

Expected Source Region of Jupiter's Hectometric Radiation Relating to Magnetotail Reconnection

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ABSTRACT

It has been known that Jupiter's auroral radio emission in the hectometric wave range (HOM) is roughly classified into two type occurrence components. One is a component relating to solar wind variations (sw-HOM) appearing around CML(Central Meridian system III Longitude of an observer) $\sim 180\text{deg}$ when solar wind pressure enhances. The other one is generally more intense than sw-HOM and has no or weak relation with solar wind variations (nsw-HOM) appearing around CML $\sim 110\text{deg}$ and $\sim 280\text{deg}$ for major components when D_e (Jovicentric declination of an observer) $\sim 1\text{deg}$ (Nakagawa+, 2000; Nakagawa, 2003). Recently, we found one more nsw-HOM component appearing around CML $\sim 340\text{deg}$, which highly correlates occurrence of magnetic reconnection events in the magnetotail region based on the WIND/WAVES data analyses (Misawa+, 2018). This new component is an important role for the studies of global magnetospheric dynamics of Jupiter since it is a possible remote marker of the reconnection events occurring in the magnetotail. However, due to difficulty in precise direction finding in the hectometric wave range, the radio source of the new component, that is, location of transported energy input originated from reconnection events, has been still unrevealed.

In order to investigate source location of the new nsw-HOM we have made a comparison study of the new component with appearance features of Jupiter's aurora observed by the Hubble Space Telescope and the Hisaki spacecraft, and also have surveyed expected source regions by calculating observable rays using a magnetic field model. The result shows that the occurrence of the new component well correlate with intensification of Jupiter's internally driven type aurora, and expected radio sources are located around dawn (spot) region and/or polar region.

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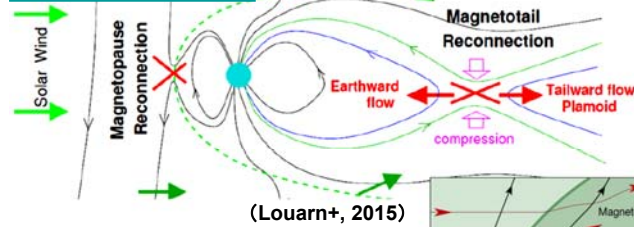
[ABSTRACT]

It has been known that Jupiter's auroral radio emission in the hectometric wave range (HOM) is roughly classified into two type occurrence components. One is a component relating to solar wind variations (sw-HOM) appearing around CML(Central Meridian system III Longitude of an observer) ~ 180 deg when solar wind pressure enhances. The other one is generally more intense than sw-HOM and has no or weak relation with solar wind variations (nsw-HOM) appearing around CML ~ 110 deg and ~ 280 deg for major components when De (Jovicentric declination of an observer) ~ 1 deg (Nakagawa+, 2000; Nakagawa, 2003). Recently, we found one more nsw-HOM component appearing around CML ~ 340 deg, which highly correlates occurrence of magnetic reconnection events in the magnetotail region based on the WIND/WAVES data analyses (Misawa+, 2018). This new component is an important role for the studies of global magnetospheric dynamics of Jupiter since it is a possible remote marker of the reconnection events occurring in the magnetotail. However, due to difficulty in precise direction finding in the hectometric wave range, the radio source of the new component, that is, location of transported energy input originated from reconnection events, has been still unrevealed.

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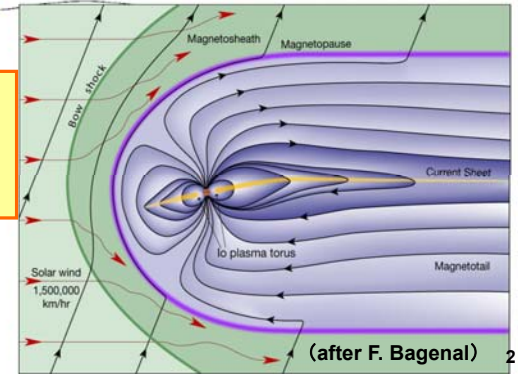
Outstanding Questions on Jupiter's magnetosphere

EARTH:
Solar wind driven



(Louarn+, 2015)

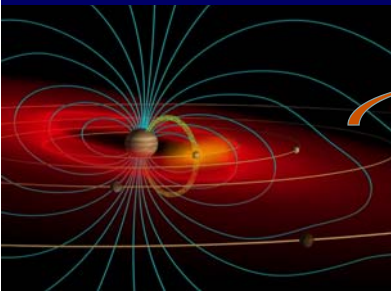
Jupiter:
(mainly) Rotationally driven ...
Roll of logenic plasma?
Roll of solar wind variation?



(after F. Bagenal)

Fig. Earth's & Jupiter's magnetospheres

Expected internal-driven process (IDP)



(©J. Spencer)

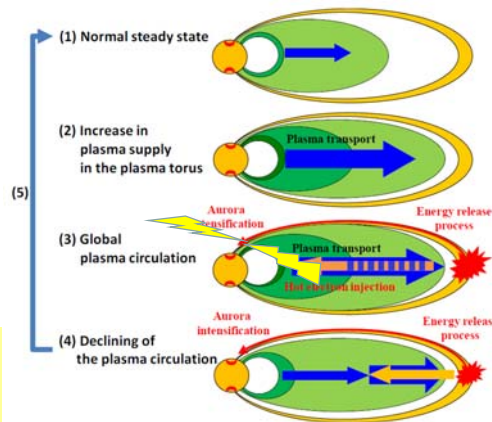


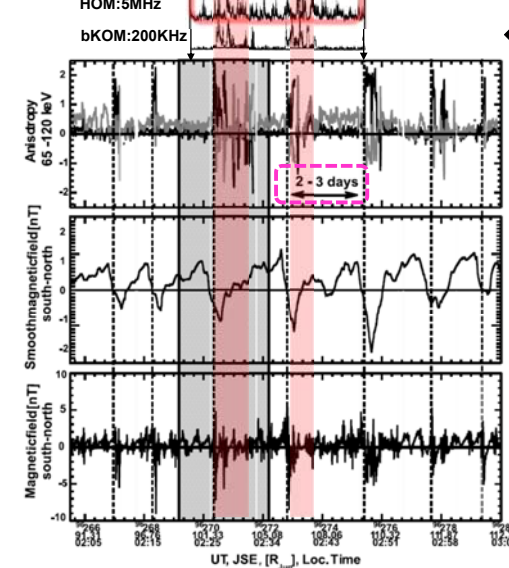
Fig. Schematic plots of expected sequence of Jupiter's internal driven process (Tsuchiya+, (2018))

Subjects:

- ✓ What characteristics does IDP have? (phenomena, time scale,,)
- ✓ How does IDP globally affect to Jupiter's magnetosphere? (area, degree,,)

Signature of internal-driven process : QP nature

Galileo/PWS
 HOM:5MHz
 bKOM:200KHz
 ←Fig. Radio intensities for 5MHz HOM and 200KHz bKOM observed by Galileo in late Sep.1996. (Louarn+, 1998)



← Fig. Anisotropies in the radial and corot. directions (top), s-n comp. of mag. field (smooth & high res.) (Kronberg+, 2005)

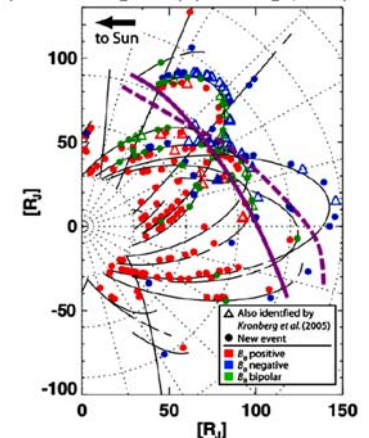


Fig. Positions of detected reconnection signature (Louarn+, 2015)

Characteristics of HOM : What is QP-HOM?

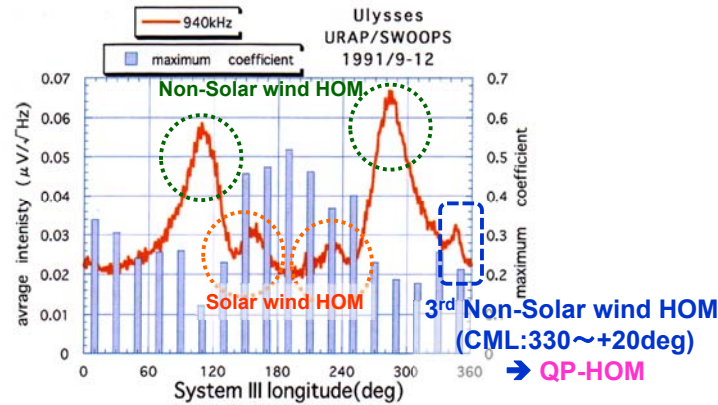


Fig. HOM occurrence dependence on CML and correlation coefficients for solar wind pressure (Nakagawa+, 2000)

5

HOM occurrence in 1996 (Galileo era)

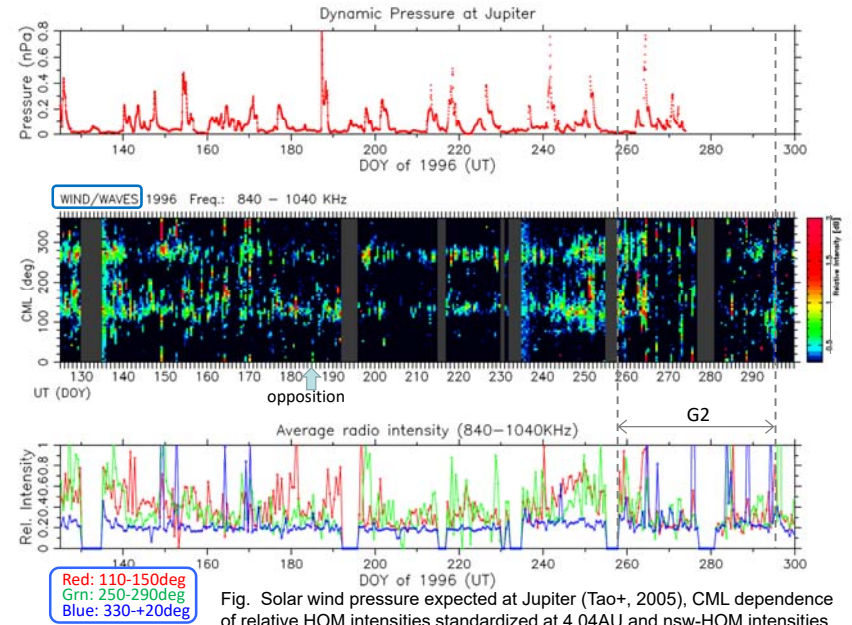


Fig. Solar wind pressure expected at Jupiter (Tao+, 2005), CML dependence of relative HOM intensities standardized at 4.04AU and nsw-HOM intensities.

6

Relation of the 3rd nsw-HOM occ. & recon. events

Table. Statics of the relation between reconfiguration (reconnection) events and occ. of the 3rd nsw-HOM

Orbit No.	Obs. period	No. of remarkable reconfig. event (Kronberg+, 2005)	No. of identified 3rd nsw-HOM (BG+2σ)	Matching rate ⁰ : HOM during remarkable reconfig. Event (%)	Matching rate ¹ : HOM during all reconfig. event ² (%)	Rate of remarkable reconfig. event without HOM ² (%)
G2	1996.9~10	14	14	86	93	14
G7	1997.4	0	0	-	-	-
G8	1997.5~6	6	10	40	90	17
C9	1997.7~9	4	2	100	100	50
C10	1997.9~10	4	5	40	60	25
E16	1998.7~9	3	2	100	100	0
Summary		31	33	67	88	19

- 0: Definition of "Matching": the 3rd HOM events occurred within 10hrs with respect to the period of reconfiguration events
- 1: Reconfiguration events are referred from Vogt+, 2010.
- 2: The period of reconfiguration events when heavy solar bursts appeared are rejected from the statics.

- The 3rd nsw-HOM is identified as having QP nature in the Galileo era.
- The 3rd nsw-HOM appears when reconnection events occurs with 88% matching rate.
 - the 3rd nsw-HOM would be a proxy of indicators reflecting occ. of internal-driven process.
- Next step ... → Where & How are the 3rd nsw-HOM generated ?
- The occ. of the 3rd nsw-HOM is not simultaneous with occ. of the 1st and 2nd nsw-HOM.
 - Energy sources ~ gen. regions and/or phys. cond. would be different. ... > Future study.

7

Inferred internal-driven variation in aurora

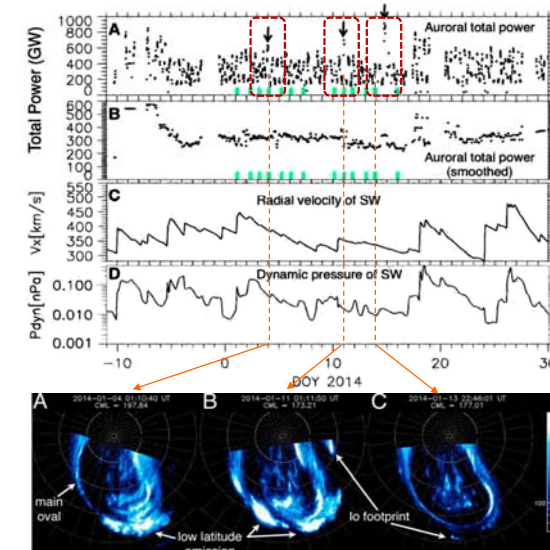
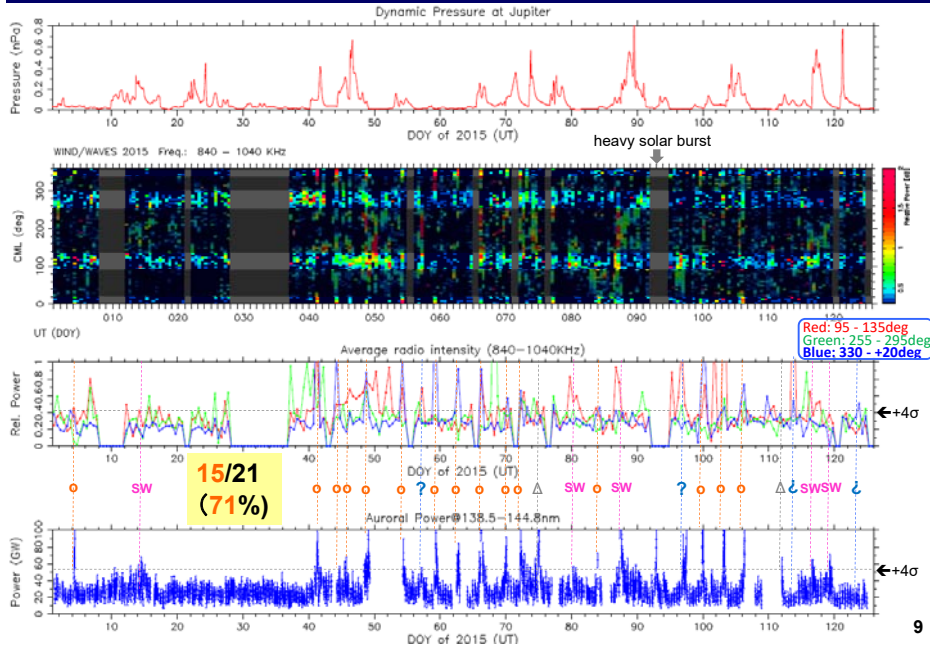


Fig. Auroral total power observed by HISAKI and solar wind condition expected at Jupiter (upper panels), HST UV auroral images corresponding periods (bottom panels). (Kimura+, 2015; see also Gray+, 2016)

→ Short (& QP) variation ~ internal-driven process ~> affecting to low lat.

8

Relation between the 3rd nsw-HOM & Aurora in 2015



Discussion: What are the 3rd nsw-HOM?

Questions about origin of the 3rd nsw-HOM component

- Where are their source regions ?
- Why at CML=+330~+20deg ?

Expected source @ $f \sim f_c$
 $\rightarrow h_{HOM} \sim 1R_J$

$$\omega - k_{\parallel} v_{\parallel} = \omega_{ce} / \Gamma$$

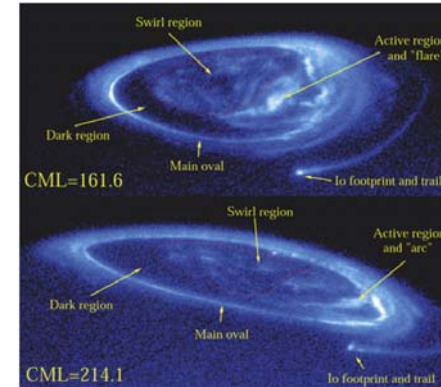


Fig. Jupiter's UV aurora (Grodent+, 2003)

- Auroral condition for N & S ?
- Needs to consider rotational phase (CML)

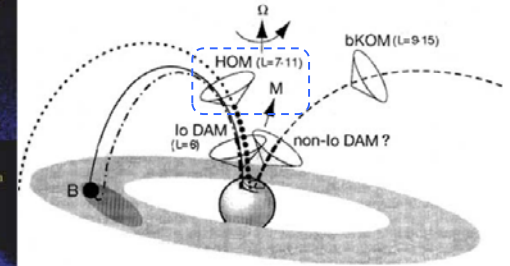


Fig. Expected source locations of Jupiter's radio emissions (Zarka, 2004)

- Needs to consider expected source height @ $f \sim f_c$

10

Discussion: What are the 3rd nsw-HOM?

• Apparent features of aurora for each phase of nsw-HOM

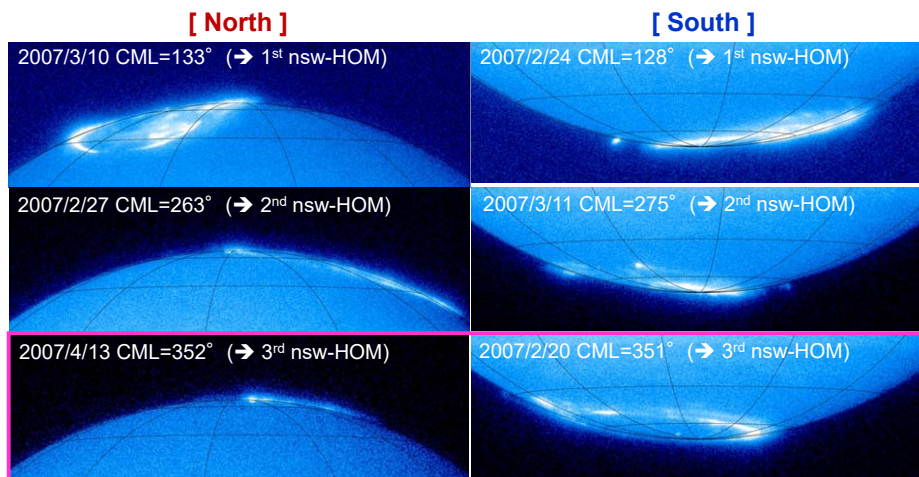


Fig. Jupiter's UV aurora images taken by HST for the campaign obs. period of New Horizon's Jupiter encounter in 2007.

N or S? → Polarization analysis (TBC)

11

Discussion: What are the 3rd nsw-HOM?

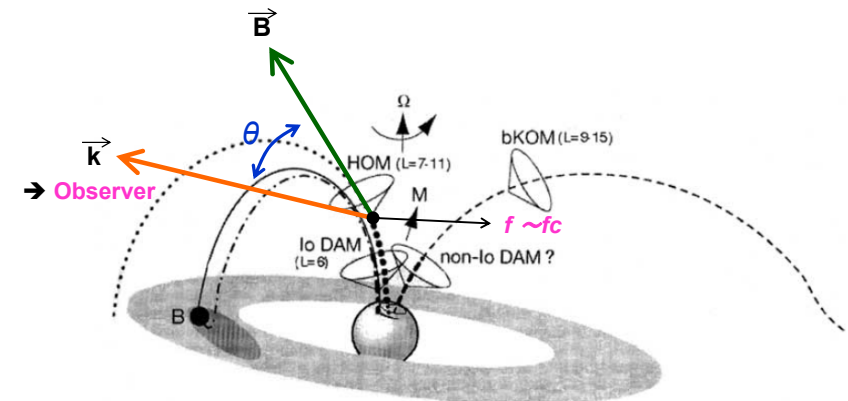
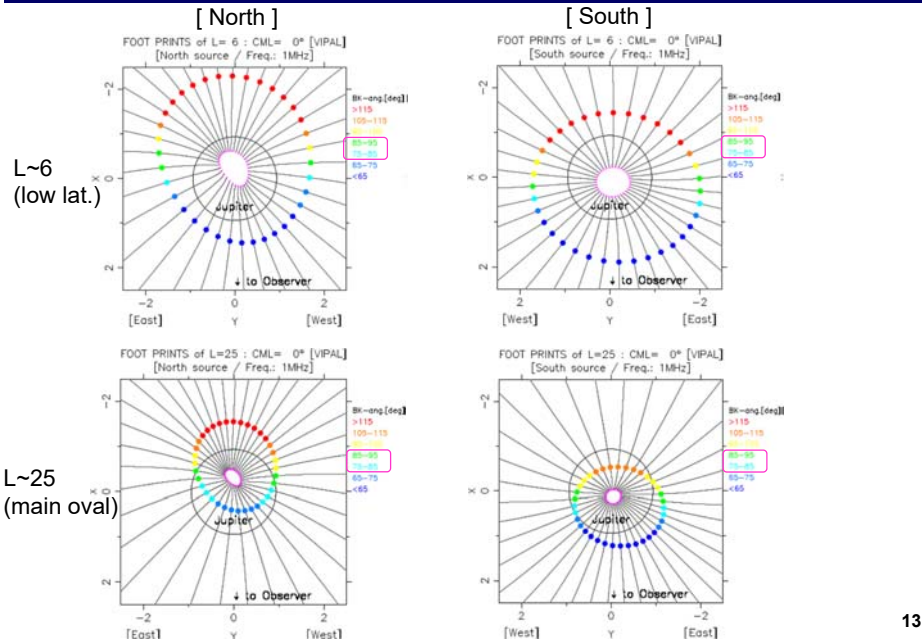


Fig. Expected source locations of Jupiter's radio emissions (Zarka, 2004)

- θ is expected to be less than 90 deg. (Imai+, 2017 etc.)
- θ is simply calculated using the VIPAL mag. Model (Hess+, 2011)

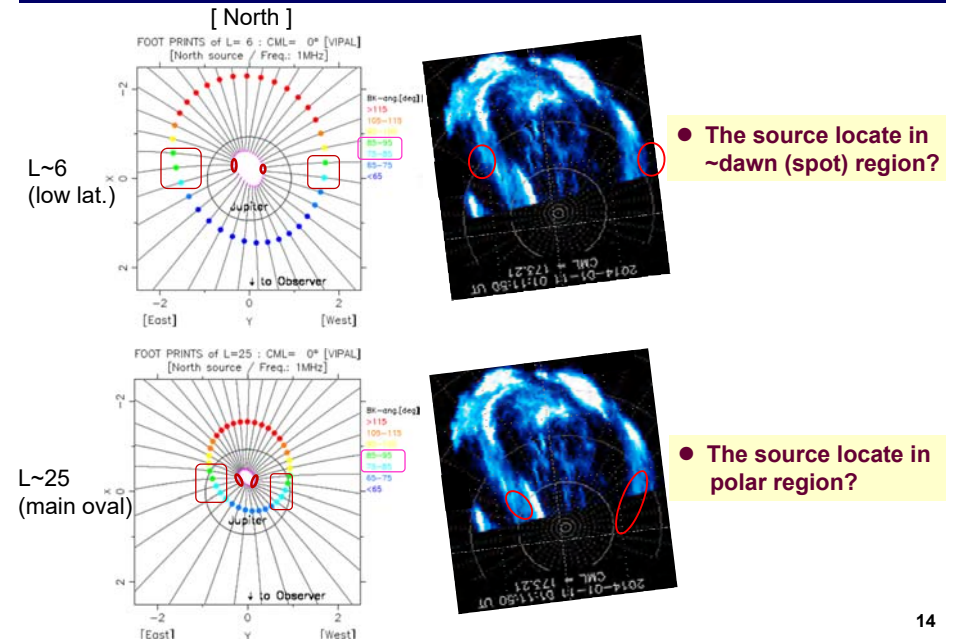
12

Discussion: What are the 3rd nsw-HOM?



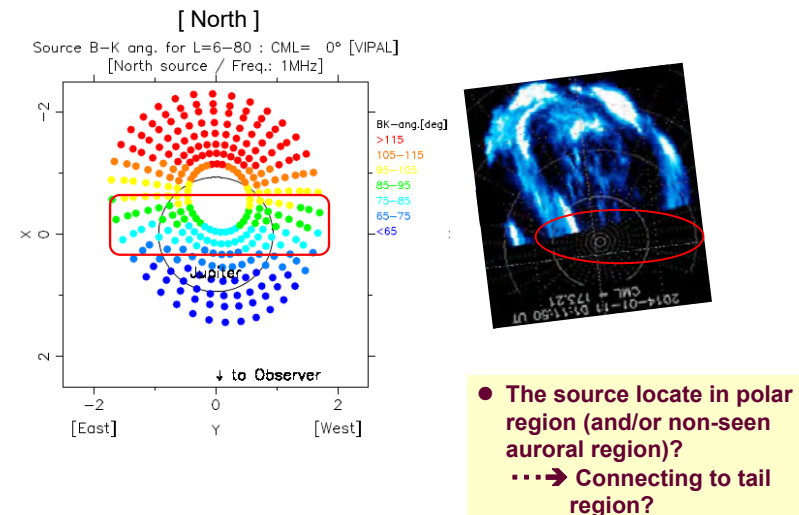
13

Discussion: What are the 3rd nsw-HOM?



14

Discussion: What are the 3rd nsw-HOM?



15

Summary

[Purpose] Elucidation of back-ground physical processes of Jupiter's HOM especially its new (3rd) non solar wind controlling components ("3rd nsw-HOM")

[Analysis] Investigation of HOM data observed by WIND and Comparison of the occurrence characteristics with the aurora observed by HISAKI.
Investigation expected source region using the VIPAL mag. model.

[Results] The 3rd nsw-HOM shows the following natures.

1. Highly correlate occurrence with the magnetospheric reconnection events (Prob.>88%).
2. Well correlate (expected) internal-driven type aurora.
3. Expected 3rd HOM source is dawn (spot) region? or polar region? (if the sources are in the north-hemisphere.)

[Conclusions]

- ✓ The 3rd nsw-HOM would be generated by Jupiter's internal-driven process.
- ✓ The clarifications of its precise source processes & the difference of the other nsw-HOMs are still future studies. (confirm. of polarization, comparison with JUNO...)

16