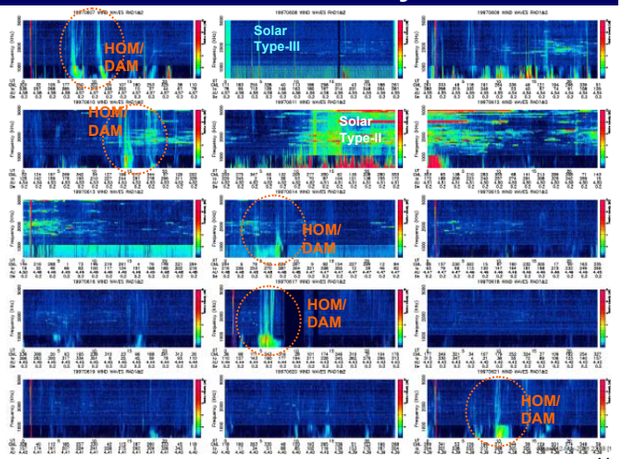
[HOM/DAM observed by WIND/WAVES near the Earth]



Jupiter's HOM/DAM emission observed near the Earth implies occurrence of substorm-like events in Jupiter's magnetosphere.
➔ HOM/DAM gives significant information on further SFV study.

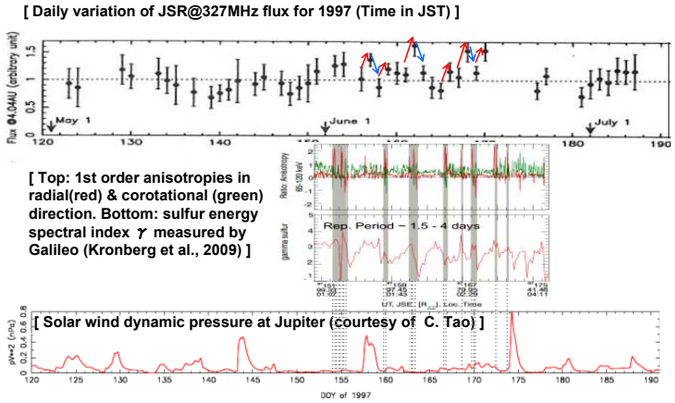
Results: substorm inferred by HOM/DAM

1997
Doy=
158~
172



Affected by Solar wind ?

[Daily variation of JSR@327MHz flux for 1997 (Time in JST)]



[Top: 1st order anisotropies in radial(red) & corotational (green) direction. Bottom: sulfur energy spectral index γ measured by Galileo (Kronberg et al., 2009)]

JSR 'SFV event' may not be triggered by solar wind pv^2.

Perspective : new obs. for JSR, HOM/DAM & opt.

New UHF interferometer (for regular JSR obs.) 201?~

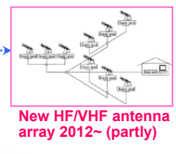
Expansion plan of remote obs. facilities toward collaborative studies

VHF-UHF	Add 1-2 antenna for constructing an interferometer
HF(Decameter)	High sensitive array / domestic & international collaboration
VIS/IR	Newly Developement & Move to Maui, Hawaii

Iitate, Fukushima

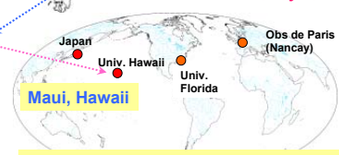
Kiso, STEL

Zao



New HF/VHF antenna array 2012~ (partly)

New Planetary telescope (1.8mϕ) & 0.6mϕ VIS/IR telescope (move from Iitate) 2013~



Maui, Hawaii

(International DAM obs. collaboration : plan with Obs. de Paris(Nancay), U. Florida and U. Hawaii)

Summary

●Purpose:

1. investigation on characteristics of Sudden radio Flux Variation event.
2. Assessment of relation between SFV and substorm-like event

●Analysis:

1. SFV events survey: 325MHz radio flux data observed by the IPS radio telescope, STE lab., Nagoya University.
2. Substorm like event survey: Galileo in-situ data (Kronberg et al., 2009) & HOM near the Earth (WIND/WAVES)

●Results:

1. JSR 'SFV event' and 'substorm-like event' shows correlation to some extent.
   ➔ Magnetic reconfigurations in the middle-outer magnetosphere may affect the inner magnetosphere.
2. HOM/DAM observed near the Earth shows relatively high correlation with occurrence of substorm-like event.
   ➔ HOM/DAM enables us to make further investigations on SFV process.

●Perspective: Further observations

- Source locations by 2 or 3 ele. interferometer @ Iitate (hope recovery!)
- Simultaneous JSR & HOM/DAM/Aurora obs. with new systems

14