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Observation of a Wave Structure of Haze in Jupiter's Polar areas by the Ground-based Telescope

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Stratospheric haze formed by aerosol particles covers both polar regions in Jupiter. It has been reported based on the imaging using deep methane band filter at 890 nm by the Hubble Space Telescope (HST) from 1994 to 1999, and by the Cassini ISS in 2000 that the stratospheric haze shows cap structures and their edges show a wave structure spreading in longitudinal direction. This structure is clearly seen in the Jupiter's south pole than northern, and contrast of the wave is particulary prominent at a lattude of about 67 S. And it was suggested that this wave structure is caused by a planetary Rossby waves because this wave structure lasts for a longer period and moves westward relative to the background flow [Sánchez-Lavega, 2008].

However, detailed origin and generation mechanism of this wave structure is not clear so far and the structure shows unknown behavior (e.g. the vertical structure of the wave, change of the propagation velocity of the wave in the short time scale) because the observations of the wave structure are not enough performed. Thus, we have carried out the telescopic observations of Jupiter in the period from 2011 to 2014 by using the Pirka telescope.

In this publication we show results of our observations of the wave structure in Jupiter's polar regions. We found a north-south asymmetry of the wave structure in the polar regions. The wave structure at 67°N spread to 42°N in the northern hemisphere, however it does not exist in the southern one. In addition, we found that the wave structure has varied in the vertical direction a bit between altitude of 361 mbar and 750 mbar.

1. Introduction

In Jupiter's polar regions in the stratosphere, there is stratospheric haze that formed by scattering aerosol particles (squares in Fig. 1.1). This structure can be seen as bright cap using deep methane band filter at 889 nm, whose edges show a wave structure propagating in longitudinal direction in latitudinal range of 60° - 70°S.

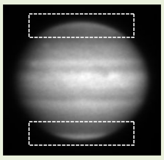


Fig. 1.1 The Pirka image of Jupiter (889 nm)

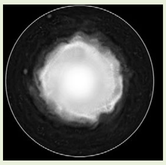


Fig. 1.2 The Cassini image of Jupiter's south polar (890 nm) [*Barrado-Izagirre at al.*, 2008]

Jupiter's polar regions have been observed by the Hubble Space Telescope (HST) from 1994 to 1999 and by the Cassini ISS in 2000.

→ It was shown those wavenumber was 12 - 14 and westward velocity of the wave structure in System Ⅲ was 0 - 10 m/s [*Barrado-Izagirre at al.*, 2008].

In previous works, propagation velocity of this wave was shown, but the variance of short time scale (about month) and the wave structure in the vertical direction are not clear.

<Purpose>

We determine whether or not the wave observed at the edge of the stratospheric haze in polar regions is Rossby wave. We investigate the meridional / vertical wavenumbers and phase speed of the observed wave structure and zonal wind speed.

2. Observation

We have observed Jupiter since 2011 by the 1.6 m Pirka telescope and Multi-Spectral Imager (MSI). We can obtain images at multiwavelengths (infrared and visible wavelength regions) with short time exposure, which enables high spacial resolution.

< Spec. of MSI >

Minimum exposure time (Full frame, EM-CCD)		31 ms
LCTF VIS-10		400 - 720 nm
	Bandwidth	5 - 19 nm
LCTF SNIR-10		650 - 1100 nm
	Bandwidth	5 - 15 nm

Fig. 2.1 The 1.6 m Pirka telescope and Multi-Spectral Imager (MSI)

・In Jupiter polar regions, sensitivity altitude at 889 nm and 750 nm are 361 mbar and 750 mbar, respectively.

・The longer wavelength between 890 - 950 nm, the lower observed Jupiter altitude.

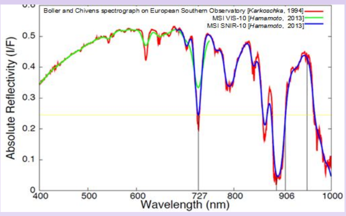


Fig. 2.2 Jupiter Spectrum by the European Southern Observatory (red line) [*Karkoschka*, 1994] and by the 1.6 m Pirka telescope (green and blue line) [*Hamamoto*, 2013]

<Observation data>

Date	Jupiter angular diameter (arcsec)	Seeing size (arcsec)	Wavelength (nm)
Oct. 19 - 20 2011	49.5	2.0 - 2.6	727, 750, 830, 850, 889 601 - 634, 700 - 757, 872 - 950 (step 3 nm)
Oct. 29 - 31 2011	49.6	1.6 - 2.0	727, 750, 889, 950
Nov. 16 - 17 2011	48.8	2.3 - 4.0	619 - 945 (10 colors)

3. Analysis

We plotted the brightness of Jupiter image observed by MSI image at 67°S (red line in Fig. 3.1). We used the information at 67°S within longitudinal extent of 60° around center meridian (Fig. 3.2). We composed the plotted lines made for different times for same longitudes. We plotted the data averaged for 3° at every 3° (Fig. 3.3).

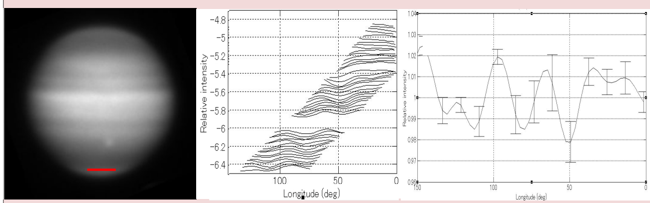
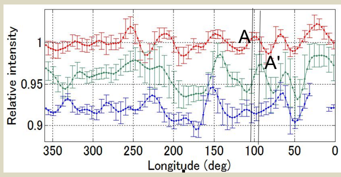


Fig. 3.1 Jupiter image Fig. 3.2 The polar waves Fig. 3.3 The composite of wave

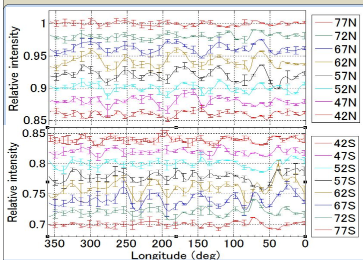
4. Results



If A and A' are the identical peak, the phase velocity of the wave structure is estimated be about 3 m/s.

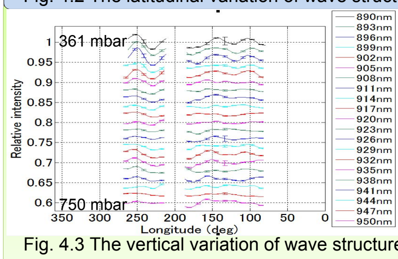
The blue line wave (Nov. 16 - 17 2011) is different from others probabry because of bad seeing (The worst is 4.0 arcsec).

Fig. 4.1 The temporal variation of wave structure (Red line: 10/19 - 20, Green line: 10/29 - 31, Blue line: 11/16 - 17)



The wave structures at different latitudes show north-south asymmetry, and wave in north hemisphere show at 42°N.

Fig. 4.2 The latitudinal variation of wave structure



As observing wavelength becomes longer, the amplitude of polar wave becomes smaller. Based on Fig. 4.3, it is infared that the wave structure in the vertical direction varied between altitude of 361 mbar and 750 mbar.

Fig. 4.3 The vertical variation of wave structure (The bandwidth is 10.3 - 11.8 nm)

5. Conclusions & Future Work

We investigated the wave variation in latitudinal range of 60° - 70°S in 2011.

We found: (1) The phase velocity of the wave structure is estimated be about 3 m/s (2) The wave structures at different latitudes show north-south asymmetry. (3) The wave structure in the vertical direction varied between altitude of 361 mbar and 750 mbar.

We will analyze Jupiter image data obtain in 2014 in order to estimate zonal wind speed in Jupiter polar regions.

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