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Ground-based measurements of the change in the propagation period of Y-feature on Venus

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Abstract

Venus long-term observations covering one Venus year (225 days) were conducted using a ground-based telescope. The propagation periods of planetary-scale UV features were estimated for six observing periods (each observing period has 2-4 weeks) from August 2013 to June 2014. A significant periodicity of 5.2 days was detected in August 2013 while that of 3.5 days in May and June 2014. On the other hand, other observational periods, which are in a time between August 2013 and May 2014, didn't show a clear periodicity. It seems to take 8 months or less that the propagation period changes to another one. This time scale is obviously shorter than one Venus year.

1. Introduction

The dynamical mechanism of Venusian super-rotation remains a mystery for a long time. This phenomenon is that the Venus atmosphere in around 70 km cloud level moves westward at a velocity 60 times faster than the planetary rotation and wind speed reaches as fast as 100 m/s. Several theses suggest planetary-scale waves are associated with the super-rotation [e.g. 1, 2]. And also these waves are considered to form planetary scale UV features (named "Y-feature") in Venus dayside. Pioneer Venus orbiter (PVO) observed that the propagation of planetary-scale UV feature cause the periodical variation of UV brightness with the period 4-5 days [3]. They suggested that the period of brightness variation corresponds to the propagation of planetary wave and it change on a time scale of 5-10 years. Periodicity change can be argued as the vacillation of dynamical states and investigating the source of planetary waves is required to understand the super-rotation.

After the PVO mission, Venus Monitoring Camera (VMC) on-board Venus Express spacecraft provided us very beneficial images to study about long-term variation of UV features. However, the VMC captured UV features in global scale only in the southern hemisphere because Venus Express is in elliptic orbit with apocenter in the southern hemisphere. Since its orbital plane is nearly fixed in the internal frame of reference, there are some difficulties to investigate the variation of propagation periods of Y-feature in one Venus year without interruption. Therefor, the seasonal properties of Venus planetary waves are not well investigated only with spacecraft.

2. Observations and Analysis

Ground-based telescope enables us to monitor Venus with enough resolution to observe the Y-feature except near Venus conjunction seasons. Our ground-based observations were conducted at about one month intervals from mid-August 2013 to end of June 2014. Our observation covers about one Venus year (225 days) and have good potential for investigating the monthly change as compared to the Pioneer Venus observation. Used instruments are a visible multi-spectral imager (MSI) [4] with 365 nm narrowband filter (FWHM: 10 nm) installed on 1.6m Pirka telescope, constructed and operated by Planetary and Space Group in Hokkaido University.

The relative UV brightness was measured from equatorial to mid-latitudinal regions in both hemispheres based to the mean brightness of Venus disc. This analysis technique was applied for Galileo observed images, which clearly show the Y-feature, and it was confirmed that the propagation period can be derived from this analysis. When the prominent Y-feature exists and propagates with a certain period, our data show the bright and dark features having periodical and symmetrical patterns about the equator.

Brightness variation indicates the inverse relation between equatorial region and mid-latitudinal regions and the boundary of bright and dark region locates near the latitudes of 30° N and 30° S. The periodicity of the propagation of the Y-feature is studied from our relative brightness data using Lomb-Scargle periodgram [5]. UV images from VMC (narrowband channel centered at 365 nm) are also used to compare with our data and investing the periodicity.

3. Results and Discussions

From results of our ground-based observation (shown in Table 1), it was revealed that the periodicity in the UV brightness variation changes with in a Venus year (225 Earth days). In August 2013, we detected ~5.2 days periodical brightness change in equatorial and both in northern and southern mid-latitudinal regions. The retrieved periodical and symmetric bright and dark pattern suggests the existence of prominent Y-feature in this observation period. In contrast, after the mid-September 2013, there was no prominent and periodical brightness variation in the most of the observation period. The absence of the periodical variation was also confirmed in February 2014. However, our last two observational periods showed ~3.5 days periodical variation again. Since estimated periods of sinusoidal variations are same in May and June 2014 and their phases are consistent, 3.5 days period is considered to last for about two months. It is pointed out from our study that the possibility of the change of dynamical states occurs in one Venus year. The exact time scale of this change is under investigation, and our further observation has started from April 2015.

Table 1: List of periods of analysis with 90% significance or more. In three out of six observing periods, we can find clear periodicity (~5.2 and ~3.4 days) in UV brightness variation.

	Observing period	Period [days]
# 1	Aug 19 – Aug 29, 2013	5.15
# 2	Sep 23 – Oct 8, 2013	-
# 3	Oct 18 – Dec 8, 2013	-
	Jan 11, 2014: Interior Conjunction	
# 4	Feb 25 – Mar 28, 2014	-
# 5	May 6 – June 1, 2014	3.49
# 6	Jun 19 – Jun 30, 2014	3.49

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