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The long-term rotation period of Saturn's hexagon

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Abstract

We present measurements of the positions of the edges of Saturn's hexagon wave from December 2012 to April 2013 using images obtained in the visual range submitted to the IOPW-PVOL database by observers around the world. We compare the rotation period of the hexagon with that obtained in 1980-81 and in 1990-95. We find that Saturn's hexagon has the most steady long-term rotation period observed in the planet, ranging from 10hr 39min 20.6s to 10 hr 39min 49s, making the hexagon rotation a serious candidate to constrain the internal period of the planet.

1. Introduction

Saturn's singular hexagon-wave was discovered on Voyager images obtained in 1980-81 [1] and, because of its quasi-stationary motion in the System III rotation period (10hr 39min 22.4s from SKR modulation at the Voyager epoch [2]), it was proposed as a possible tracer of Saturn's internal rotation [3]. Centered at latitude 78ºN, it was also observed in 1990-95 both from the ground [4] and from Hubble Space Telescope [5], accompanied at the time by a large anticyclone nicknamed the North Polar Spot (NPS) [6]. Interior to the hexagon, an intense zonal jet flowed eastward with wind speeds of 100 m/s and it was proposed that the hexagon is a Rossby wave forced when the NPS impinges on the jet [7]. In the Cassini era the hexagon was partially observed in nighttime at infrared wavelengths using the VIMS instrument in 2008 [8]. Recently the ISS camera [9] has captured the complete hexagon, and a large number of ground-based images have become available. We report and analyze them here.

2. Observations

The hexagon became visible to ground-based telescopes with the increasing northward view of the North Pole of the planet along 2012. We have measured colour composite images submitted to the IOPW-PVOL database (http://www.pvol.ehu.es/pvol/) obtained with telescopes ranging from 36-40 cm in aperture using the lucky-imaging method technique. Additionally we used a set of images obtained with the 1.23 m telescope at Calar Alto Observatory and PlanetCam instrument [10]. The images were navigated and measured using two different software packages (Laia and WinJupos) and polar projected to show more clearly the hexagon wave (Figure 1).

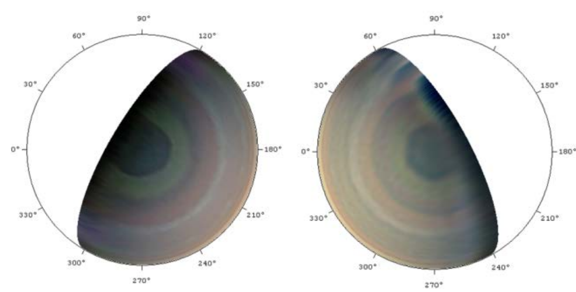

Figure 1: Polar projections maps of Saturn's North hemisphere showing the hexagon wave. Left: Damian Peach (April 20th, 2013); Right: Trevor Barry (March 7th, 2013). System III longitudes are indicated.

For each detected hexagon vertex we performed 3-4 measurements of its longitude – latitude position with a typical error of 1º (SD). The six vertices were tracked between December 2012 and April 2013 and their drift charts lead to their unambiguous identification, with an average separation of 60º in longitude. Their mean drift rate was +0.0.039 deg/day in System III corresponding to an absolute angular velocity of 810.8329 deg/day or a rotation period in space of 10 hr. 39 min 20.6 ± 1.6s. Some vertices showed fluctuations around the mean with a maximum separation of about ± 4º. Theaverage planetocentric latitude was 73.4º ± 0.3º. It must be noted that the NPS was not present in 2012-13 and apparently was not visible on VIMS images in 2008.

This seems to rule out the proposed relationship between the NPS and the hexagon wave that had been previously suggested [7]. It is worth noting that the hexagon has survived to the long polar northern nights produced by the tilt of 26.7º of the planet rotation axis relative to the orbital plane. The hexagon wave is therefore insensitive to the strongly variable seasonal insolation heating in the polar regions, suggesting that it is a deeply rooted atmospheric feature.

2. Discussion

In Table 1 we compare the measured rotation period from December 2012 to April 2013 with those derived previously.

Table 1: This Long-term rotation period of Saturn's hexagon measured at visual wavelengths

Epoch	Period	Reference
1980-81	10 hr 39 min 24.3 s	1, 3
1980-81	10 hr 39 min 25.2 s	4, 6
1990-91	10 hr 39 min 25.2 s	5
1990-95	10 hr 39 min 23.8 s	4, 6
1980-95	10 hr 39 min 49.4 s	Combined (*)
2013	10 hr 39 min 20.6 s	This work

(*) Using the NPS for the long-term identification.

It becomes notorious that the absolute rotation period of this atmospheric feature varies only very slightly on the long-term (more than a Saturn year which amounts to 29.5 years). Currently there is an open debate about the rotation period of the planet itself, which is unknown [11]. The period of the SKR radio emission, proposed as a signature of the intrinsic rotation of the planet, has varied in the last 30 years and even shows two simultaneous periods that differ on each hemisphere [12]. Alternative rotation periods for the planet have been proposed based on the gravitational field [13] and in the atmospheric dynamics [14]. However these are shorter by 5 to 7 minutes relative to the SKR mean and hexagon rotation periods (Table 1). We propose that Saturn's planetary rotation must be close to that of the hexagon.

Acknowledgements

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