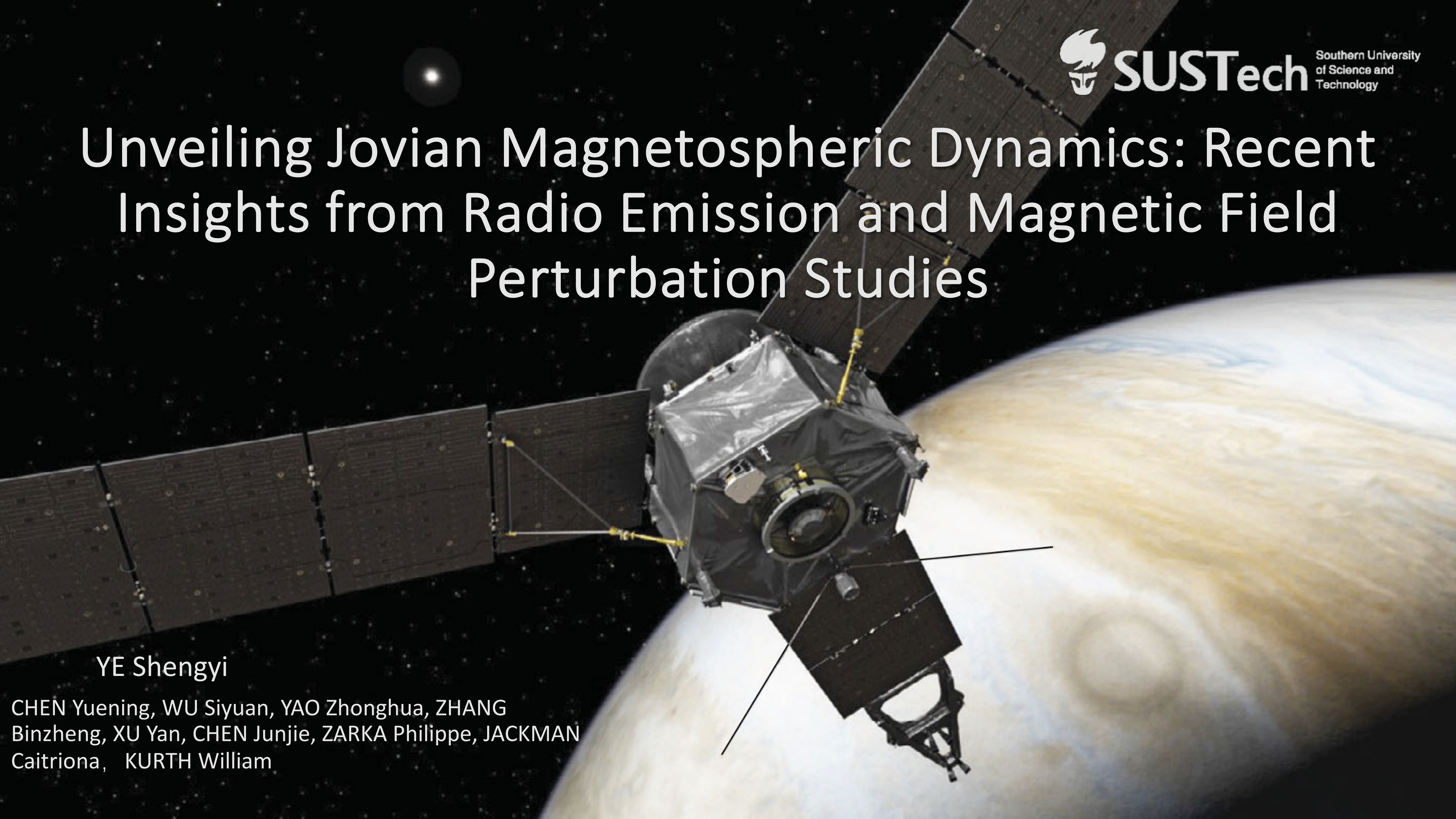


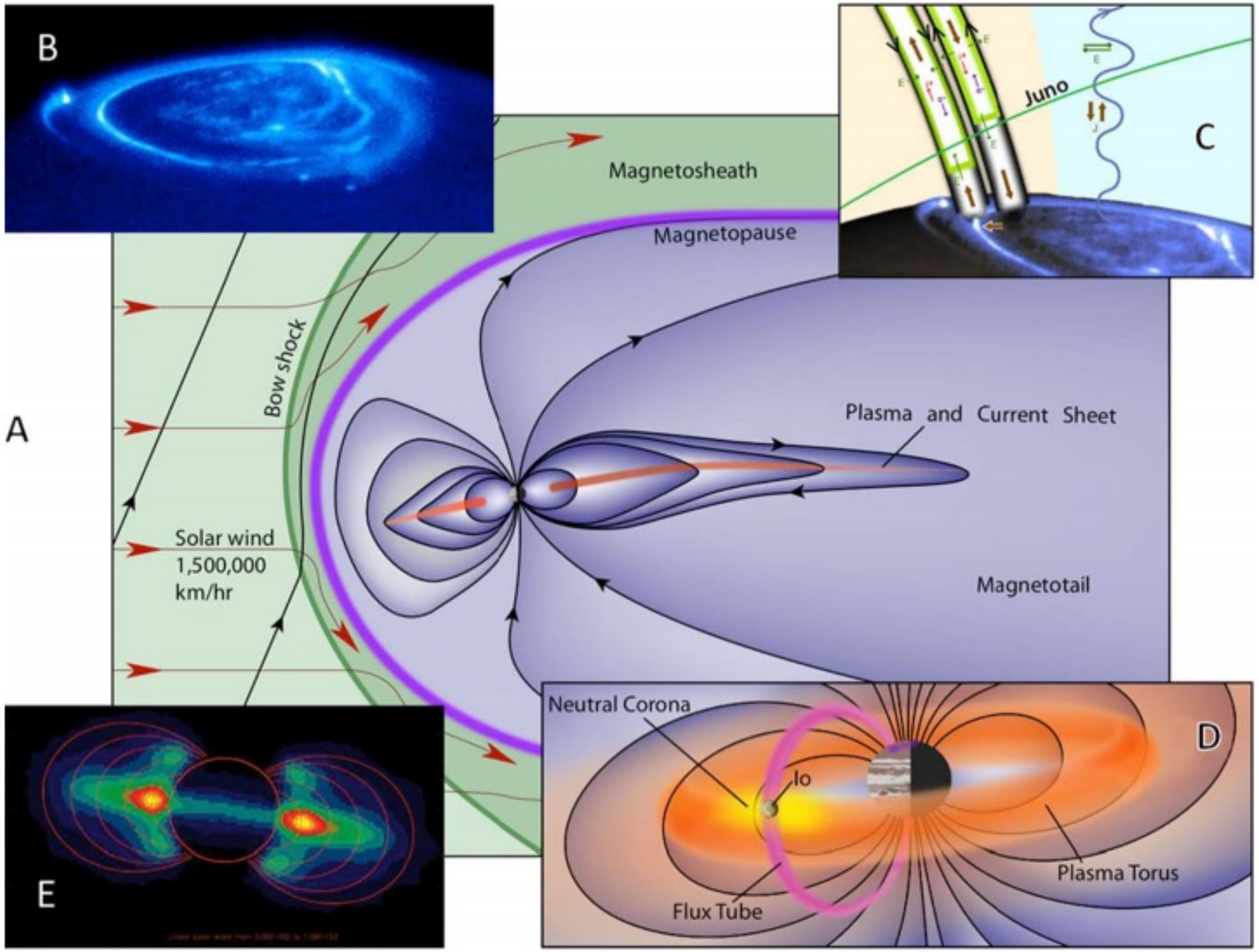
Southern University of Science and Technology

Unveiling Jovian Magnetospheric Dynamics: Recent Insights from Radio Emission and Magnetic Field Perturbation Studies

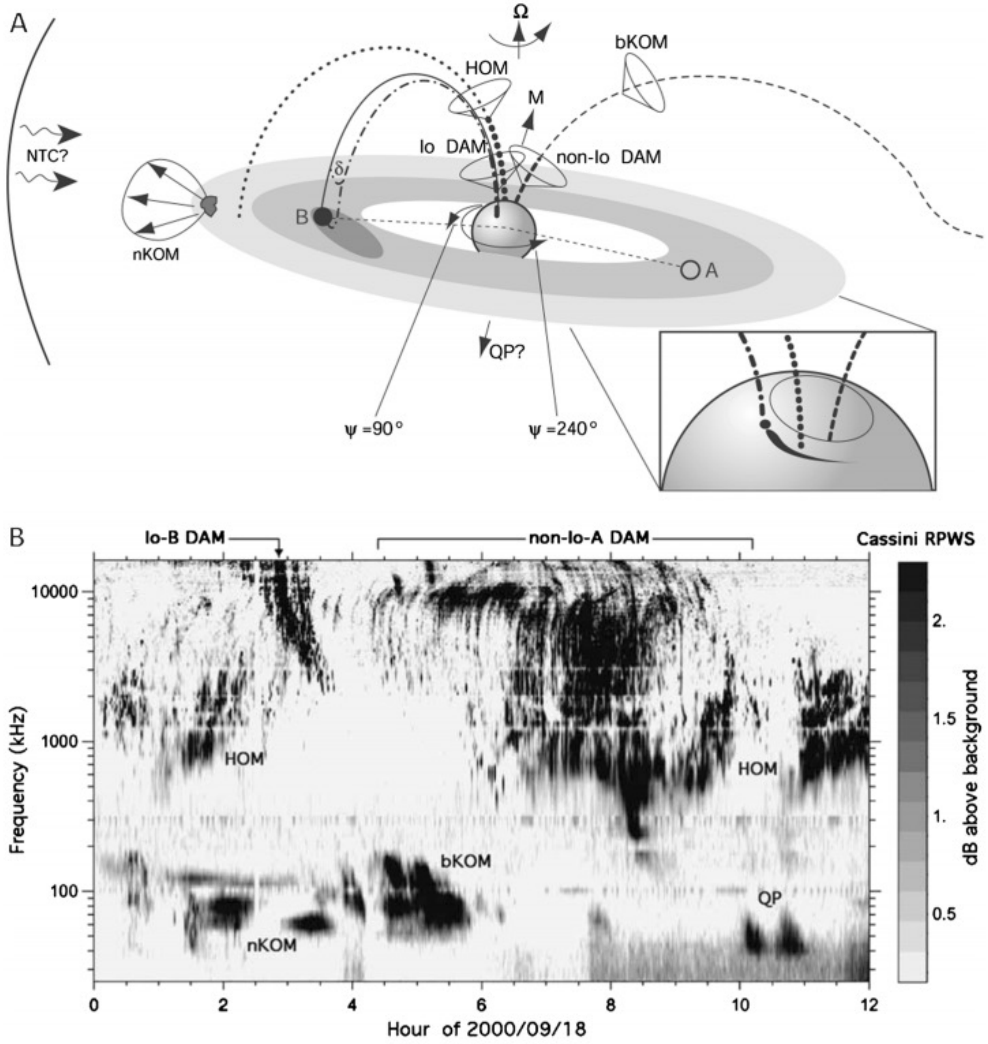
YE Shengyi

CHEN Yuening, WU Siyuan, YAO Zhonghua, ZHANG Binzheng, XU Yan, CHEN Junjie, ZARKA Philippe, JACKMAN Caitriona， KURTH William

Space Environment of Giant Planets



Bagenal et al. 2017



Zarka et al. 2001ab

Solar wind and internally driven cycles

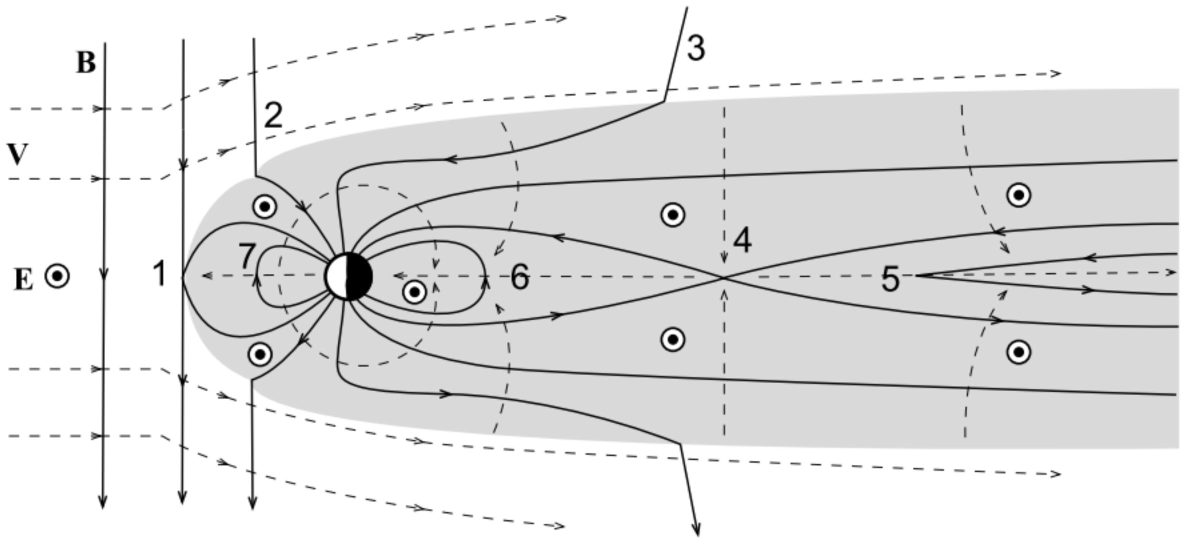
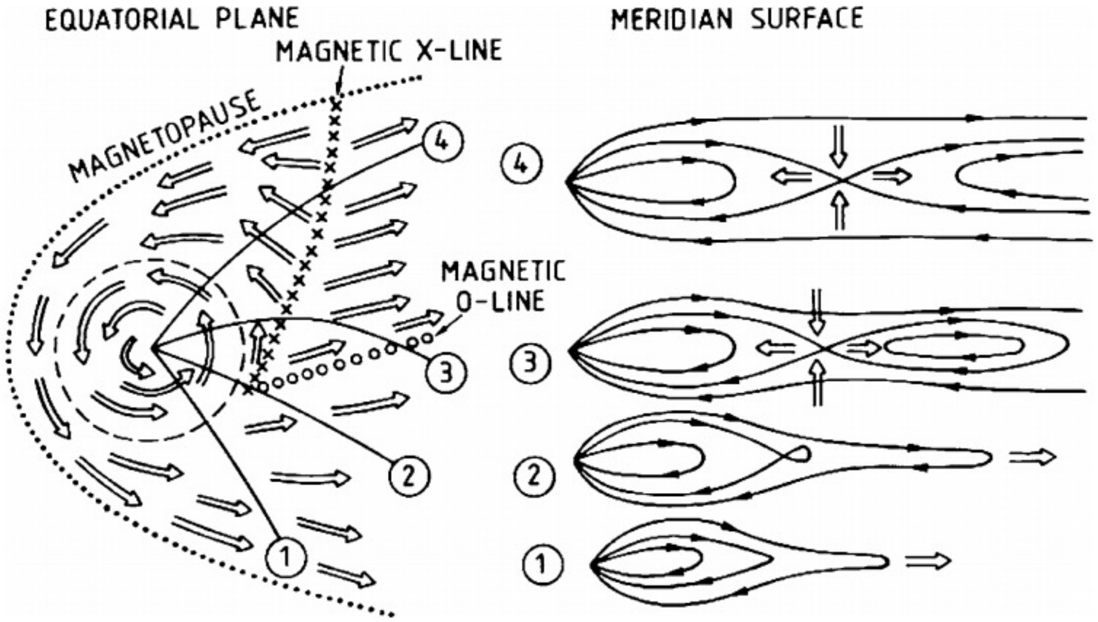


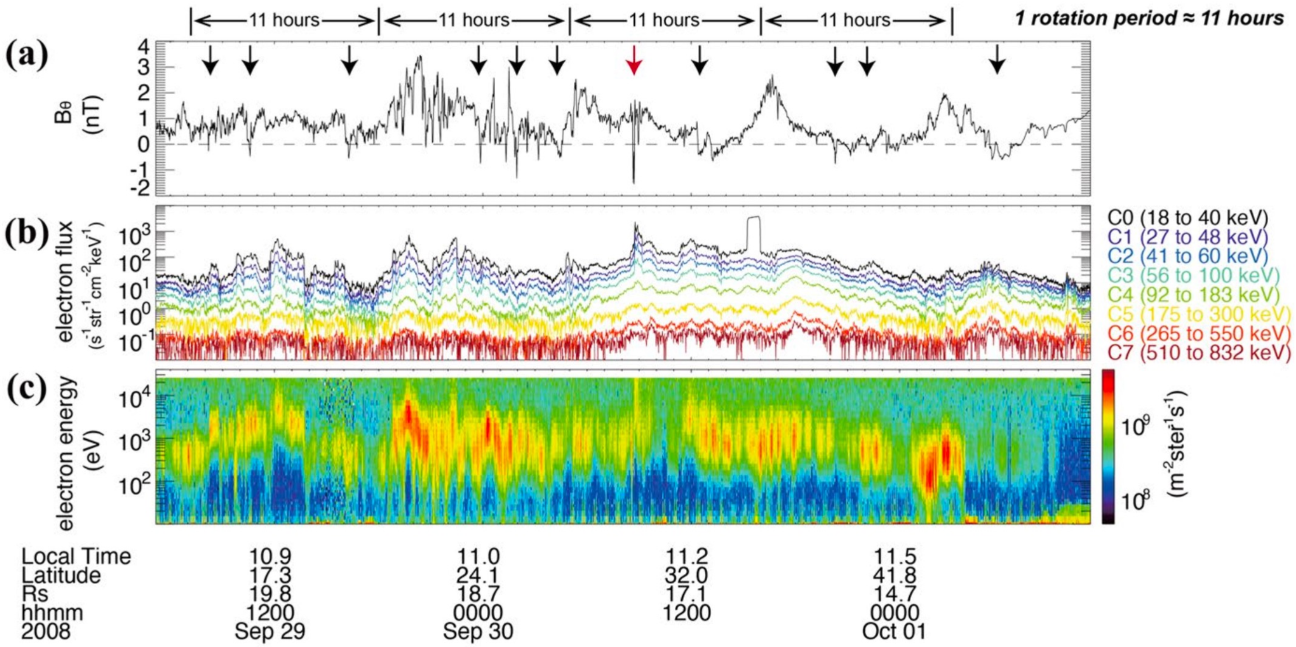
Illustration of Dungey Cycle by Steve Milan



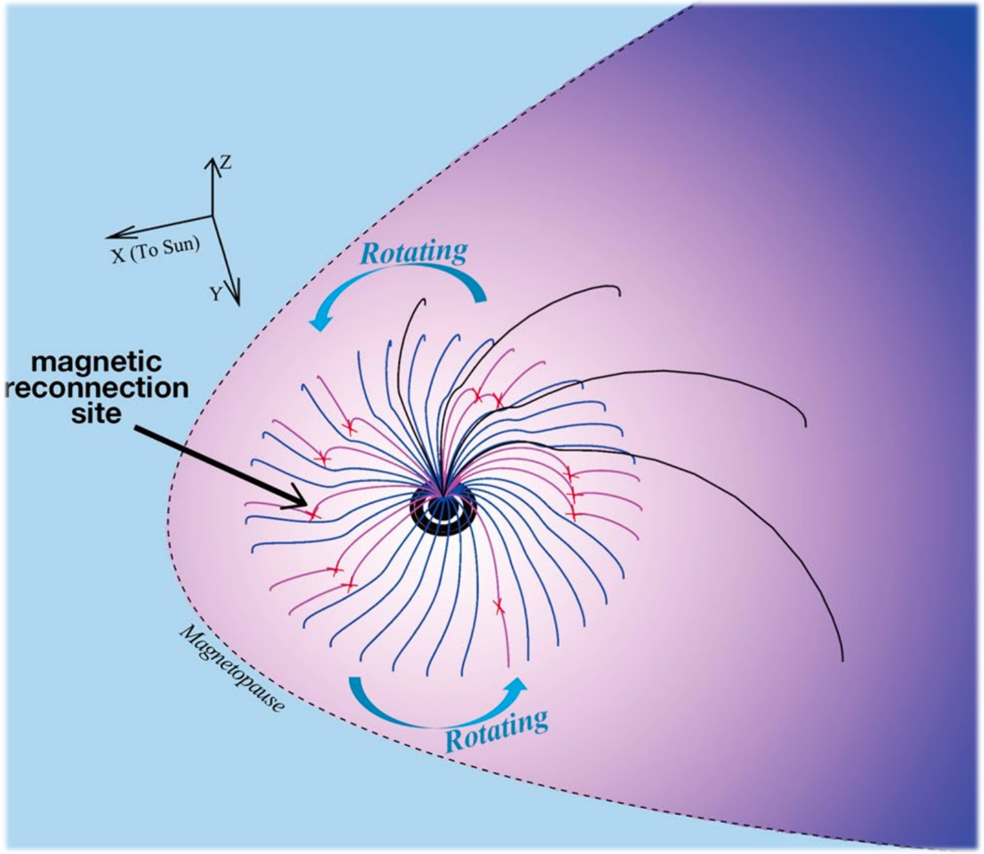
Vasyliunas 1983

Long-standing small-scale magnetodisk reconnection process

Magnetic reconnection can occur at the dayside magnetodisk

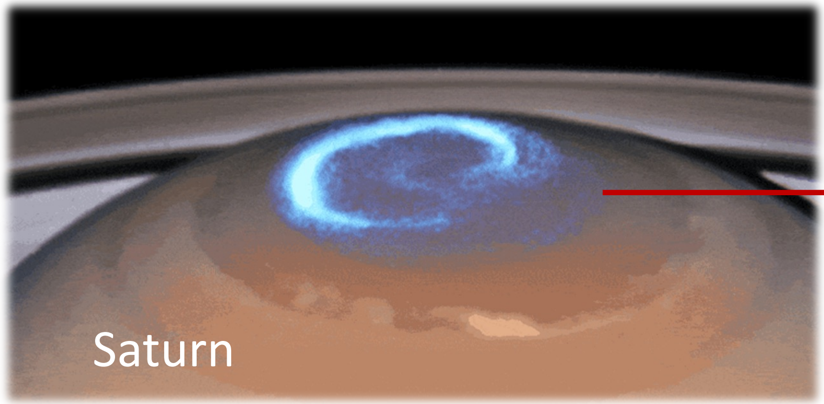


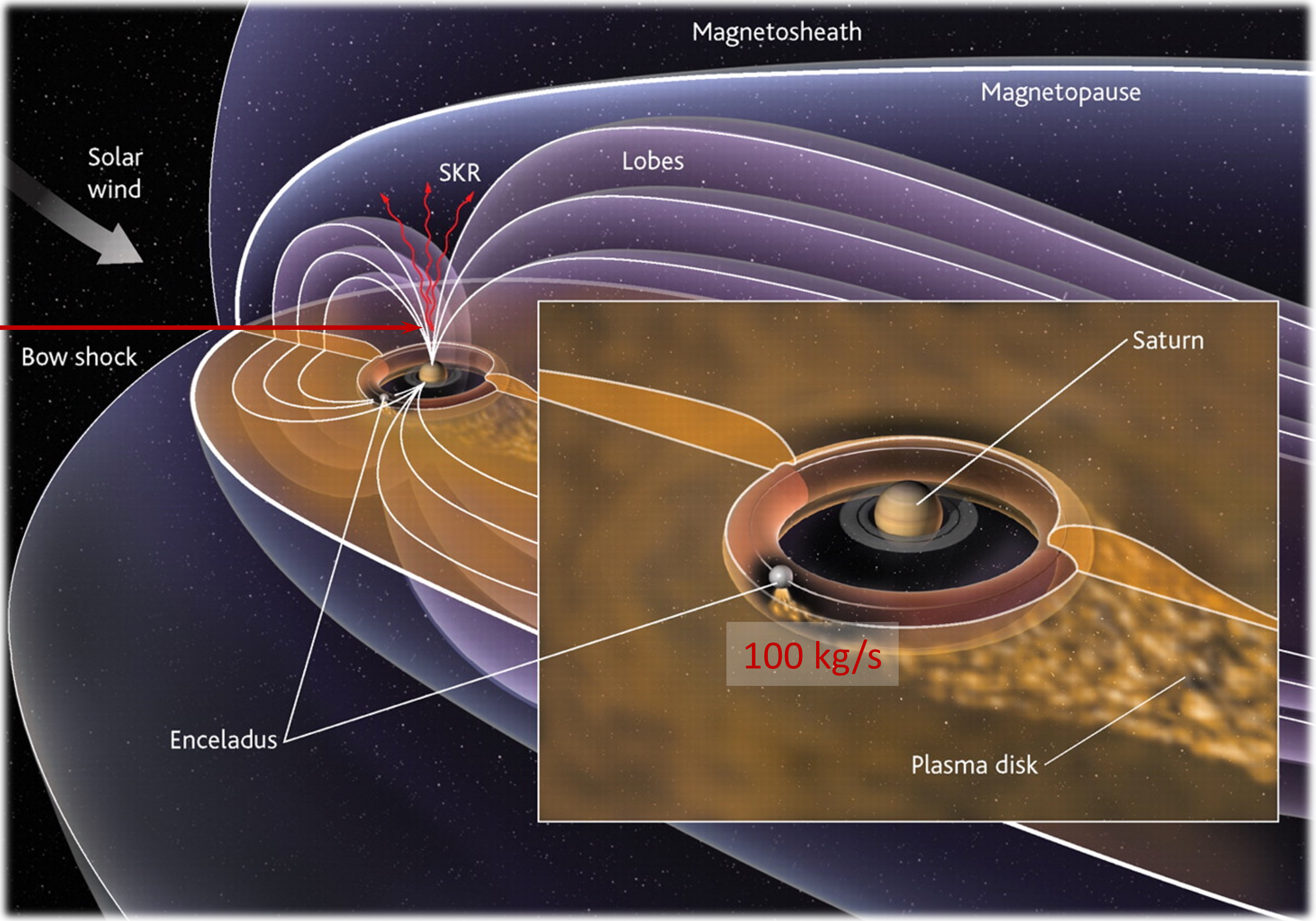
(Guo et al., 2019)



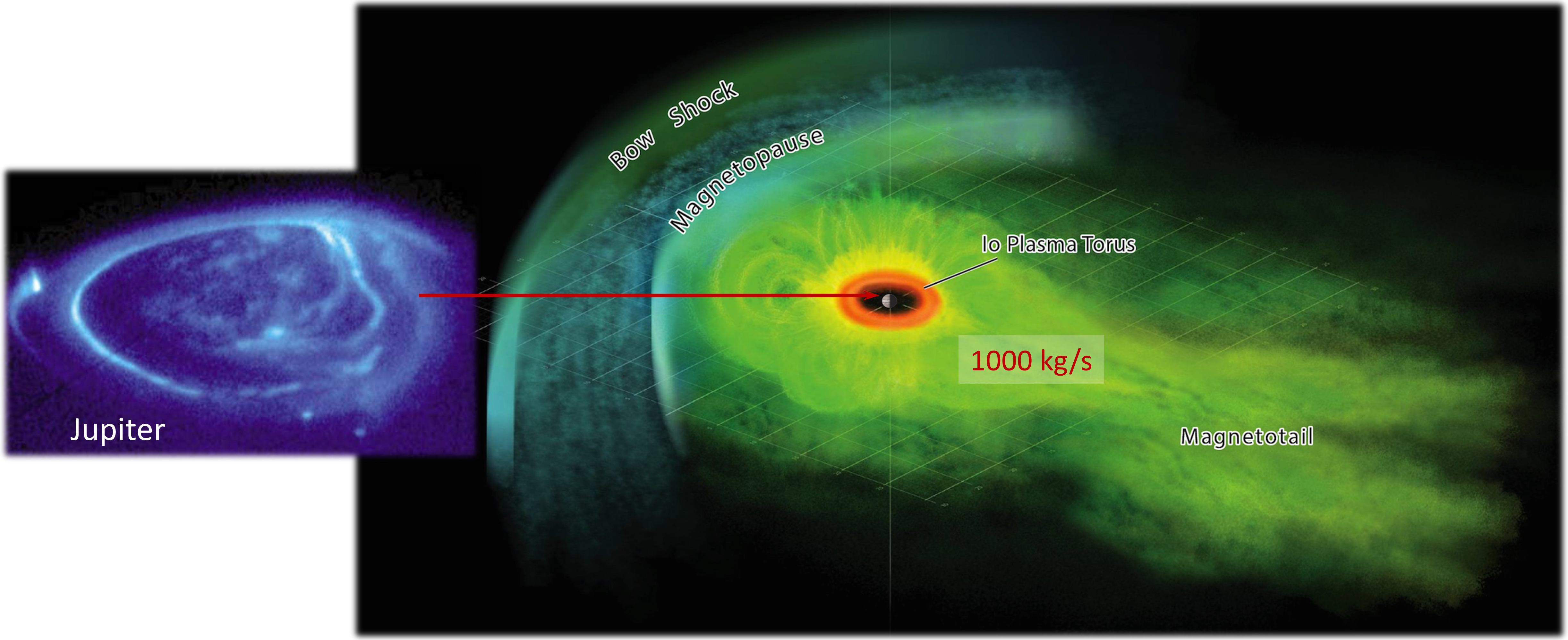
(Xu et al., 2021)

Saturn aurora driven by both solar wind and internal geological processes



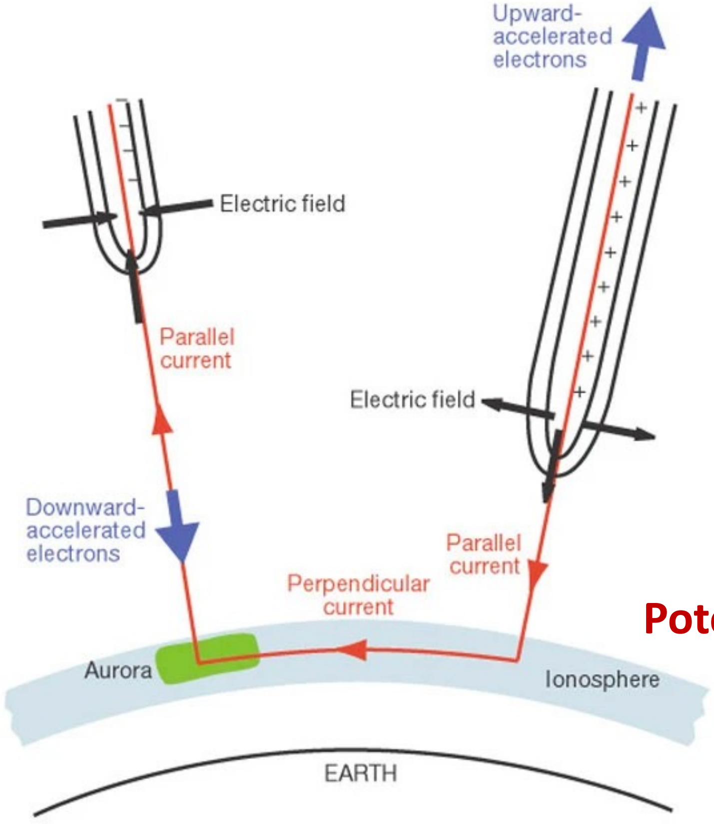


Jovian aurora driven by material released from Io



Two acceleration mechanisms for auroral electrons

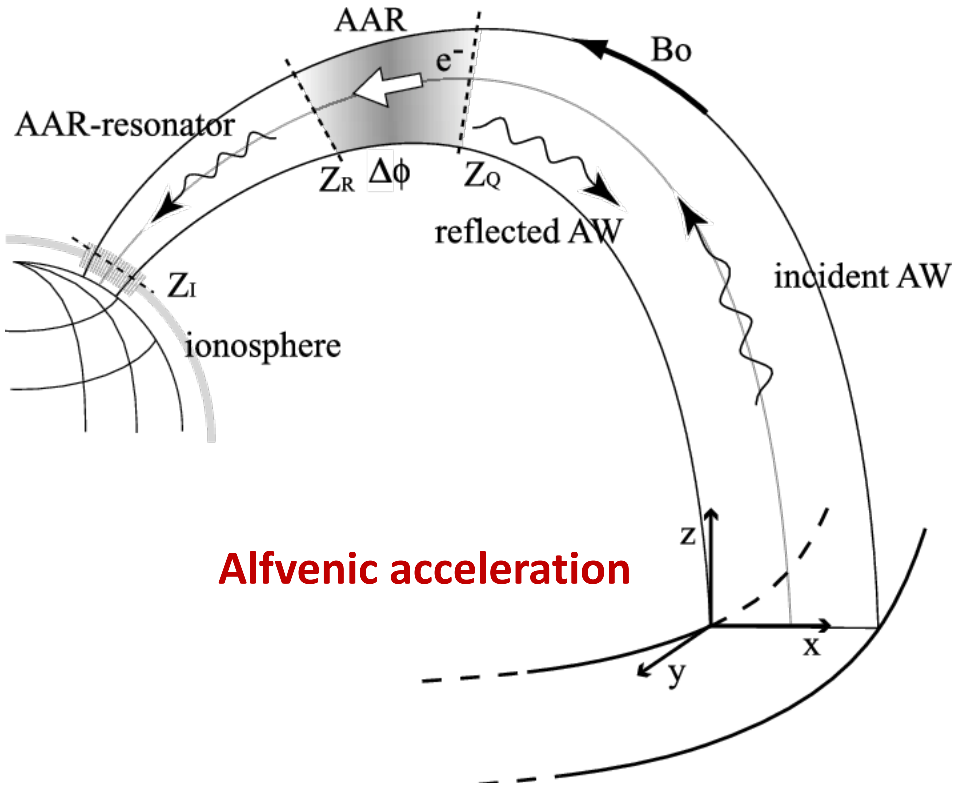
Field-aligned currents



Potential drop

(Marklund et al., 2001)

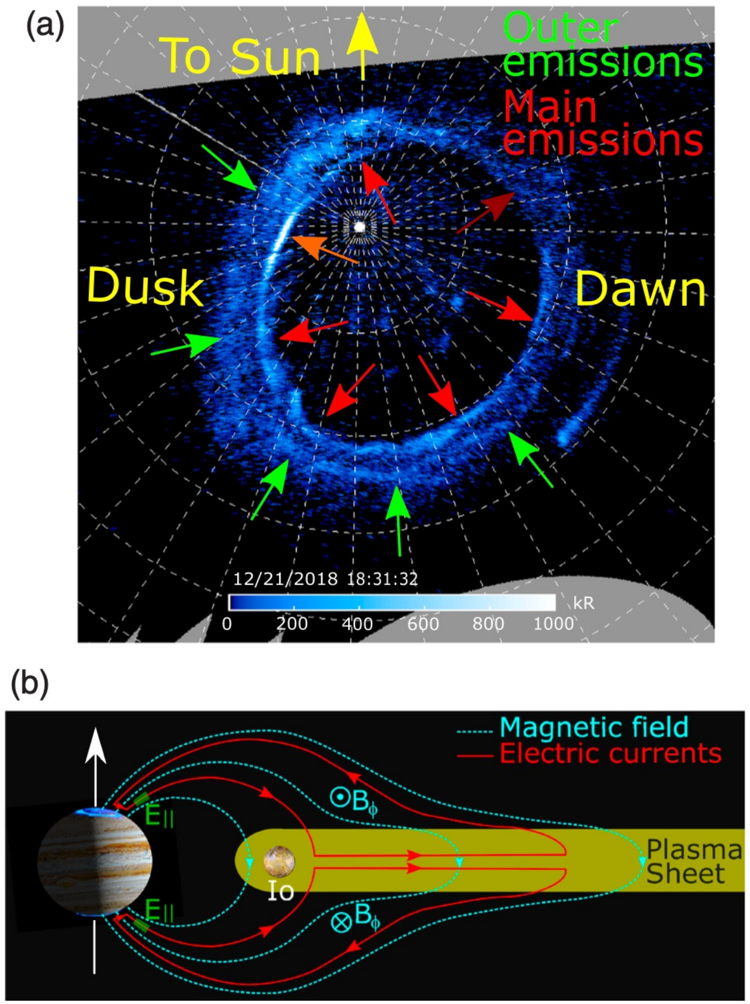
Wave-particle interaction



Alfvenic acceleration

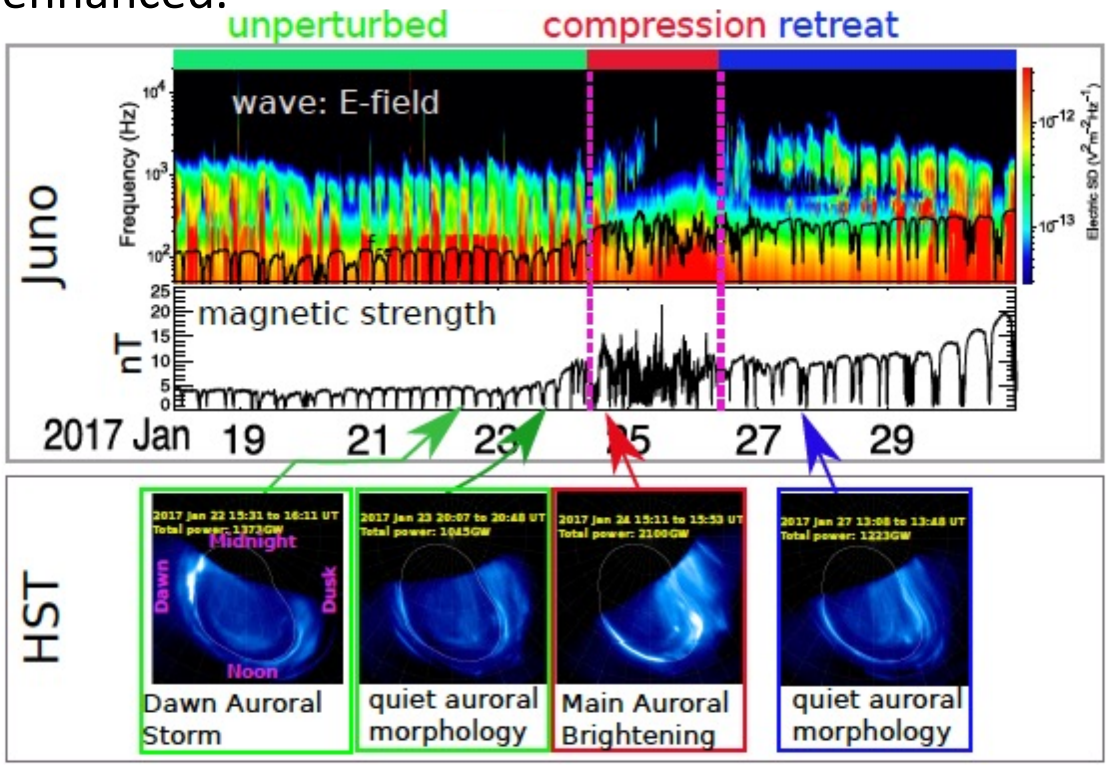
(Pilipenko et al., 2004)

Jovian auroral response to solar wind compression



Bonfond et al. 2020

Solar wind compression may reduce corotation breakdown enforcement current, but the auroral precipitation associated with Poynting flux may be strongly enhanced.

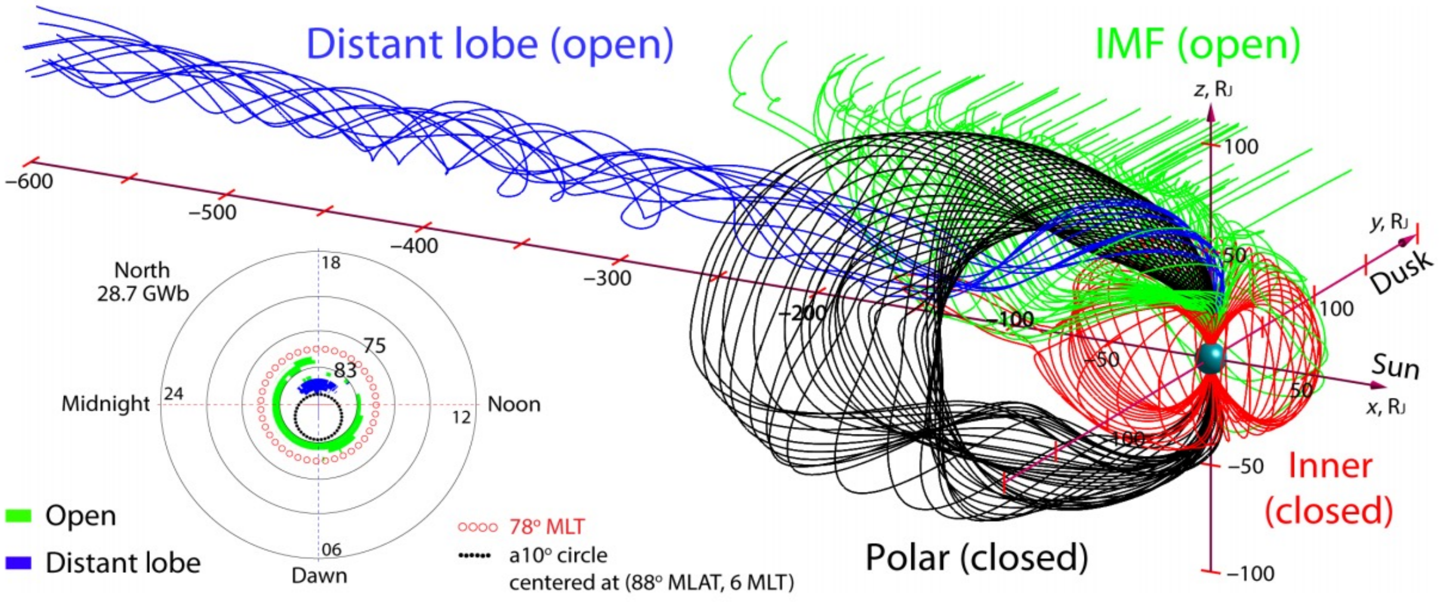


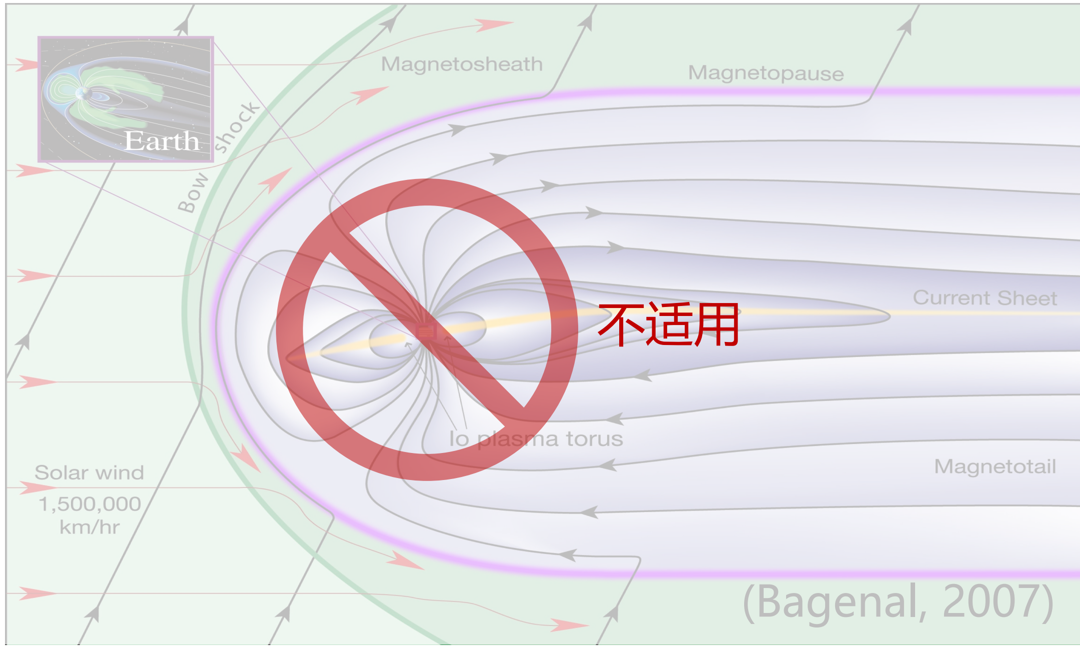
Yao et al., 2022

10/10 compression events show global auroral enhancements

Complex magnetic field structure of Jupiter

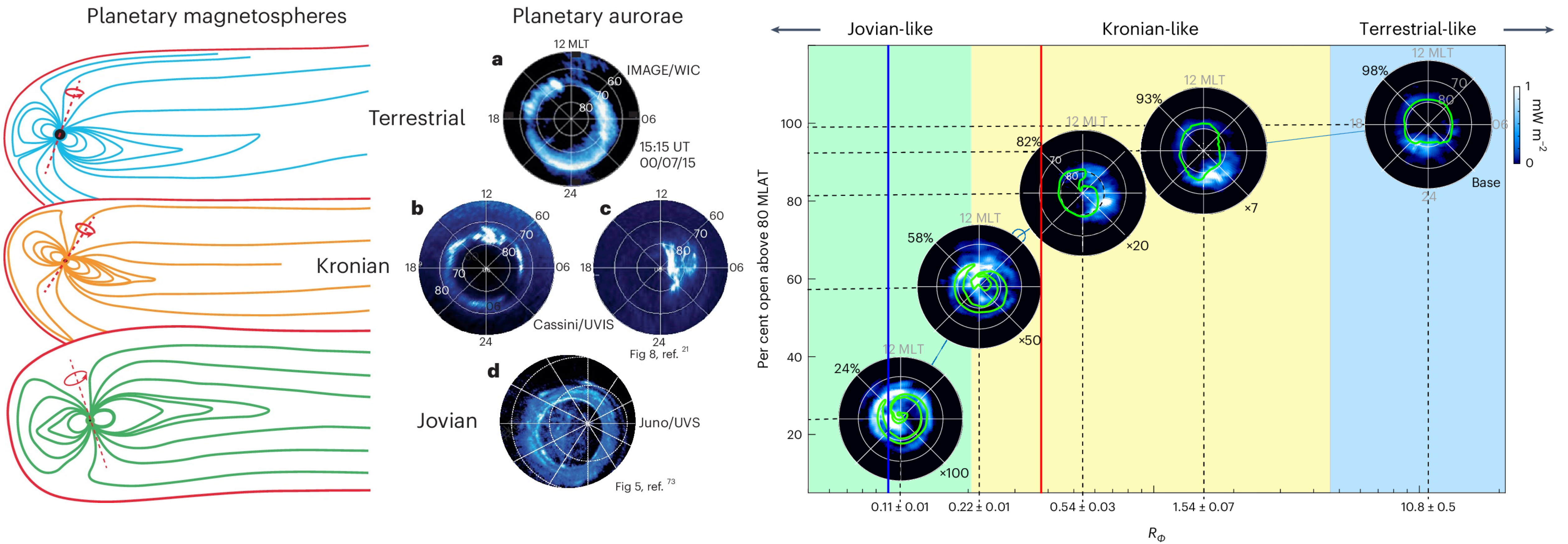
(Zhang et al. 2021)





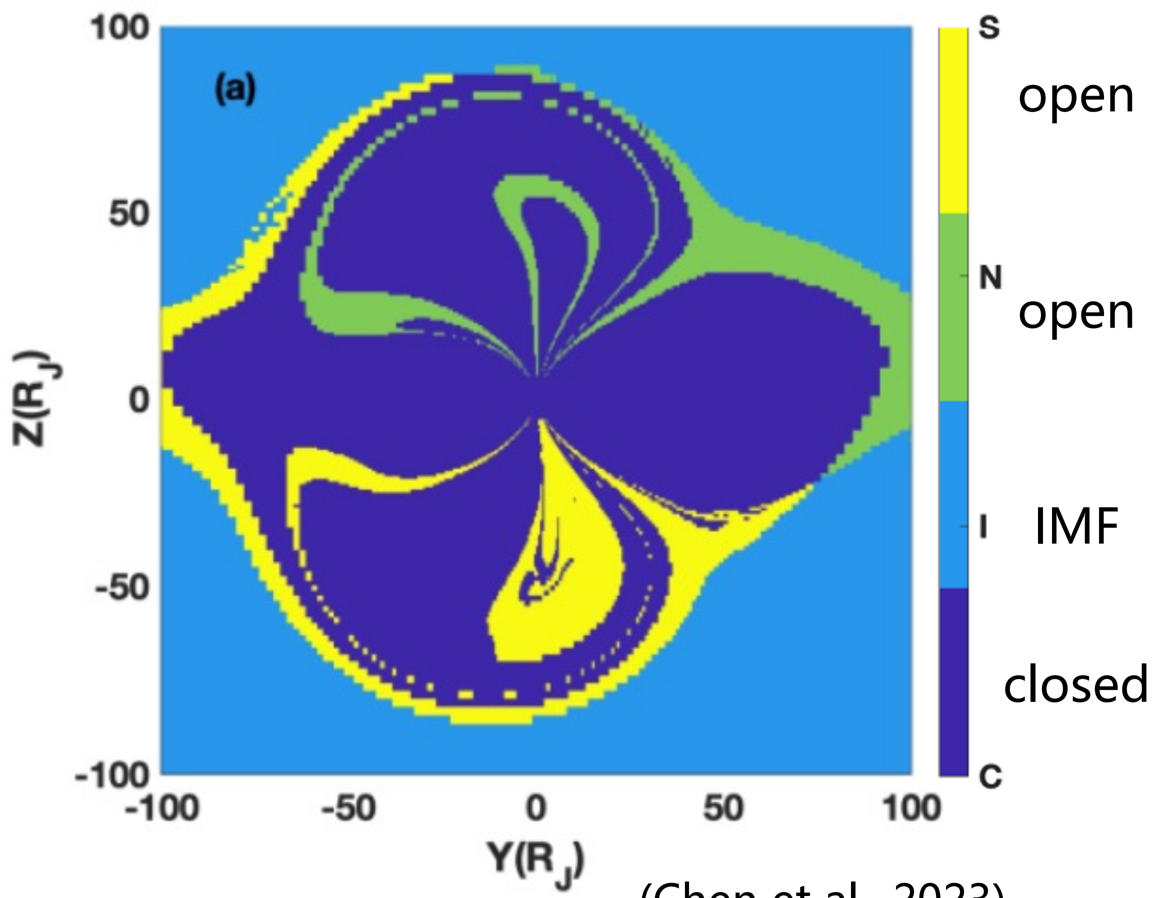
- Day side reconnection rate is too low to generate an Earth-like polar cap with open magnetic field lines on the time scale of the planet's rotation
- A small crescent-shaped polar cap and the formation of open magnetic field lines on the dusk side
- Most of Jupiter's polar cap is passed through by helical closed magnetic field lines

A unified framework for global auroral morphologies of different planets

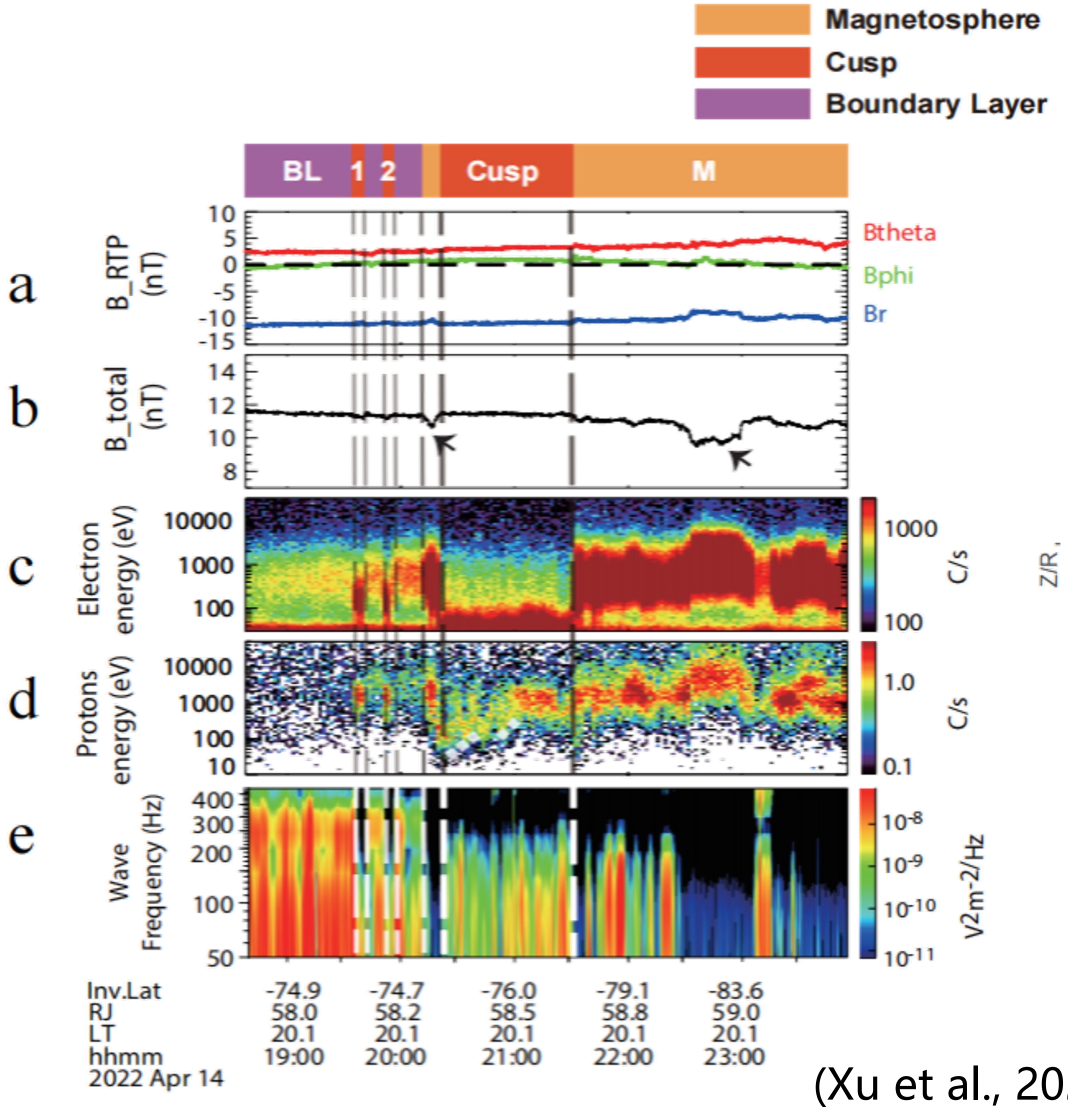


(Zhang et al., 2024)

Asymmetry: Dusk side cusp region



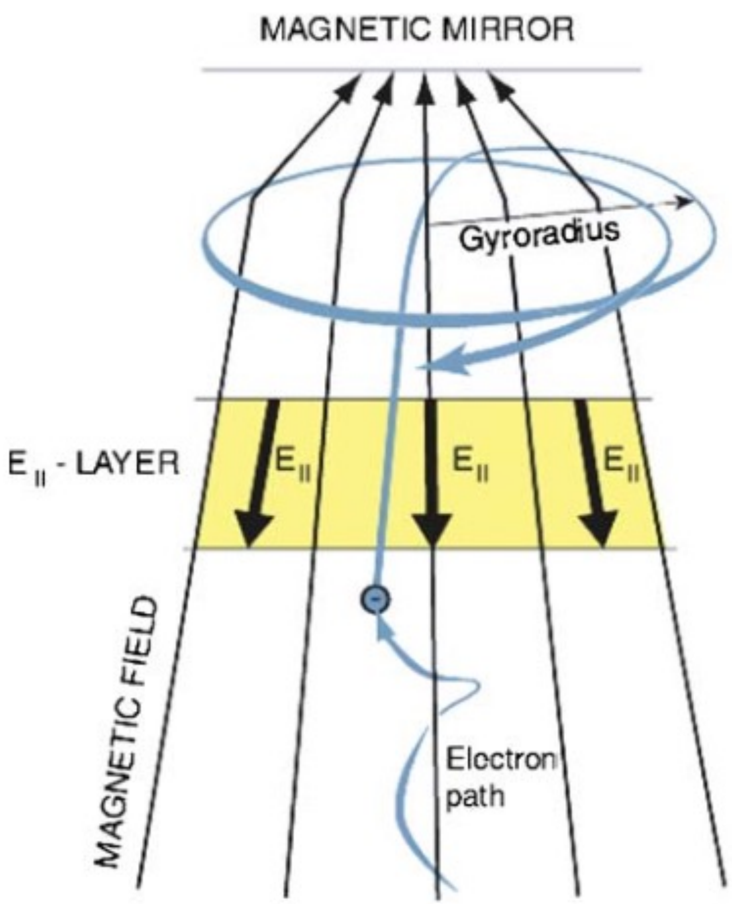
(Chen et al., 2023)

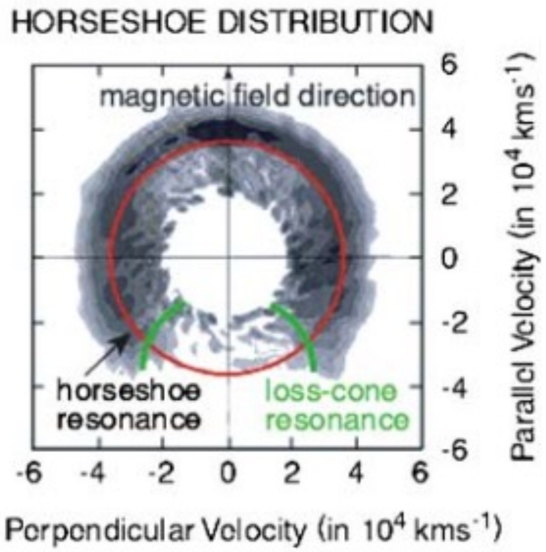


(Xu et al., 2024)

Cyclotron maser instability

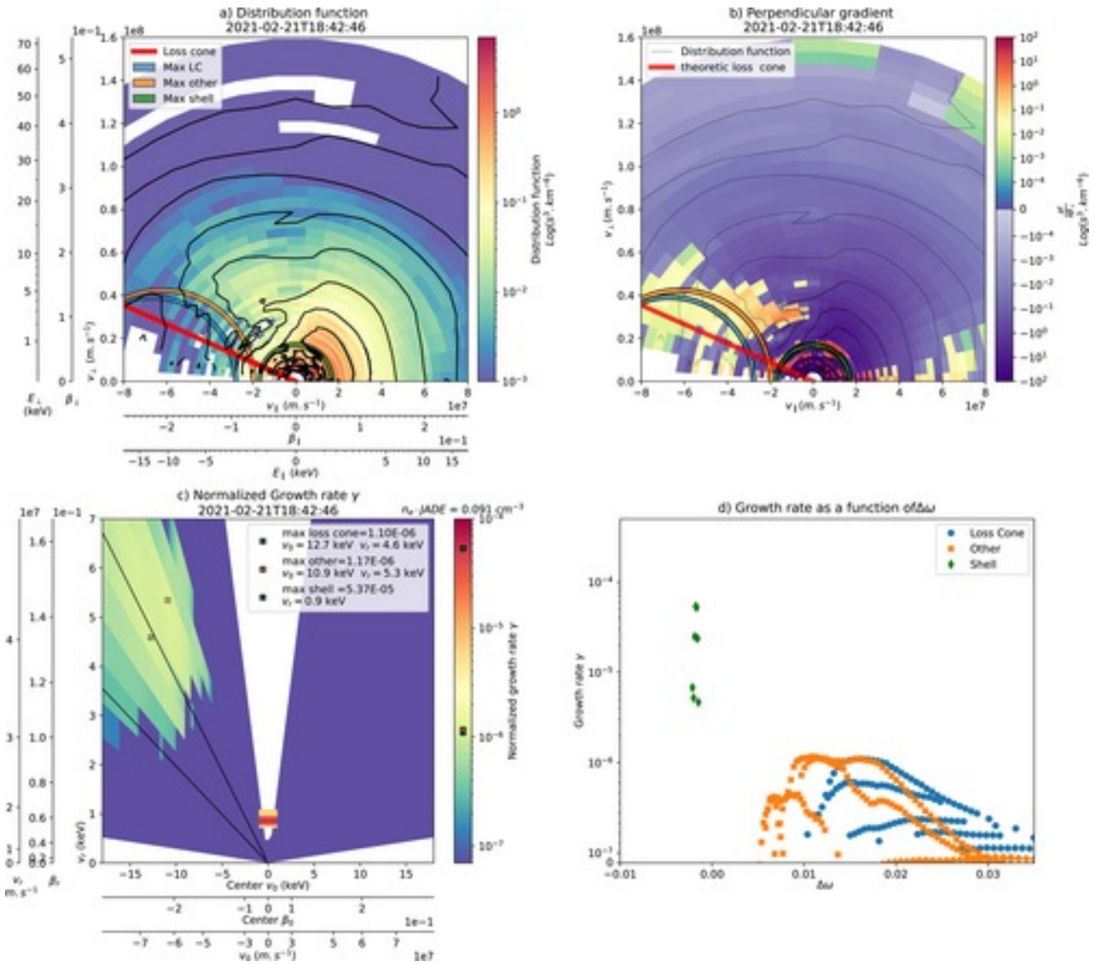
$$\omega - k_{\parallel} v_{\parallel} = l \frac{\omega_{ce}}{\gamma}$$





(Treumann, 2006)

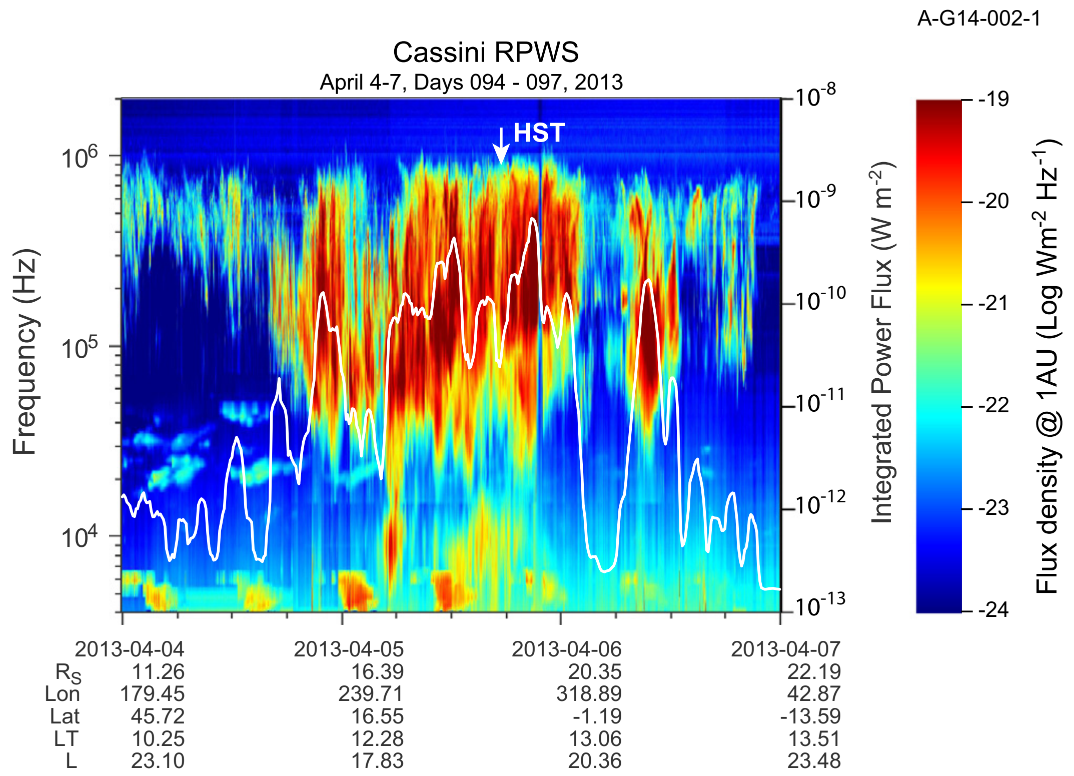
HOM source

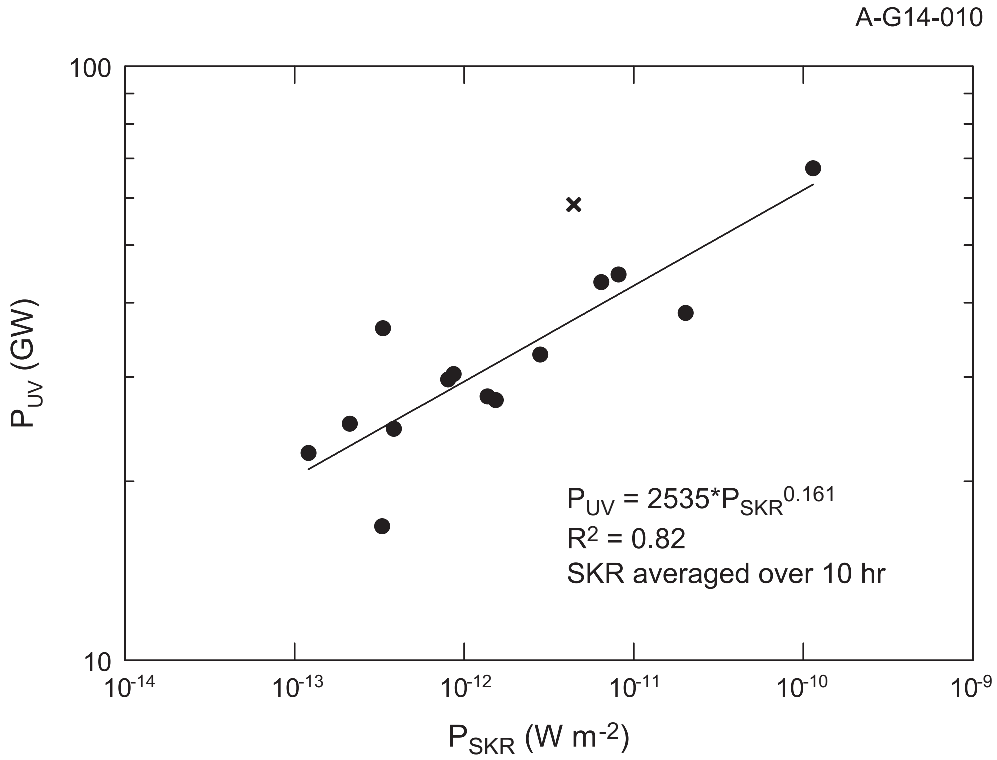


(Collet et al. 2024)

CMI emissions as a proxy of auroral activity

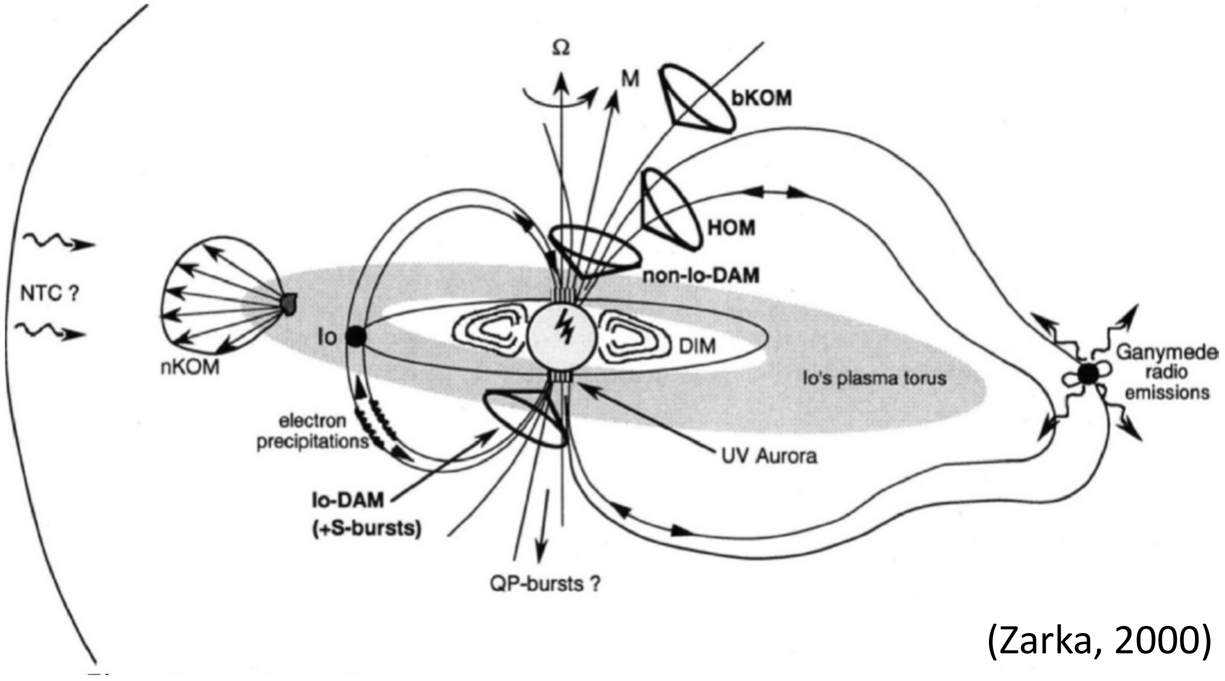
- SKR excited by the auroral precipitating electrons via cyclotron maser instability (CMI) (Wu and Lee, 1979).
- Good correlation between 10-h averaged SKR power and auroral UV brightness level.



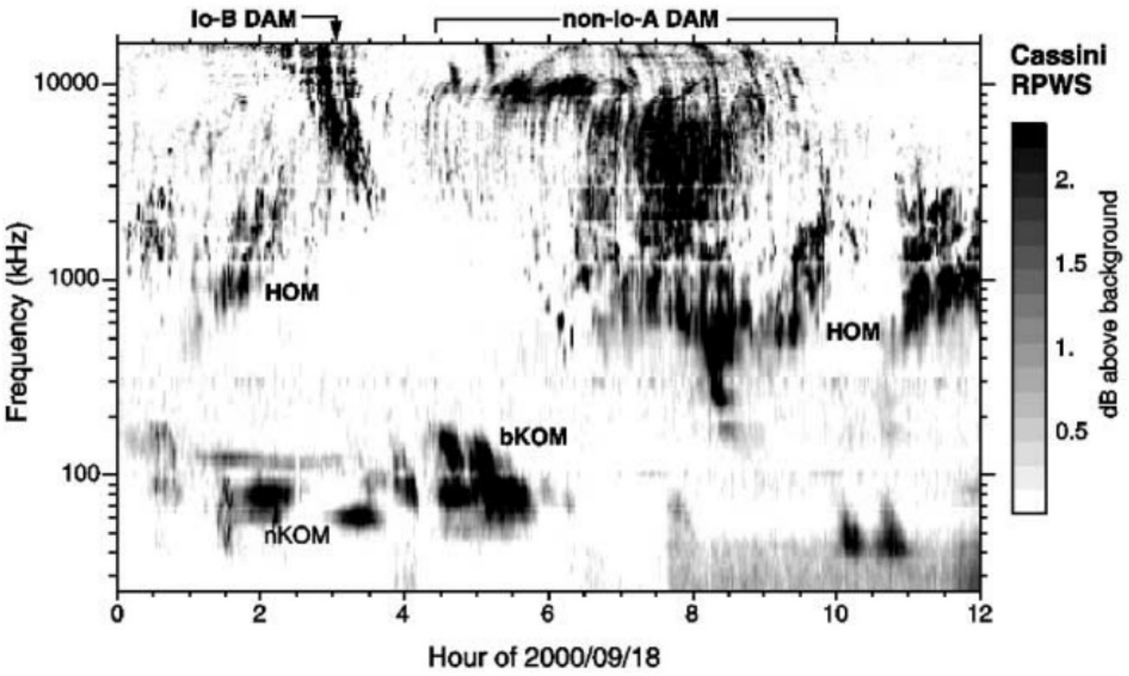


(Kurth et al., 2016)

Jovian radio emissions



(Zarka, 2000)



(Zarka et al., 2001)

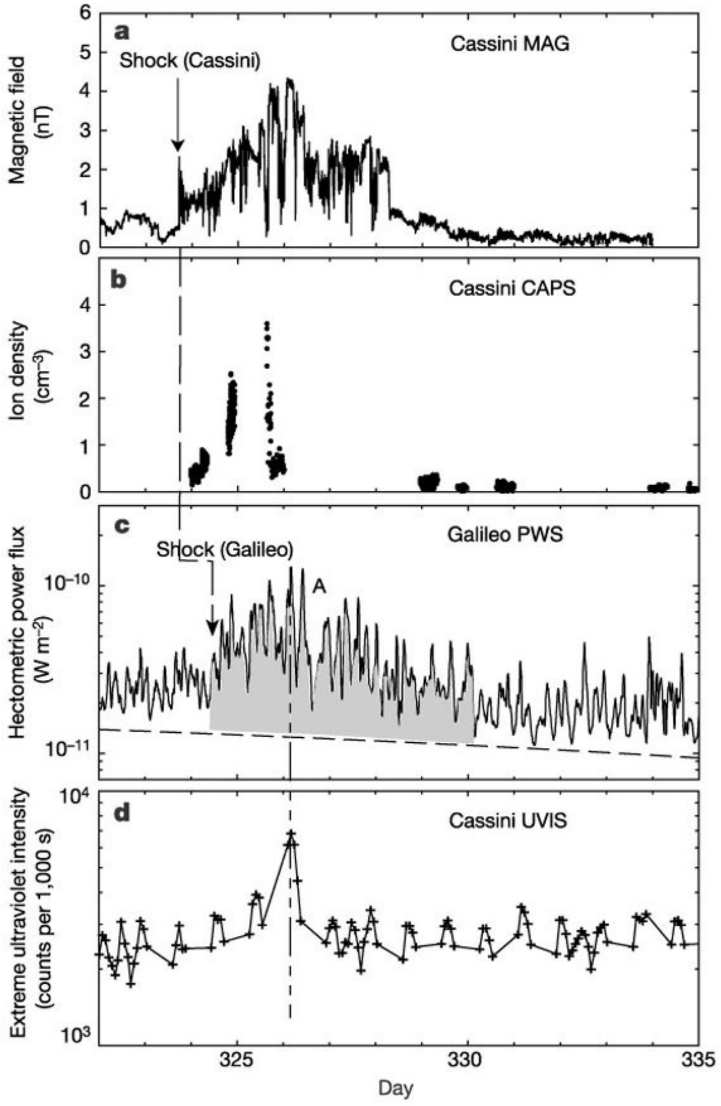
- Closely related to particle and energy transport
- Low frequency radio components: QP, nKOM, bKOM, HOM and DAM

(Zarka, 1998, 2004; Kurth et al., 1989; Gurnett et al., 1983; Kaiser and Desch, 1980)

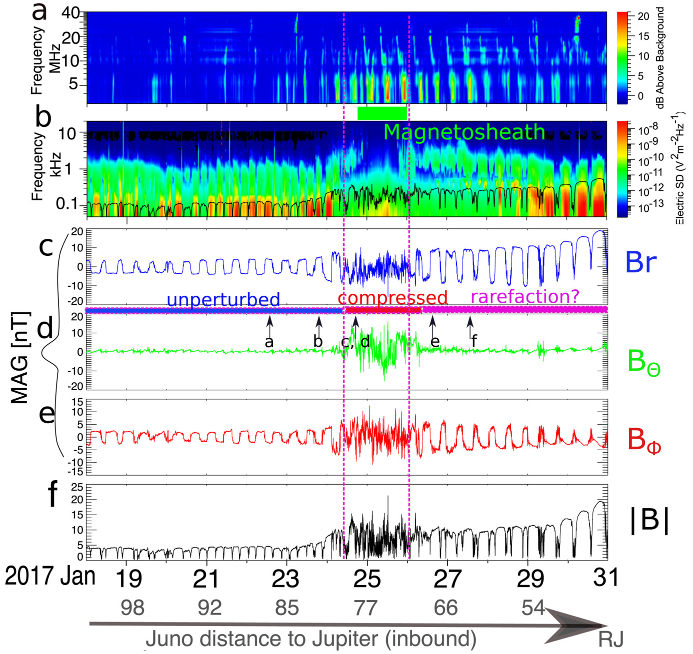
- bKOM auroral field lines; nKOM outer edge of Io plasma torus

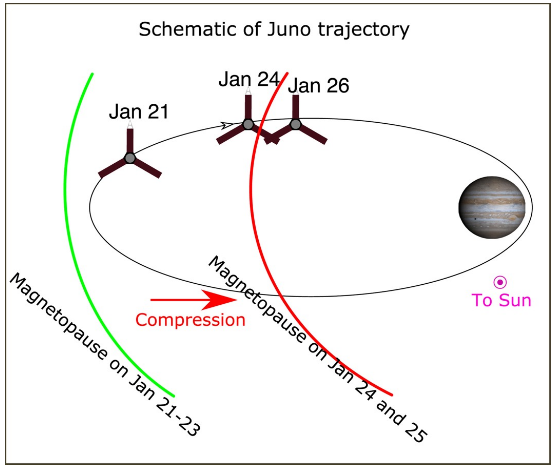
(Kurth et al., 1980; Ladreiter et al., 1994; Reiner et al., 1993)

Jovian radio emissions response to solar wind



(Gurnett et al., 2002)





(Yao et al., 2022)

- HOM triggered by interplanetary shock

(Gurnett et al., 2002)

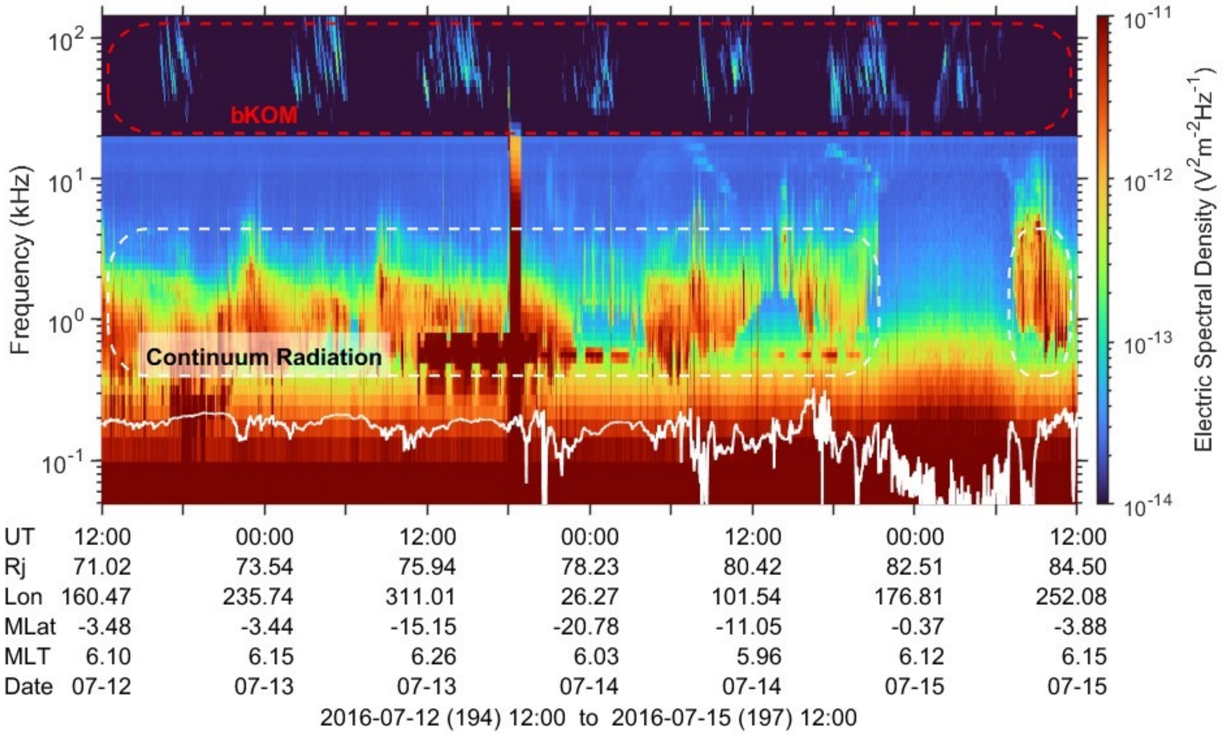
- non-Io DAM preferably observed during solar wind compression, intensity increasing with dynamic pressure

(Hess et al., 2012)

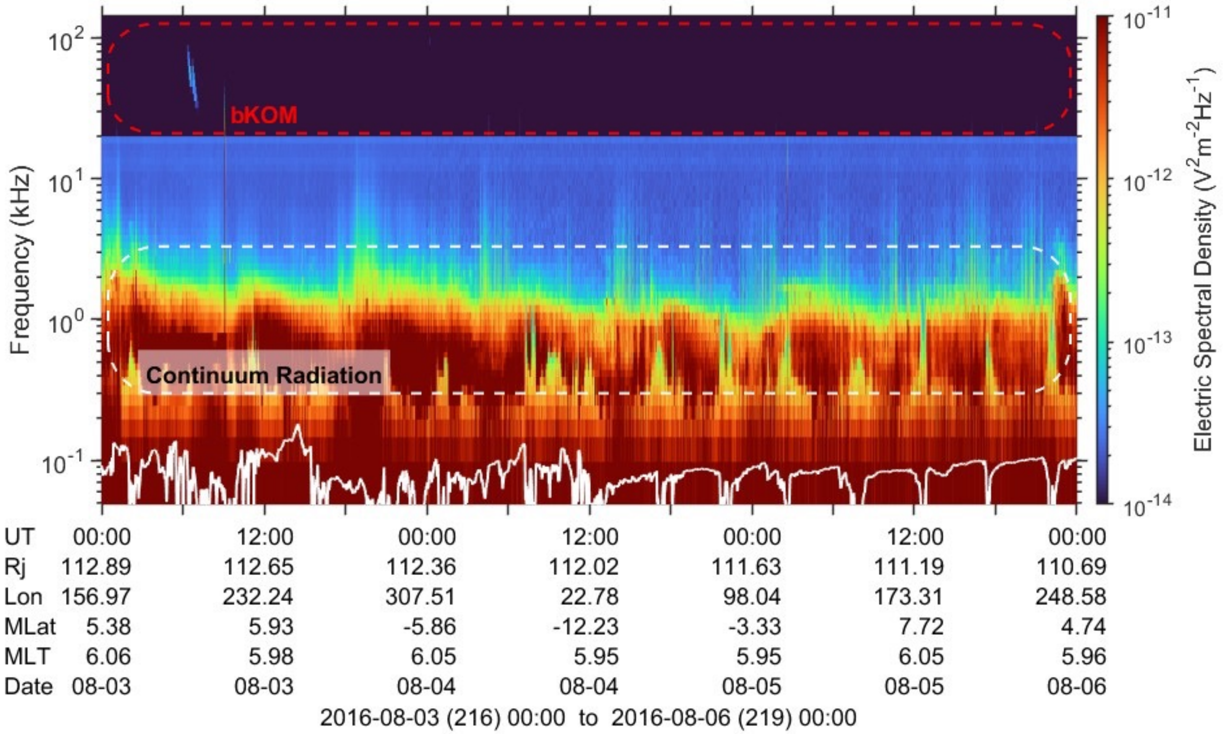
- HOM and non-Io DAM significantly enhanced during solar wind compression

(Yao et al., 2022)

bKOM observation w/wo solar wind compression

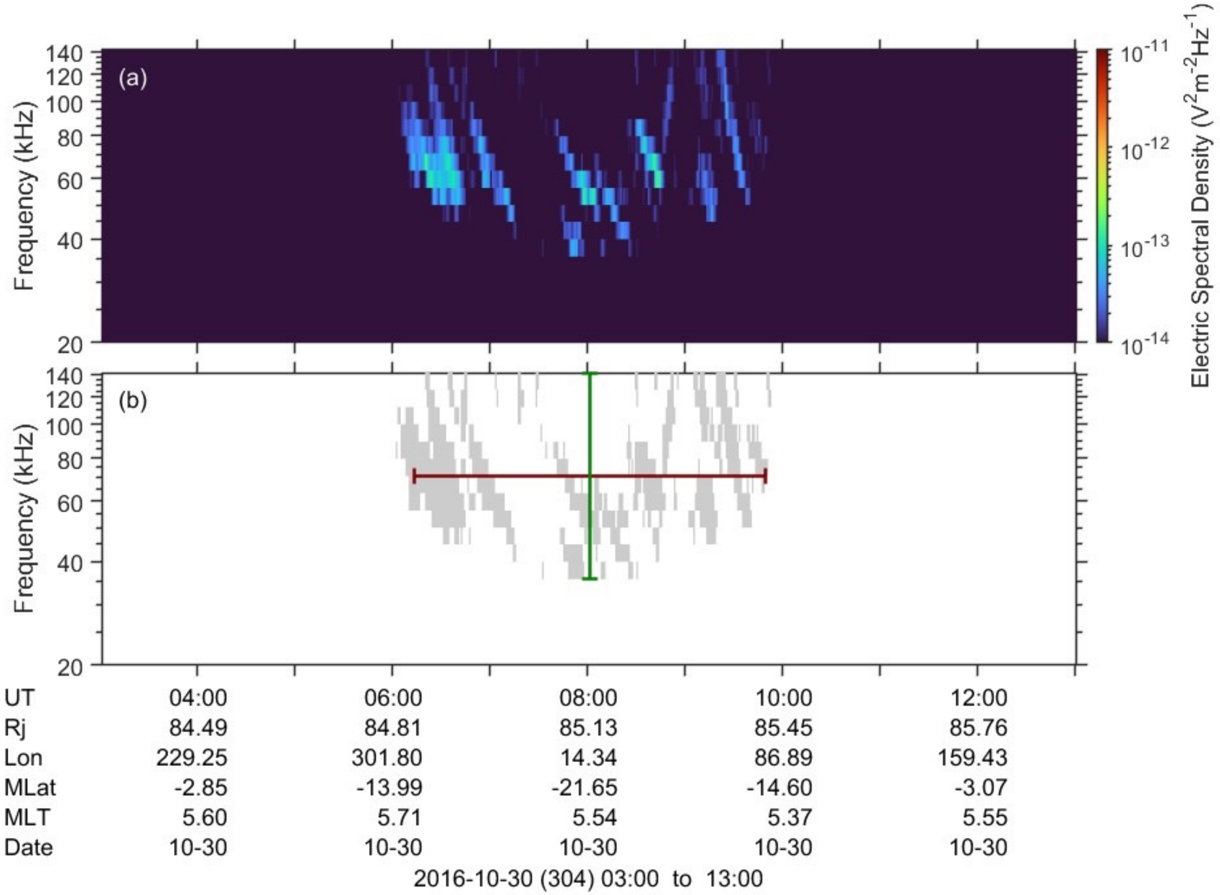


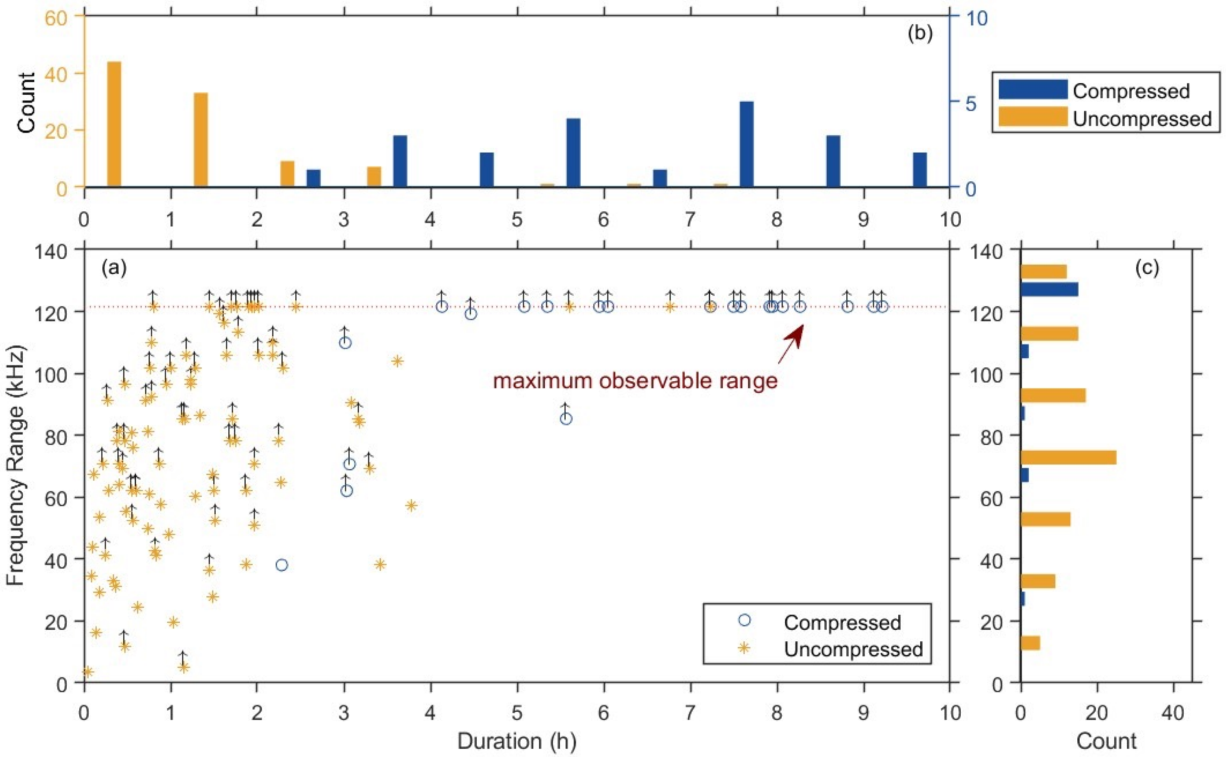
Compressed magnetosphere
50 Hz-140 kHz spectrogram
White line fce



Uncompressed magnetosphere
50 Hz-140 kHz spectrogram
White line fce

bKOM duration and frequency range increase during compression





(Chen et al. 2024)

- Longer duration and larger frequency range of bKOM during solar wind compression events.
- The bKOM source extended in altitude and longitude

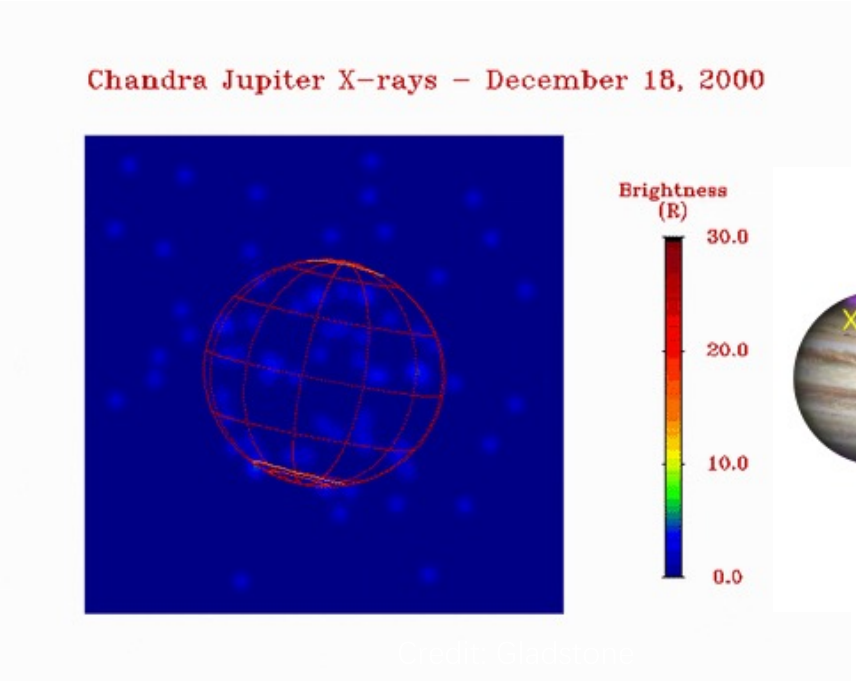
Jovian soft X-ray aurora

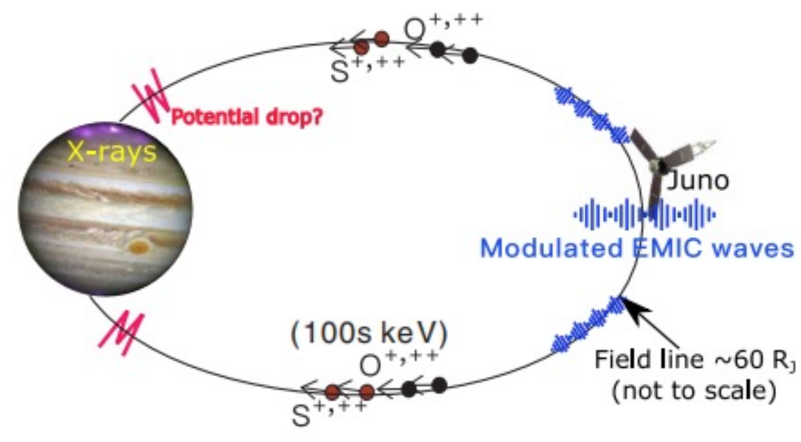
- Driven by precipitating ions pitch-angle scattered by EMIC waves into the loss cone.
- Tens of minutes periodicity

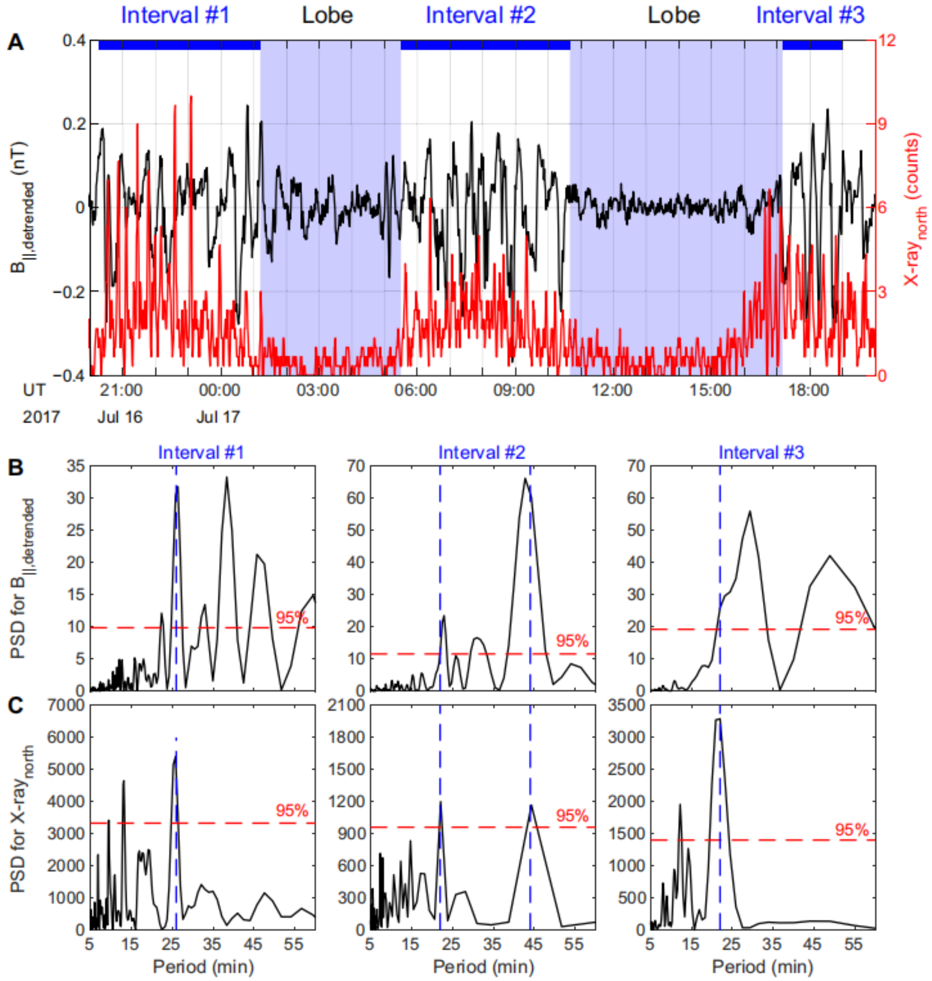
(Gladstone et al., 2002)

- EMIC waves modulated by the compressional waves

(Yao et al., 2021)

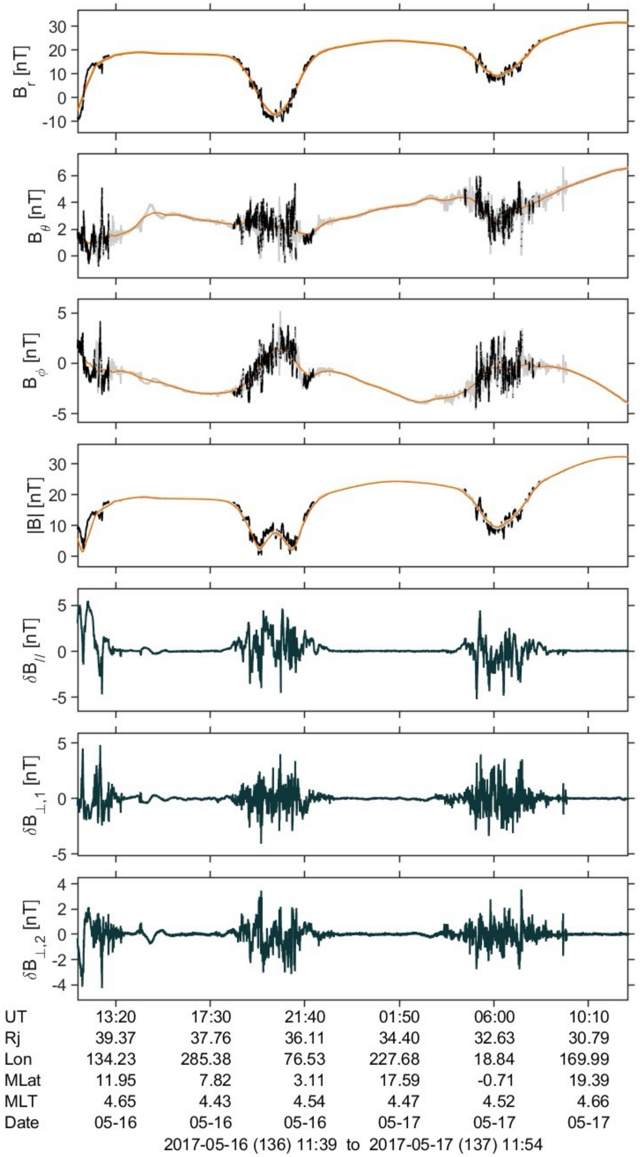


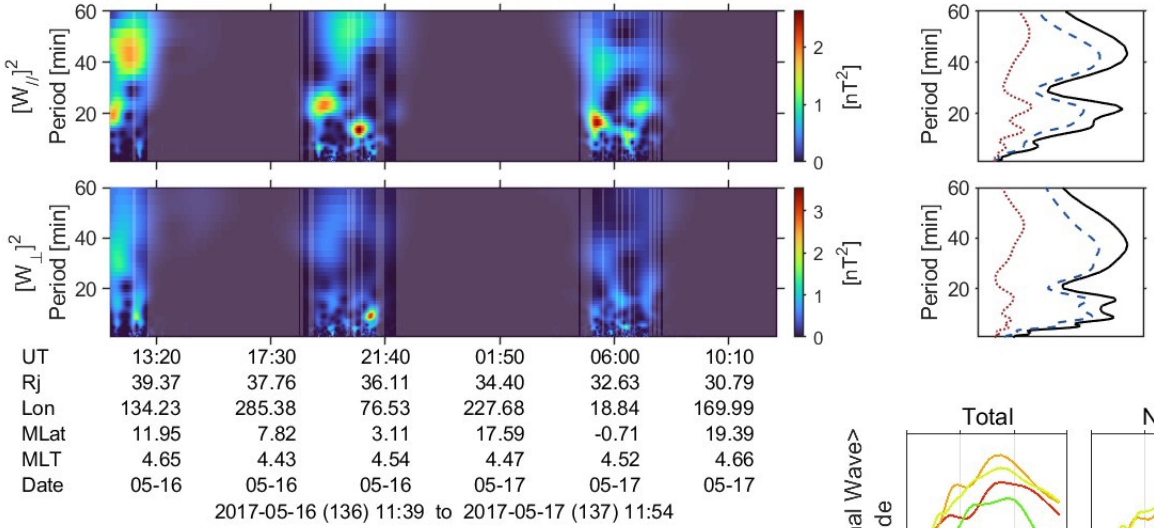


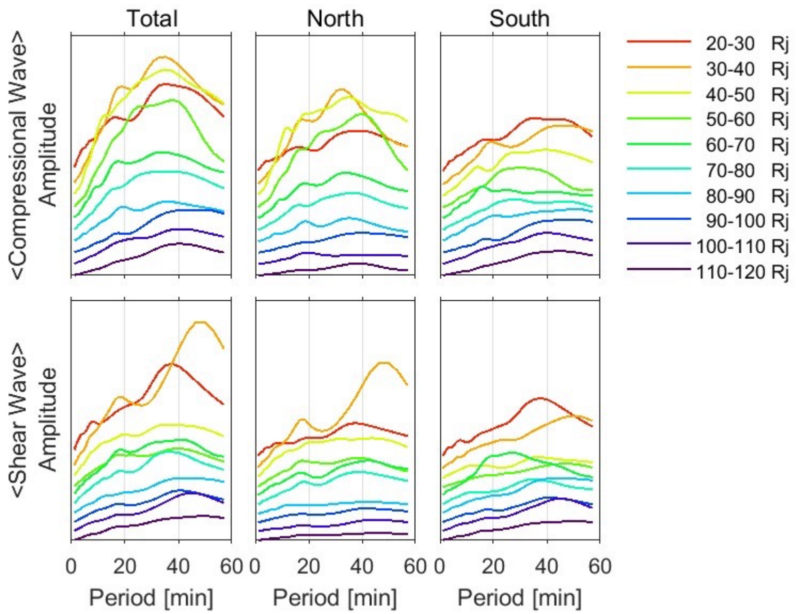


(Yao et al., 2021)

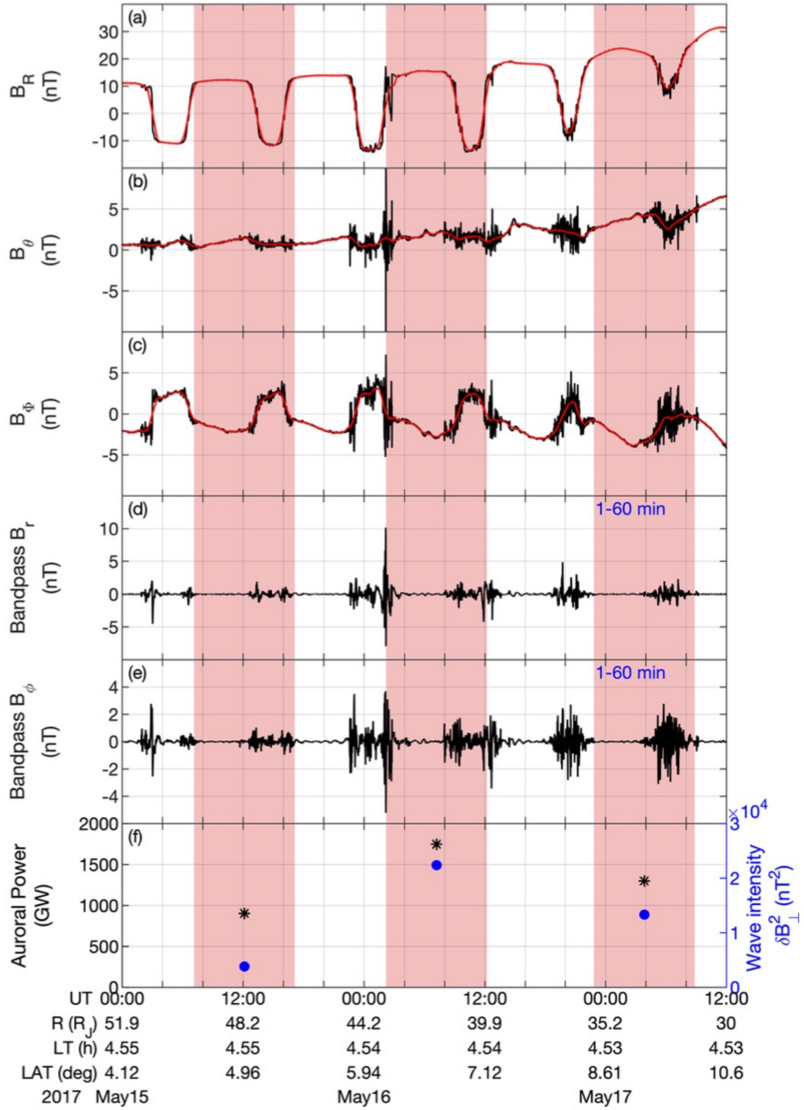
Compressional waves in Jovian plasma sheet boundary layer

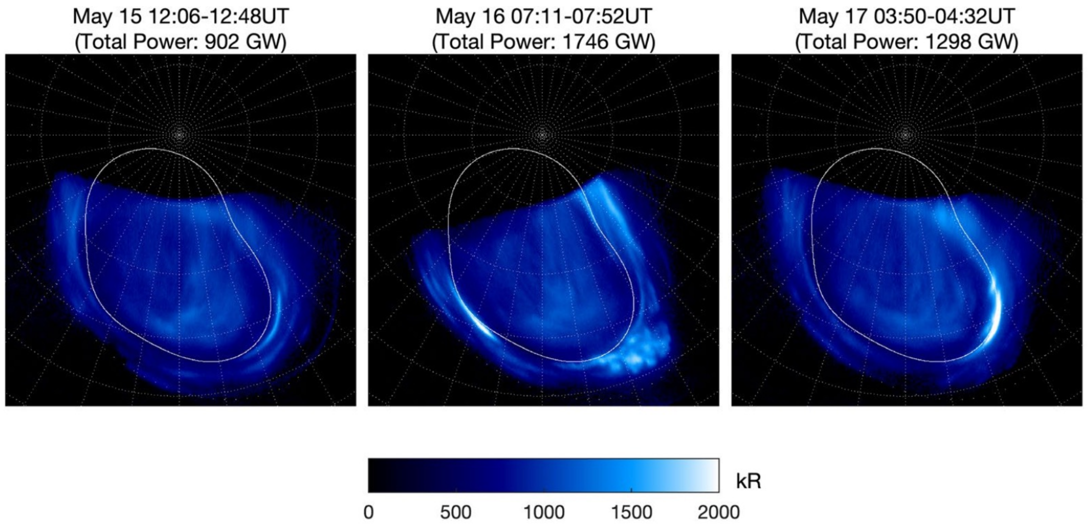


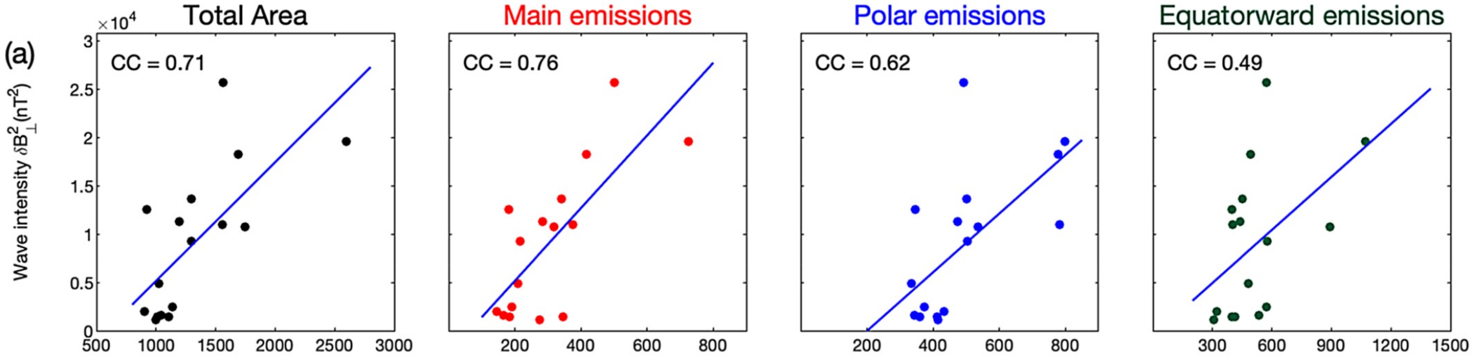




Jovian aurora and Alfven waves



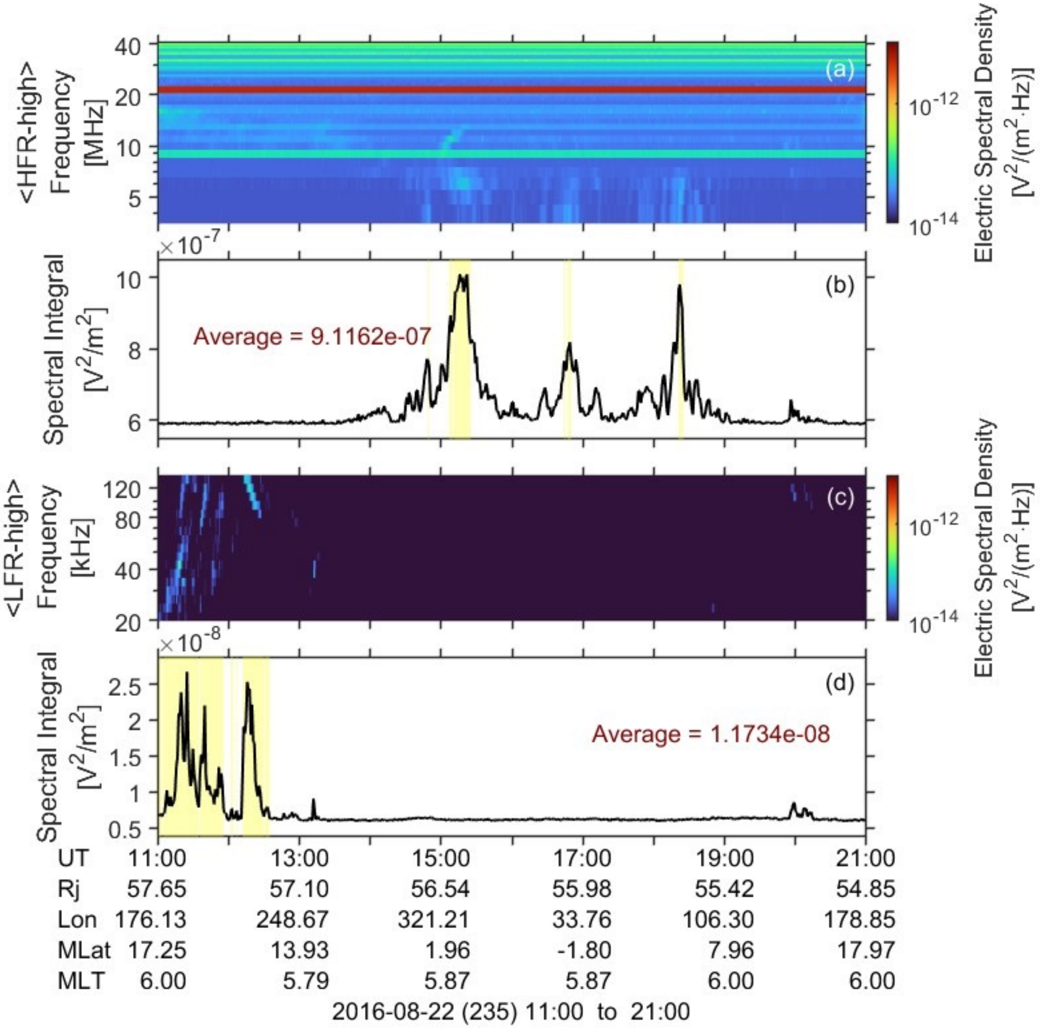


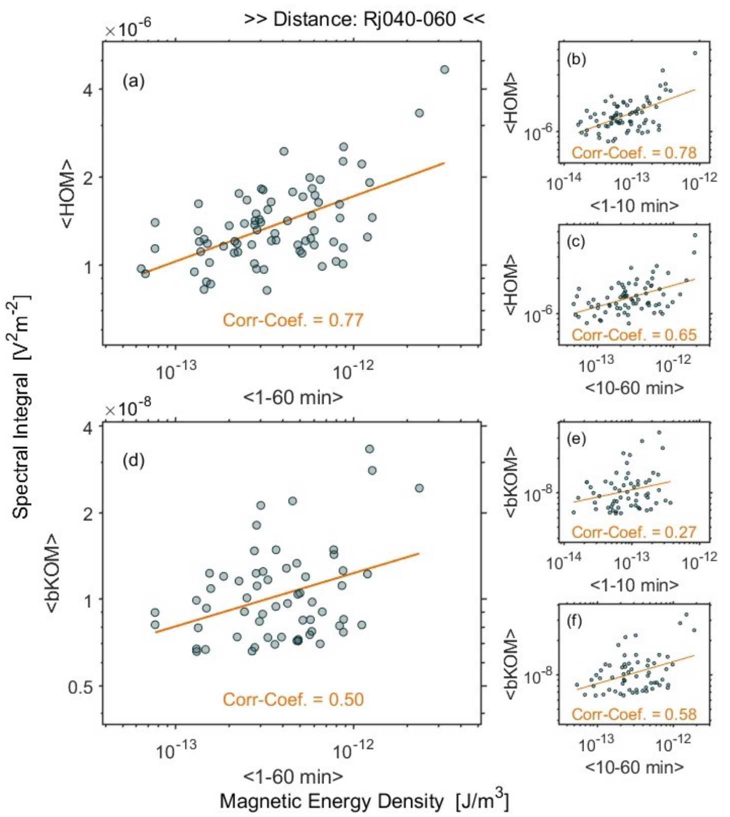


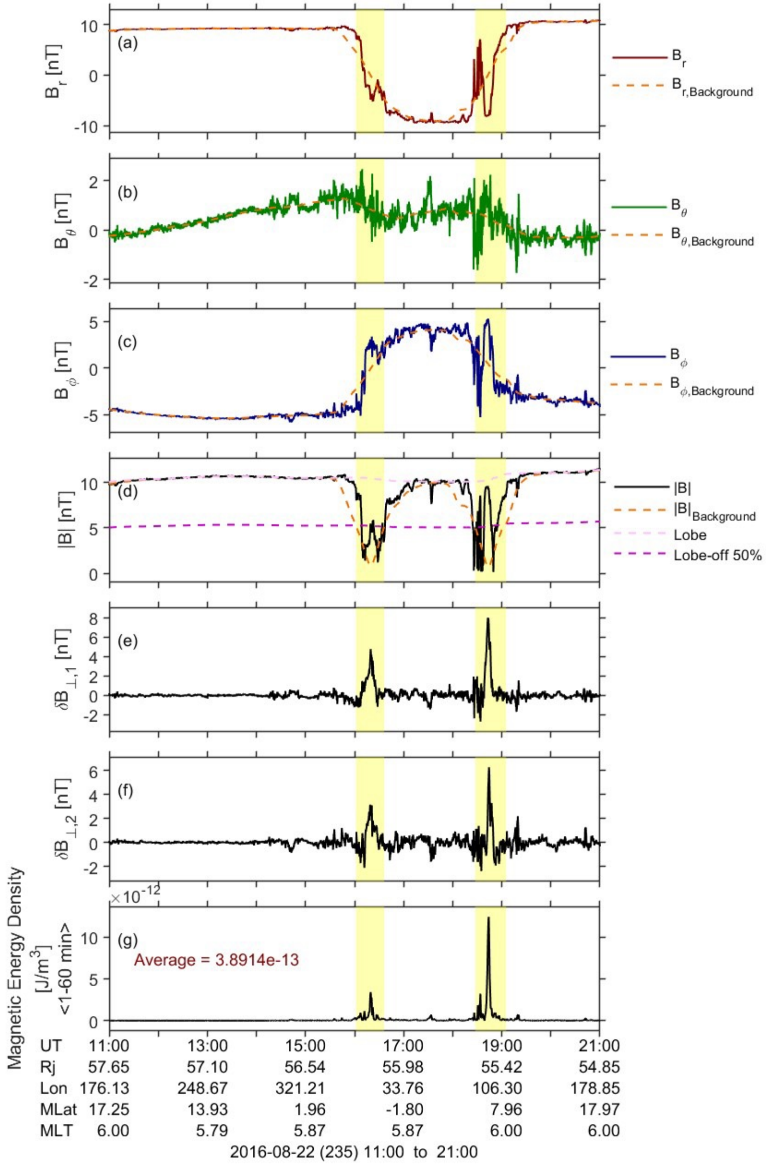
Aflven waves likely the main source of power for driving the Jovian aurora

Pan et al. 2021

Correlation of Jovian radio and ULF waves







Confirming the critical role of Alfvén waves in magnetosphere-ionosphere coupling at giant planets.

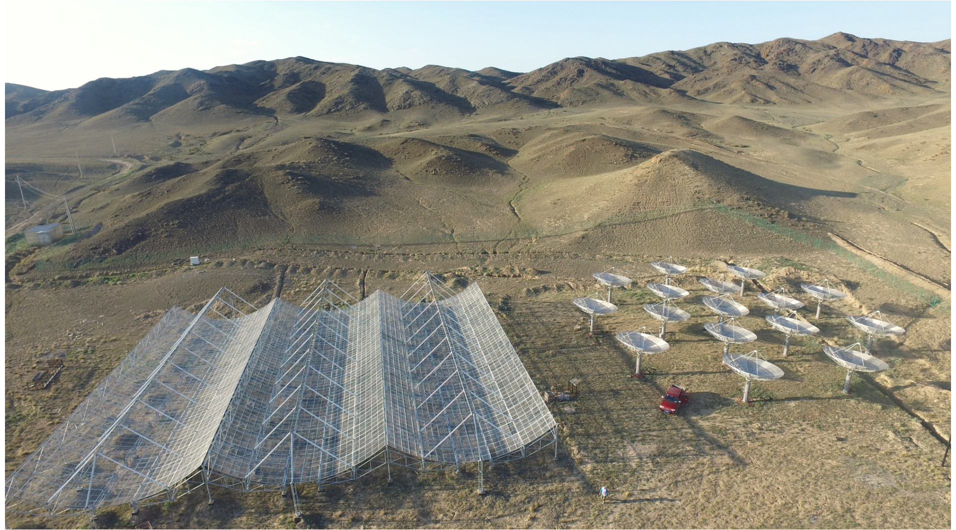
Summary

- Solar wind compression enhances planetary auroral emissions, suggesting the Alfvenic waves are probably the major contributors for planetary aurorae
- Perturbation caused by the solar wind modifies/modulates the properties of the plasma within the magnetosphere.
- Non-thermal distributions in the plasma provide energy for the generation of radio emissions and plasma waves.
- Radio emissions and auroras offer mutually complementary observational insights, revealing spatial-temporal dynamics of energy dissipation in polar regions of Jupiter.

Radio Arrays in China

NSSC
Daocheng
Solar Space
Weather
150-450 MHz

NAO
Tianlai
Cosmo
400-1500
MHz



NAO
QUEST
Pulsars FRB
1050-
1450MHz

Thank you!

南方科技大学
SOUTHERN UNIVERSITY OF SCIENCE AND TECHNOLOGY