전천카메라를 이용한 극지방 양성자 오로라 지상관측

Ground based observations of proton aurora using All-Sky Camera at polar regions

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About Proton Aurora

- Most of the precipitating protons are provided by the shocked solar wind, and partly provided by the tail plasma sheet particles because of a minimum magnetic field existing off the equator in the high latitude dayside region of the magnetosphere (e.g., Tsyganenko magnetic field model).
- Precipitating protons easily exchange the charge in collisions with atmospheric particles such as N₂, O₂, and O, creating a neutral hydrogen atom in an excited state: subsequent relaxation leads to "proton aurora."
- The resulting hydrogen atom still has most of the initial energy of the original proton, but is not bound by the geomagnetic field anymore.
- It maintains the direction of the pitch angle of the spiraling proton, and causes

Observation Site

- Jangbogo Station, Antarctica (JBS) (MLAT 79.87S, MLON 53.56W)
- Kjell Henriksen Observatory, Longyearbyen, Norway (LYB) (MLAT: 75.58N, MLON:108.90)
- Observation of precipitating protons entering into the Cusp region

Parameter	JBS-PASC1	LYB-PASC2
Number of Pixels	1024 x 1024	1024 x 1024
Actual Interval time	25 sec	20 sec
Exposure time	15 sec	15 sec
ICCD Gain	1000	1000
Moving cycle of Filter	17	11
Velocity of stage	10 mm/s	16 mm/s
Permanent observation time	-10 deg	-10 deg
according to solar elevation angle		
Concentration Observation time	18:30 – 22:30 (UT)	7:45 – 11:45 (UT)
at cusp region (MLT noon)	(20:30)	(9:45)





the energetic particles to spread out horizontally.

Even the "bright" proton aurora are dim in an absolute sense. Significantly less structured than the electron aurora.



- Stripping

Capture

H⁺**/H** Charge exchange

- **Doppler shifted Hydrogen emissions** occur only in proton aurora.
- Lyman-a line in the EUV, Balmer Ha at 656.3 nm, Balmer H β lines at 486.1 nm
- A red shifted component of the line profiles observed from the ground indicates **upward-going hydrogen atoms** due to angular redistribution of the precipitation
- An elevated blue shifted component signals high energy precipitation. It varies with magnetic local time (MLT), with narrower spectra and smaller mean Doppler shifts found on the dayside than the nightside.
- \rightarrow Doppler profile of Hydrogen Line shows energy distribution of
 - the incident proton flux
 - the particles after they have penetrated the thermosphere and undergone multiple collisions.

-> Proton precipitation, especially Cusp auroral precipitation, provides a direct source of energy for the highlatitude dayside upper atmosphere, contributing to chemical composition change and global climate variability.



proton aurora image (in magnetic local time-latitude) by IMAGE/SI12 (Lyman-a)

Visual examination of the images



Images of stars so as to map (or coordinate) the images (LYB)









Comparison with electronic aurora; One of keograms (LYB) (producing keograms at various locations to avoid miss the event.)

*** Issue to think for observation & data analysis

The brightness of the aurora is very faint.

All-sky camera for Proton Aurora (PASC)

- H_{a} (656.3 nm) filter
- Observation of **Doppler shifted image** by tilting the filter.
- ICCD with gain of x1000
- 1024 x 1024 pixels
- Developed by Johns Hopkins University Applied Physics Laboratory







Stationary protons will have the profile as shown with the black curve centered at 656.3 nm.

The movement of protons will make the center of the line shift as shown with **the red curve**.

By tilting the filter, the wavelength of the center of filter is shifted and we can identify the line profile as

An angle-specific image of each filter within a cycle (above: LYB, below: JBS)



- \rightarrow long exposure and high gain of ICCD was required
- Proton aurora by secondary electrons are mixed.
- (Secondary electrons produced by proton precipitation cause additional auroral emissions)
- The images are contaminated by interference pattern by filter.
- The noise Amplification of stray light by ICCD gain.
- Due to the high gain of the ICCD, ambient light is also amplified.

Determine of Doppler-shifted profile from the images.



Future Work

- Flat-field calibration to eliminate the sprite noise.
- Development of analysis algorithm



indicated with red dots. Traditional wideband filter (blue box) do not provide information of the Doppler shift.

It's worth trying new science with a new technique. If we can find one good event, It pays our effort.

determine the Doppler-shifted profile according to filter position.

- Identification of precipitating proton aurora - Differentiate proton auroras by secondary electrons.