Comparative Planetary Auroralogy

Action item for CIP3:
Universality of Auroral Structure

as part of the
International Heliophysical Year 2007

Coordinated by

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We define 'Auroralogy' as a discipline of space science that study the physics of auroral processes and the origin and production mechanism of auroral emissions through the analysis of auroral emission observations and modeling.

In the present document, we are trying to review auroral emissions observed in the Solar System and their mechanisms, as a basis for comparative planetary auroralogy.

YOUR INPUT on PLANETARY AURORA WOULD BE DEEPLY APPRECIATED, in particular, regarding:

- Wavelength(s)/energy(ies) at which observed.
- Emitted Power
- Special characteristic (e.g., temporal, spatial)
- Observed or inferred – name of instrument/observatory
- Process/mechanism of Production and Source of production

supported by references.

Feel free to add directly your input in the tables on the following pages and in the reference list below using a different color such that we can identify it easily. Alternatively, you can send us your input directly in the body of an email.

EMAIL US DIRECTLY (anil_bhardwaj@vssc.gov.in; m.galand@imperial.ac.uk). PLEASE **DO NOT REPLY TO THE WHOLE LIST** in order to avoid filling the mailbox of other subscribers. We will send an updated version regularly and post it as well on the website below for availability to the whole community. Feel free to circulate it among your colleagues and friends for their feedback.

For more information regarding the Coordinated Investigation Programme 3 (CIP3) focusing on "Universality of Auroral Structure", please visit: *http://www.sp.ph.ic.ac.uk/~mgaland/ihy/cip3.html*

Observation of Aurora at the Solar System Bodies

Overview

Yes = √
Potentially = ? (Emissions detected but can we call them aurora?)

We define aurora as a processes initiated due to the collision of atmospheric species with particles external to the 'local atmosphere' of a planet or any planetary body having an atmosphere. Hence, auroras are expected to be observed on all planetary bodies having a significant atmosphere as well as having an intrinsic magnetosphere or are embedded in a plasma flow which impacts their upper atmospheres.

NO = ×

Wavelength → / Object ↓	X-ray	Ultraviolet	Visible	Infrared	Radio	At any other (wavelength)
Mercury			?			
Venus		√**?**				
Earth	√	√	√		√	Gamma rays (?)
Mars		√				
Jupiter	√	√	√	√	√	
Saturn	?	√	√	√	√	
Uranus		√				
Neptune		√				
Moon						
Ganymede		√**?**	√			
Europa						
Io		√	√			
Titan		√**?** ref ??				
Triton		√?				
Io Plasma Torus						

Rings of Saturn						
Exoplanet					Predicted	

Observation of Aurora at the Solar System Bodies

Emitted Power (in comparison with solar emitted power for reference)

Please provide your inputs (with reference) for blanks and comments/corrections on values given

Wavelength → / Object ↓	X-ray	Ultraviolet	Visible	Infrared	Radio	At any other (wavelength)
Sun	10^{20} W					
Mercury						
Venus						
Earth	10-30 MW	~1-10 GW (FUV, 140-180 nm; N2)	~0.2-2 GW		~100 MW	
Mars						
Jupiter	0.40-1 GW (0.1-2 keV) ~50 MW (2-10 keV) A 3-σ upper limit for x-ray emissions at 27-48 keV is 0.11-0.56 GW [*Hurley et al.*, 1993].	2–10 TW (FUV, 80-180 nm; H_2) Galileo UVS data indicate that MUV (162–320 nm) auroral emissions from Jupiter contain about 8 times less flux than FUV auroral emissions [*Pryor et al.*, 1998].	~10–100 GW (385-1000 nm)	4–8 TW (H_3^+, 3–4 μm) ~40 TW (hydrocarbons, 7–14 μm)	~10 GW (10 kHz to a few MHz) Decametric emission (DAM) ~100 GW	

Saturn	ND	< 50 GW (FUV, 80-180 nm; H_2)	??	~150–300 GW (H_3^+, 3–4 μm)	~1 GW (10 kHz to a few MHz)	
Uranus	ND	~40 GW (FUV, 80-180 nm; H_2)	NIA?	~250 GW (H_3^+, 3–4 μm)	~30 MW (10 kHz to a few MHz)	
Neptune	NIA	~100 MW (FUV, 80-180 nm; H_2)	NIA?	<12 GW (H_3^+, 3–4 μm)	~20 MW (10 kHz to a few megahertz)	
Moon						
Ganymede						
Europa	1.5 MW					
Io	2 MW					
Titan						
Triton						
IPT	0.1 GW					
Comets	0.2-1 GW					
Heliosphere	10^{16} W					

ND = Not Detected
NIA = No information Available

Observation of Aurora at the Solar System Bodies

Production Mechanism

Please provide your inputs for blanks and comments/corrections on those already provided.

Wavelength → / Object ↓	X-ray	Ultraviolet	Visible	Infrared	Radio	At any other (wavelength)
Sun						
Mercury						
Venus						
Earth	E>2keV: largely electron Bremsstrahlung emission; E<2keV: K-shell emission by atmospheric species via e- excitation + bremsstrahlung	High latitude: Excitation of atmospheric constituents by energetic e- and H+ precipitation (H Lyman emitted by energetic H) Low and mid-latitude: excitations by ions and charge-exchanged energetic neutral atoms (H, O) of ring current origin	Excitation of atmospheric constituents by energetic e- and H+ precipitation (H Balmer emitted by energetic H)		Earth kilometric radiation	

Mars		Excitation of atmospheric constituents by electrons deposited in regions of crustal magnetic field cusps via: 1. Quasi-static parallel electric fields AND/OR 2. Photoelectrons transported across the terminator AND/OR 3. magnetic reconnection				
Jupiter	E>2keV: largely electron Bremsstrahlung; E<2keV: Energetic heavy (C, S, O) ion precipitation from magnetosphere and/or solar wind	Excitation of atmospheric constituents by energetic electrons; e.g., H_2 Lyman and Werner bands and H Ly alpha emissions	Excitation of atmospheric constituents by energetic electrons			
Saturn		Excitation of atmospheric constituents by energetic magnetospheric electrons			Saturn kilometric radiation	
Uranus		Excitation of atmospheric constituents by energetic magnetospheric electrons			Uranian kilometric radiation	

Neptune		Excitation of atmospheric constituents by energetic magnetospheric electrons			Neptune kilometric radiation	
Moon						
Ganymede		Polar emissions	Equatorial emissions			
Europa						
Io		Equatorial aurora				
Titan						
Triton						
IPT						
Comets	Charge-exchange emissions from heavy highly ionized solar wind ion interaction with cometary neutrals					
Heliosphere						

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- OI UV emissions (OI 130.4 nm and 135.6 nm)

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