Saturn during the 2005/2006 apparition

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A report of the Saturn, Uranus & Neptune Section. Director: Mike Foulkes.

This report describes observations of Saturn made by members of the Saturn Section during the 2005/2006 apparition. In particular, this report describes the observations of a bright storm that appeared in southern mid-temperate latitudes, which was also observed by the *Cassini* spacecraft. Details of other storms observed are described, including a light spot at high southern latitudes. Only a small segment of the northern hemisphere was visible but within this, a narrow bright blue zone was recorded. Observations of an occultation of the star BY Cancri are also presented.

Introduction

This apparition commenced after solar conjunction on 2005 Jul 23.[1] Opposition was on 2006 Jan 27,[2] when the planet was in the constellation of Cancer and lying at the southern edge of the Beehive Cluster. At opposition, the planet's apparent magnitude was –0.2; its apparent equatorial diameter was 20.4″ and the apparent major axis of the rings was 46.2″. This apparition finished at solar conjunction on 2006 Aug 7.[2]

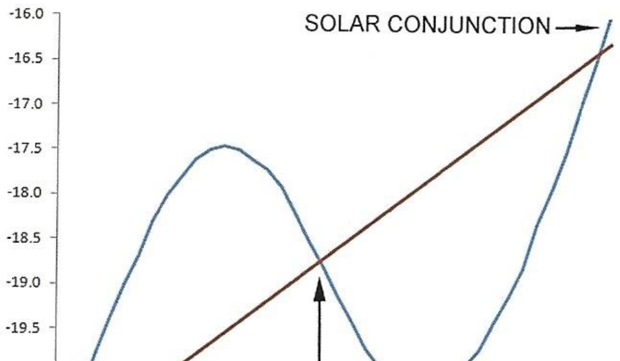

Figure 1. The variations in Saturn's polar and ring inclination as seen from the Earth (parameter B) and from the Sun (parameter B′) during the 2005/2006 apparition. Negative values indicate that the south pole and south face of the rings were inclined towards the Earth and the Sun. The dates of opposition and solar conjunction are indicated.

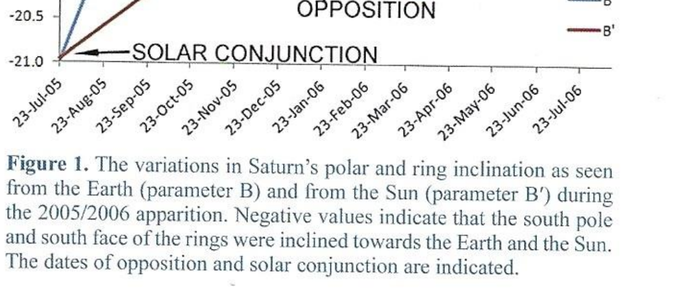

Figure 2. Belt and zone nomenclature used in this report. 2006 Apr 10, 01:10 UT; CM1= 356.4°, CM2= 50.9°, CM3=102.4°. *(Image taken in Barbados by Tyler)*

The variation of the apparent inclination of its pole and rings with respect to both the Earth and the Sun during this apparition is shown in Figure 1.

At opposition the ring inclination with respect to the Earth was –18.9°.

Observations

A large number of observers contributed to this report, with the majority using digital imaging techniques. Those who contributed visual observations are shown in Table 1. Table 2 shows those who provided digital images.

The first observation of this apparition was made on 2005 Sept 23 by Maxson and the last was made by McKim on 2006 May 30. The largest telescopes used were by Gray, McKim and Parker, with apertures of over 400mm. Some images were taken with colour cameras, but a number of observers used red, green and blue filters to construct colour images. Some observers also used infrared (IR) and ultraviolet (UV) filters, as shown in Table 2.

During 2006 April, Kingsley, Peach and Tyler made an expedition to Barbados to image the planets under favourable seeing.[3] Their observation programme concentrated on Jupiter and Mars, but a number of Saturn images were also taken. Peach was able to provide images from Apr 8–23 inclusive.

The *WinJUPOS* software was used to derive spot longitudes, average spot drifts and belt latitudes. [4]

Nomenclature & terminology

Abbreviations and terminology are as defined in ref. 5. All drawings and images shown in this report are orientated with south upwards and with the preceding (*p.*) edge to the left. Planetographic latitudes (the default in *WinJUPOS*) are used unless otherwise stated.

Figure 2 shows belt and zone nomenclature used in this report.

Latitudes

Latitudes of the edges of the belts were derived by measuring a number of the best colour images using the *WinJUPOS* software. Table 3 shows the derived latitudes; values are given in both the planetographic and planetocentric systems.

The standard deviations given in Table 3 were derived from the individual measurements. However, it is likely that the uncertainty of the latitudes may be higher than this.

No significant changes in belt latitudes were observed during this apparition. The latitude estimates show that the Equatorial Belt (EB) was asymmetrically placed with respect to the planet's equator, *i.e.* it lay predominantly in the southern hemisphere. The bright bluish-coloured zone in the northern hemisphere has been designated as the North Temperate Zone (NTZ) for the purposes of this report, although its true designation is uncertain.

The derived latitudes of the southern hemisphere belts are comparable with those found during the previous apparition.[6] However a full comparison of the southern hemisphere belt latitudes over apparitions recent, earlier and subsequent to this one will be given in a later apparition report.

Table 1. Visual observers, 2005/2006

Observer	*Location*	*Telescope**
Biver, Nicolas	Versailles, Paris, France	256 & 407mm Newt.
Bowan, Richard	Wakefield, West Yorks., UK	300mm Newt.
Colombo, Emilio	Cambio, Italy	150mm Newt.
Foulkes, Mike	See Table 2	See Table 2
Gray, David	Kirk Merrington, Co. Durham, UK	415mm DK
Hancock, Ian	Canterbury, UK.	222mm Newt.
Heath, Alan W.	Long Eaton, Nottingham, UK	250mm Newt.
Hernandez, Carlos	Miami, Florida, USA	229mm Mak.
Hurst, Guy M.	Basingstoke, UK	444mm Newt. & 125mm Mak.
McKim, Richard	See Table 2	See Table 2
Niechoy, Detlev	Göttingen, Germany	203mm SCT
Parish, Peter	Rainham, Kent, UK	152mm OG
Porter, Malcolm	Petts Wood, London, UK	178mm Mak.–Newt.
Rogers, John H.	Linton, Cambridge, UK	250mm Newt.

*Cass.= Cassegrain; DK= Dall–Kirkham Cassegrain; Mak.= Maksutov–Cassegrain; Newt.= Newtonian; OG= refractor; SCT= Schmidt–Cassegrain.

Visual intensity & colour observations

Only five observers provided visual intensity estimates of the belts and zones; these are shown in Table 4. Gray made the largest number of estimates. No colour filters were used in these observations. For each belt or zone, the table gives the average value derived by each observer plus the overall average based on all observations.

There are differences in the values recorded by some observers for certain features. However the results show the EZ(S) to be the brightest zone and the SEB(N) & SPB to be the darkest belts.

Visual colour estimates of the belts and zones are shown in Table 5. This table also shows a visual assessment by the author of the colours shown in the colour images.

During this apparition, a number of images were taken using a variety of filters ranging from UV up to the near-IR. Typical examples of these observations are shown in Figure 3, although these images were taken by different observers using a variety of equipment and on different dates.

In UV (365nm), some regions of the planet appeared light, although the South Polar Region (SPR) and South Temperate Belt (STB) appeared dark (Figure 3(a)). The EZ also appeared dark.

Methane is a constituent of Saturn's atmosphere and this molecule very strongly absorbs light at 890nm. Light is reflected from high-altitude clouds in the upper atmosphere with less methane light absorption at this wavelength than lower-level clouds. Consequently, higher clouds appear bright and

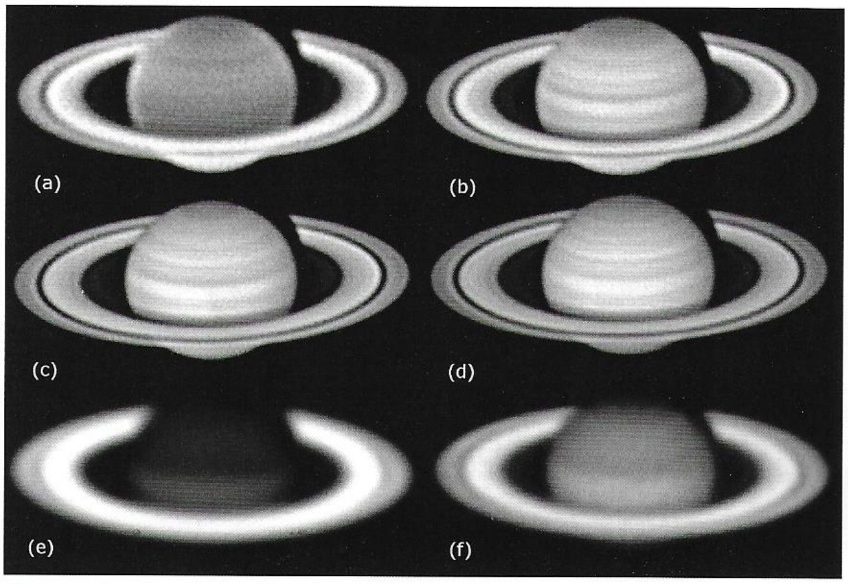

Figure 3. The appearance of the planet and rings in different wavebands.
(a) 2006 Apr 6, 20:47 UT; CM1= 189.5°, CM2= 346.8°, CM3= 42.2°. *(UV (365nm) image by Pellier)*
(b) 2006 Apr 5, 20:57 UT; CM1= 71.2°, CM2= 260.6°, CM3= 317.1°. *(Blue image by Pellier)*
(c) 2006 Apr 5, 20:48 UT; CM1= 69.5°, CM2= 255.5°, CM3= 312.1°. *(Green image by Pellier)*
(d) 2006 Apr 5, 20:13 UT; CM1= 45.4°, CM2= 235.7°, CM3= 292.4°. *(Red image by Pellier)*
(e) 2006 Feb 25, 16:08 UT; CM1= 95.2°, CM2= 110.6°, CM3= 214.5°. *(Methane (893nm) image by Akutsu)*
(f) 2006 Feb 25, 16:02; CM1= 91.7°, CM2= 107.3°, CM3= 211.1°. *(IR (980nm) image by Akutsu)*

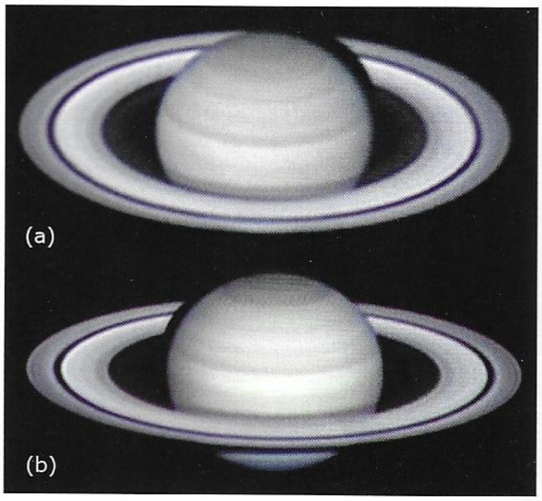

Figure 4. Changes in belt and zone colour and intensities between 2005 March & November. These images show the change in the red colour of the SPR and SPB. Note also the narrow bright blue zone in the northern hemisphere in the November image.
(a) 2005 Mar 19, 18:30 UT; CM1= 34.7°, CM2= 328.7°, CM3= 126.1°. *(Image by Tyler)*
(b) 2005 Nov 30, 04:13 UT; CM1= 14.7°, CM2= 336.4°, CM3= 185.8°. *(Image by Tyler)*

lower clouds dark in images taken with methane filters. During the apparition much of the planet appeared dark at this wavelength, although the EZ appeared light, therefore indicating relative height (Figure 3(e)). The STropZ also appeared light, but not as bright as the EZ.

Rings A & B were visible with all the filters used in Figure 3.

The planet

South Polar Region (SPR)

The most prominent feature in this region was the South Polar Band (SPB). Many observers classed the region south of

Table 2. Digital imaging observers, 2005/2006

Observer	*Location*	*Telescope**	*Camera*	*Filters*** *(IR Blocking +)*
Adelaar, Jan	Arnhem, the Netherlands	235mm SCT	ToUcam	–
Akutsu, Tomio	Cebu City, Philippines	200 & 279mm SCT	ToUcam II & DMK21BF04	UV (340nm), IR (800nm), Methane (893nm), IR (980nm)
Arditti, David	Edgeware, Middlesex	254mm DK	ATIK 1HS II, ToUcam (mono)	Trutek L, R, G, B; Baader IR
Best, Richard	Lewes, East Sussex	356mm SCT	Lumenera 075	R, G, B
Bosman, Richard	Enschede, the Netherlands	279mm SCT	ATIK 2HS	R, G, B
Brown, Mike	Huntington, York	254mm Newt.	ATIK 1HS II	–
Bucharest Astro. Club (Conu, Alex & Sonka, Adrian)	Bucharest, Romania	235mm SCT	Philips Vesta	–
Buda, Stefan	Melbourne, Australia	400mm DK	ToUcam 740	UV blocking.
Buczynski, Denis	Scotforth, Lancaster	150mm OG	ToUcam Pro	Baader Fringe Killer
Cook, Anthony	Long Eaton, Nottingham	200mm Newt.	Watec 902H	–
Cooper, Jamie	Wooton, Northants.	355mm SCT	ToUcam Pro	–
Delcroix, Marc	Tornefeuille, France	254mm SCT	ToUcam Pro	–
Edwards, Peter	Horsham, West Sussex	203mm SCT	ToUcam (mono)	–
Elston, Geoff	Hemel Hempstead	202mm SCT	ToUcam Pro II	–
Fattinnanzi, Cristian	Macerata, Italy	250mm Newt.	Philips Vesta Pro	–
Foulkes, Mike	Henlow, Beds.	203mm SCT	ATIK 1HS II	IR
Friedman, Alan	Buffalo, NY, USA	254mm Mak.	DMK 21BF04	R, G, B
Go, Chris	Cebu, Philippines	279mm SCT	DMK 21BF04	R, G, B
Hossain, S.	Dhaka, Bangladesh, India	90mm Mak.	Canon 2.1mpx camera	–
Jefferson, James	Ruislip, Middlesex	125mm Mak.	ToUcam Pro 2 & ATIK 2C	–
Johnson, Keith	West Sussex, UK	140mm Mak.	ToUcam Pro 2	–
Kingsley, Bruce	White Waltham, Maidenhead, Berks., UK & Barbados	235 & 279mm SCT.	ATIK 1HS	Astronomik, L, R, G, B
Lawrence, Peter	Selsey	250mm SCT	ToUcam	–
Lazzarotti, Paolo	Massa, Italy	315mm SCT	Lumenera LU 075M	R, G, B
Lewis, Martin	St. Albans, Herts.	222mm Newt.	ToUcam	–
McKim, Richard	Upper Benefield, Northants.	410mm DK	ToUcam	
Meredith, Cliff	Prestwich, Manchester	214mm Newt.	ToUcam	–
Mobberley, Martin	Cockfield, Sussex	245mm Newt.	Lumenera LU 075M	R, G, B
Olivetti, Tiziano	Bangkok, Thailand	180mm Mak & 275mm Newt.	Astromeccanica K-SS-8H2p	–
O'Sullivan, Tony	Prestwich, Manchester	254mm SCT & 127mm OG	Not known	–
Parker, Don	Coral Gables, Florida, USA	406mm Newt.	Lumenera 075M	Astronomik L, R, G, B
Peach, Damian	Loudwater, Buckinghamshire, UK & Barbados	235mm & 356mm SCT	Lumenera LU 075M	R, G, B
Phillips, Jim	Charleston, SC, USA	203mm OG	ATIK 2C & ATIK Mono	–
Pellier, Christophe	Bruz, France	210mm Cass.	LU 075 M & ATIK 1 HS	R, G, B, IR (630nm), UV (365nm), IR (700nm), Schuler SP 470, Wratten 47
Pratt, Alex	Leeds	200mm Mak.	ToUcam Pro	–
Sánchez, Jesus R.	Córdoba, Spain	279mm SCT	ToUcam (mono), ToUcam (colour)	–
Scagell, Robin	Uxbridge	203mm SCT	ToUcam 740	–
Sharp, Ian	Ham, West Sussex	279mm SCT	ATIK 1HS & Toucam Pro.	Astronomik R, G, B; Baader red long-pass
Tyler, David	High Wycombe, UK & Barbados	235, 279 & 356mm SCT	Lumenera 075, ToUcam 840, & ATIK 1HS2	Trutek R, G, B
Vandebergh, Ralf	Nijswiller, the Netherlands	254mm Newt.	ATIK 1HS	–
Yunoki, Kenkichi	Sakai City, Osaka, Japan	200mm Newt.	Toucam Pro	Baader UV (300–400nm), IDAS Type II B (390–530nm, W38A), G, R, IR (700nm), Methane (890nm), IR (900nm), IR (960nm)

*Cass.= Cassegrain; DK= Dall–Kirkham Cassegrain; Mak.= Maksutov; Newt.= Newtonian; OG= refractor; SCT= Schmidt–Cassegrain
**B= blue; G= green; IR= infrared; L= luminance; nm= nanometres; R= red; UV= ultraviolet

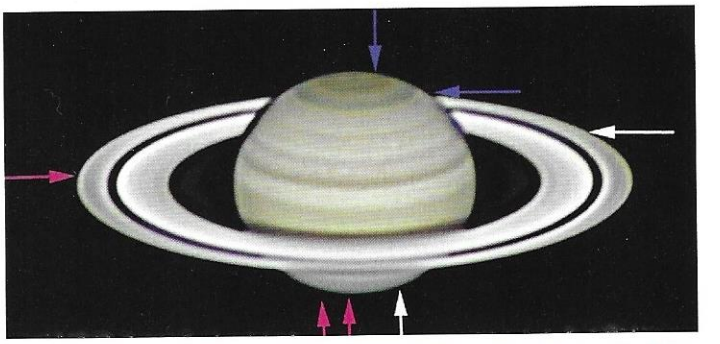

Figure 5. SPBs spot. 2006 Jan 24, 04:14 UT; CM1= 17.1°, CM2= 2.2°, CM3= 145.2°. This image shows the bright spot on the SPBs, indicated by blue arrows. The three other spots that were observed during the apparition are also shown. The STB(N) spot is indicated by white arrows and two spots in the SEBZ are indicated by red arrows. *(Image by Parker)*

the SPB as the South Polar Region (SPR), which generally appeared grey.

Within the SPR was a darker polar cap. At low resolution this appeared uniform in intensity, but higher-resolution observations showed this to have a broad belt-like boundary (described as an SSPB by McKim in ref. 6) and a light zone to the south. A dark spot was seen at the pole itself, which is the South Polar Vortex. This was detected in a number of images, but only seen visually by Gray and McKim.

A light zone was often detected between the South Polar Cap and the SPB.

During the previous apparition,[6] a reddish colouration was observed extending from the boundary of the South Polar Cap and into the SPB. During the early part of this apparition (Figure 4), this colouration had become less extensive and was only visible in the zone between the SPB and the South Polar Cap. The SPB had become dark grey in colour. The zone was generally light in red images, and the red colour was faintly visible in some images taken later in the apparition (*e.g.* by Tyler on Mar 1 and, very faintly, on Apr 10; see Figure 2). Generally this colour was not recorded in other images, although McKim visually recorded this region to be orange brown during November and January.

The SPB appeared as the darkest belt visually and was the darkest in red light images. This belt sometimes showed a double structure, and Peach recorded a wave pattern on the northern edge of the belt in red light images taken on Jan 23 & Apr 10.

The most interesting feature in this region was a light spot which appeared on the southern edge of the SPB (Figure 5). This was recorded in red light images, but was not shown in green and blue light photographs. It was only recorded in images taken by Go, Lazzarotti, Parker, Peach and Tyler.

The drift chart (longitude *vs.* time) is shown in Figure 6. There is some scatter in the longitude measurements, but this is to be expected for those at high polar latitudes. Some longitude measurements had to be made when the spot was a distance from the central meridian; this again would contribute to the scatter. The best linear fit to the longitude measurements is given in the figure and a noticeable positive drift with respect to System III is shown. Table 6 gives its derived average drift, latitude and size, with the dates when observed.

A fainter spot was detected further north on Dec 20 by Peach, at a System III longitude of 128° and latitude of 70°S. However, this was the only observation of this feature.

South South Temperate Region (SSTR)

Two very narrow belts separated by a light zone were detected between the SPB and the southern edge of the STB. For the purposes of this report, they were designated as the northern and southern components of the SSTB.

The SSTB(S) was the fainter of these two components. The South Temperate Zone (STZ) was light.

Peach detected a diffuse light spot between the components on Apr 8.

South Temperate Belt (STB) & South Temperate Zone (STZ)

The STZ appeared as a narrow light zone.

The STB appeared double, divided by a light zone. The southern component was slightly darker than the northern. This appearance was the reverse of what was observed during the previous apparition (Figure 4). On Apr 14, Peach detected a low-contrast light spot on the southern edge of the STB (STBs).

The most significant feature in this region, and indeed of the apparition, was a bright storm which appeared as a light spot on the STB(N) and is designated STB(N) spot No. 1. A selection of observations showing the spot's appearance from 2006 January until April is shown in Figure 7. It is also shown in Figures 5 & 11(b). This spot was often detected in green light images, but was either faint or not visible in red and blue light images. It was only recorded visually

Table 3. Latitudes of the belts, 2005/2006

Belt	*Measured planetographc latitudes (°)*		*Std dev. (°)*	*Derived average planetocentric latitudes (°)*
	AVERAGE PLANETOGRAPHIC LATITUDE (°)	NO. OF MEASUREMENTS		
South Polar Cap s. edge	77.9S	6	2.1	74.9S
South Polar Cap n. edge	73.9S	11	2.1	70.1S
SPBs	67.8S	11	1.6	62.9S
SPBn	63.7S	12	0.9	58.2S
SSTB(S)s	58.8S	12	1.8	52.8S
SSTB(S)n	57.2S	5	1.4	51.1S
SSTB(N)s	55.1S	5	1.3	48.8S
SSTB(N)n	52.8S	12	0.8	46.4S
STB(S)s	48.4S	12	0.7	41.9S
STB(S)n	44.9S	10	0.8	38.5S
STB(N)s	42.3S	9	1.0	35.9S
STB(N)n	39.7S	12	0.8	33.5S
SEB(S)s	34.4S	12	0.9	28.7S
SEB(S)n	30.2S	12	0.6	24.9S
SEB(N)s	25.3S	12	1.1	20.7S
SEB(N)n	19.6S	12	0.5	15.8S
C. of narrow belt in the s. EZ	15.1S	10	0.8	12.1S
EBs	7.7S	12	0.8	6.2S
EBn	1.3N	12	0.7	1.0N
NTZ	44.7N	6	2.0	38.3N

Note: Latitude measurements were made from images taken by Buda, Friedman, Peach, Parker, Phillips, Sharp and Tyler over the period 2005 Nov 20 – 2006 Apr 25. All values are given to one decimal place.

by Gray, McKim (Figure 11(b)) and Peach. Gray was sometimes able to make transit observations of the *p.* and *f.* ends of this spot, but never on the same night. The spot was however imaged by many observers.

The majority of observations of this spot were made between 2006 Jan 24 & Apr 19. However, observations by Tyler on 2005 Nov 30 and by Peach on 2005 Dec 20 both show a similar spot. In the Nov 30 image, the spot was *p.* the central meridian. This image was taken earlier than that shown in Figure 4(b). However, it was not visible in that figure. Although there is a gap of several weeks between these and the remainder of the observations, the longitudes lie on the track derived from the other observations (Figure 8). This shows that it was in existence since Nov 30.

Table 6 shows the derived drift rate, rotation period, latitude and size. The spot showed variations in both brightness and size during the apparition. Observations up to late January generally showed it to be centred within the STB(N), with little or no extension into the STropZ (see Figures 5 & 7(a)).

By the end of January/early February, it appeared much brighter than previously observed (Figure 7(b)). It then faded slightly, becoming more elongated and sometimes observed extending further into the STropZ (Figure 7(c)).

During February and early March, one or two brighter regions were suspected within the elongated spot in some observations, hinting at a double appearance (see Figures 7(c) & 7(d)). By Mar 15, images by Peach and Tyler definitely show a second light spot (designated STB(N) No. 2 in this report) immediately *f.* No. 1. Both spots (Figure 7(e) & 7(f)) were subsequently observed until Apr 19, although at low resolution both appeared as a single elongated object. To avoid any confusion, observations after Mar 15 showing both objects are plotted in Figure 8, rather than those that just show a single object.

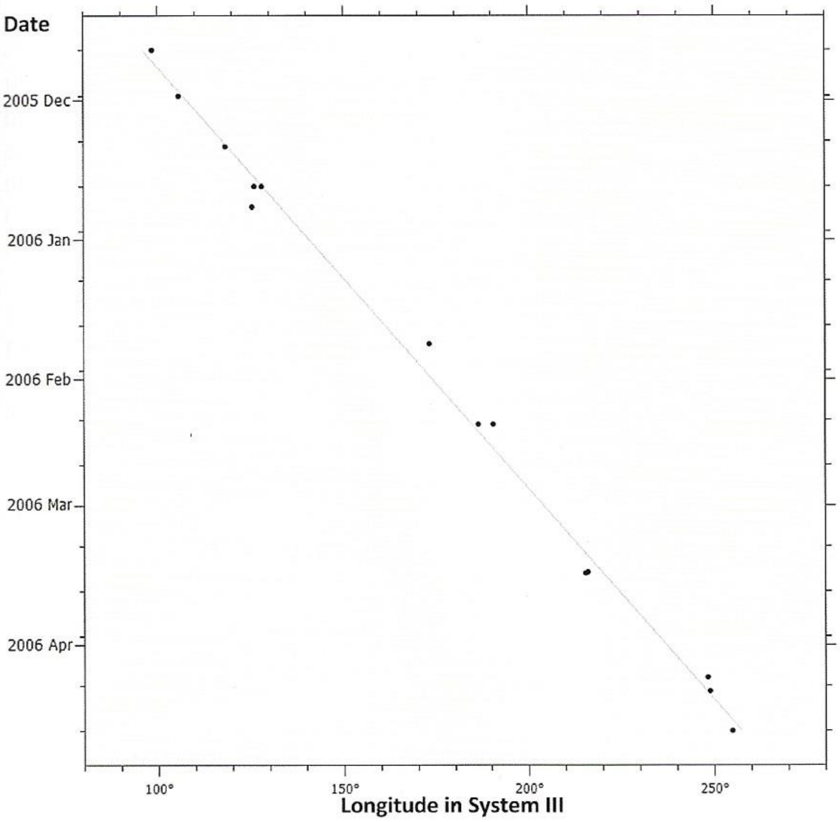

Figure 6. *Above.* Drift chart for the centre of a bright spot on the southern edge of the SPB (SPB No. 1) in System III for 2005/2006. The positions (shown by dots) have been determined from images taken by Go, Lazzarotti, Parker, Peach and Tyler. The solid line represents the average drift derived from these observations.

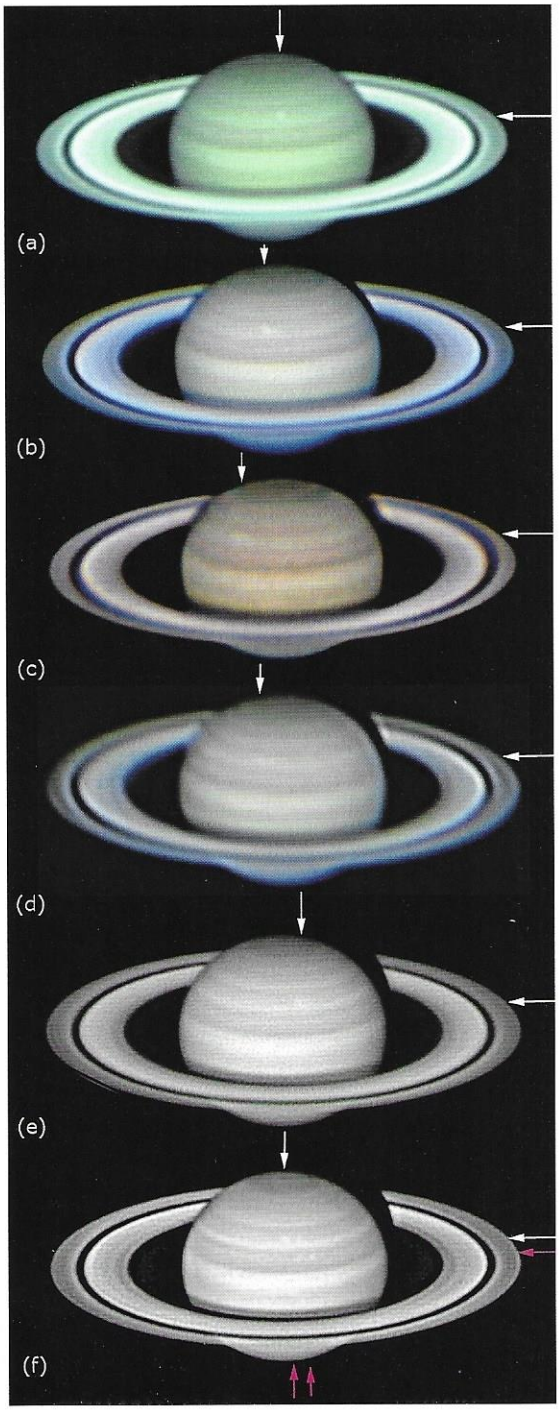

Figure 7. *Right.* The appearance of spot STB(N) Nos. 1 & 2 during 2006 January–April. The position of No. 1 is shown by white arrows. No. 2 is visible in Figures (e) & (f). The positions of the two SEBZ spots are shown by red arrows.

(a) 2006 Jan 27, 11:42 UT; CM1= 293.0°, CM2= 171.1°, CM3= 310.1°. The opposition effect for the rings is shown. *(Image by Phillips)*

(b) 2006 Feb 10, 23:50 UT; CM1= 301.0°, CM2= 70.6°, CM3= 192.1°. *(Image by Sharp)*

(c) 2006 Feb 13, 03:04 UT; CM1= 303.5°, CM2= 4.1°, CM3= 123.1°. *(Image by Maxson)*

(d) 2006 Mar 6, 23:32 UT; CM1= 34.3°, CM2= 109.1°, CM3= 201.7°. *(Image by Meredith)*

(e) 2006 Mar 19, 20:39 UT; CM1= 108.5°, CM2= 127.3°, CM3= 204.4°. *(Green image by Tyler)*

(f) 2006 Apr 19, 23:48 UT; CM1= 110.3°, CM2= 203.7°, CM3= 243.3°. The SPBs spot is not shown in this image, although it may have been on the disc. *(Monochrome image by Peach)*

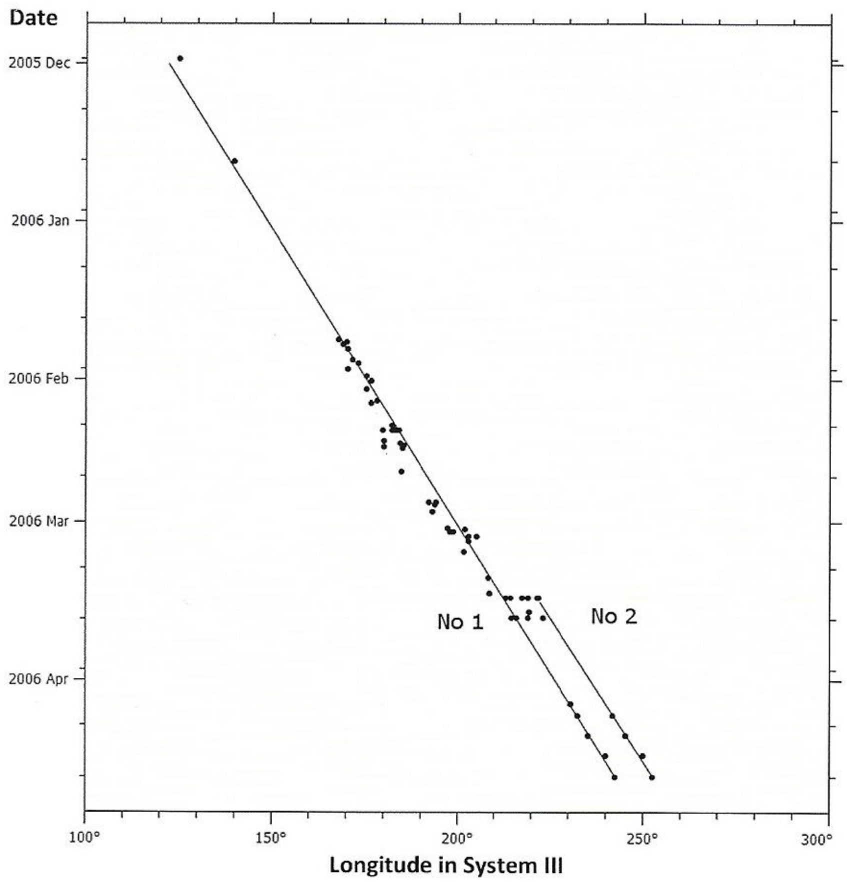

Figure 8. Drift chart for the centre of bright spots STB(N) No. 1 and No. 2 in System III for 2005/2006. The positions (shown as dots) have been derived from images taken by Adelaar, Akutsu, Brown, Delcroix, Edwards, Friedman, Go, Kingsley, Lewis, Maxson, McKim, Meredith, Olivetti, Parker, Peach, Pellier, Phillips, Sharp, Tyler, Vandebergh and Yunoki; and transits by McKim. The solid lines represent the average drift for each spot derived from these observations. Note multiple observations of No. 1 and No. 2 were made on Mar 15 & 19. The longitudes measured on these dates did differ as shown above. However, the derived longitudes were allocated to Nos. 1 or 2 as appropriate in the drift analysis.

It is possible that No. 2 formed separately from No. 1. Alternatively, No. 2 could have formed from the break-up of No. 1 after it became elongated. Unfortunately, the observations do not allow a clear indication of which of these two hypotheses is correct.

The track of spot No. 1 does not extrapolate back to anything observed during the previous apparition,[6] and no major white spot storms were observed at this latitude during the apparition which followed.[5]

Both of these spots showed similar positive drifts with respect to System III (Table 7). A summary of all the white spots observed at this latitude during previous and subsequent apparitions, and their respective drifts, will be given either in a separate summary report or in a later apparition report.

Spot No. 1 was also observed by the *Cassini* spacecraft (see Figure 9). Its instruments included a Radio and Plasma Wave Spectrometer (RPWS) which investigated plasma waves (generated by ionised gases flowing out from the Sun or orbiting Saturn), natural emissions of radio energy and dust. This instrument recorded radio bursts which were deemed to be detections of lightning. The bursts were correlated with the spot,[7] indicating that this storm was a strong convection feature.

In addition to these spots, a number of other features were observed or suspected in the region, but are not shown in Figure 8. Gray recorded a number of *p.* and *f.* ends of darker segments of the STB. A few of these were associated with white spot No. 1.

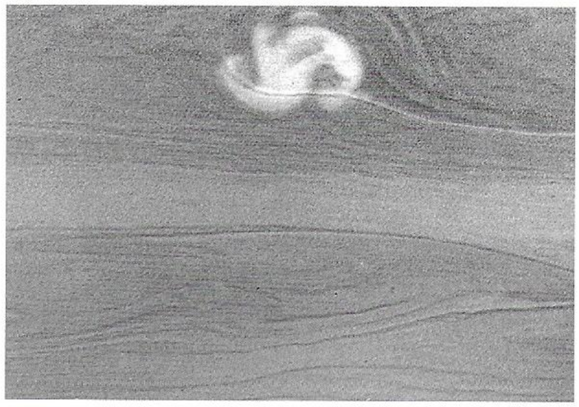

Figure 9. Image of the STB(N) storm taken by the *Cassini* spacecraft on 2006 Jan 27. (NASA image PIA07789). Compare this with the amateur images (Figures 5 & 7(a)) which were taken just before and on this date. This image was taken with the storm on the night side of the planet, and illuminated by light from the planet's rings. *Courtesy NASA/JPL-Caltech*

However, there were insufficient data to allow tracking of the other segments. Gray also reported a light spot at a System III longitude of 264.5° on Oct 2, and noted the *f.* end of light patches in the STropZ on the following dates (System III longitudes are given in brackets): Feb 18 (36°), Mar 1 (304°), Mar 4 (211°) & Mar 6 (32°). No other observations were made of these objects.

A light spot was suspected in an image by Delcroix at System III longitude 227.7° on Dec 21. Another light spot was suspected in an image taken by Vandebergh on Oct 15, but this lay over 15° *p.* of the predicted track of No. 1 and is very uncertain.

South Tropical Zone (STropZ)

This zone was one of the brightest.

South Equatorial Belt (SEB)

This belt was double, with the SEB(N) being darker than the SEB(S). These components were separated by a light SEB(Z). In some observations, the SEB(S) appeared slightly darker than during the previous apparition.

Gray reported a few *p.* and *f.* ends of darker segments on both the SEB(S) and SEB(N), but no rotation periods could be established.

White spot activity continued in the SEB(Z), but at a lower level than observed during the previous apparition.[6] Only two distinct light spots were observed and are designated SEBZ spots No. 1 & No. 2 in this report. Both were recorded in a number of images, but never observed visually. Spot No. 2 often appeared to be the slightly larger and brighter of the two; this is shown in Figures 5 & 7(f). They were often detected in red and green light images. On Nov 30, images by Peach and Tyler clearly showed spot No. 1. However, spot No. 2 was not recorded and only some brighter areas were suspected in its predicted position.

They both moved with a rapid negative drift with respect to System III. A drift chart of these spots in a longitude system moving at –7 degrees per day with respect to System III is shown in Figure 10. This figure shows that there were long gaps between some of the observations. However, as these two spots were the only distinct features observed at this latitude, there is confidence that the observations are of the same spots.

The drifts derived from the best linear fit to these measurements are shown in Table 6, giving a mean separation of 12°. These drifts are similar to that derived for one of the two long-lived spots in this region during the previous apparition,[6] and a single spot observed during the subsequent apparition.[5]

Figure 10 shows that, in some cases, there were noticeable deviations of individual observations from the derived mean drift. This may indicate some variability in the motion of each of the spots, but could also be due to other causes. Some of the images used for the measurements only showed the spots near to the limb or had smaller image scales compared to others. It is also possible that there may have been small timing errors on some combined RGB images. All of these factors could have resulted in higher scatter in the measurements.

An overview of all spots in this region over a number of apparitions will be given in a subsequent report.

Some other vague spots or brighter areas were sometimes suspected in this zone in some images, but these are uncertain. Two similar sots were suspected in an image taken by Lawrence on Feb 4, but the longitudes differed from the two SEBZ spots described above. McKim also observed a diagonal streak on Feb 15 at System III= 129°, but this was again unrelated to the two spots described above.

The Equatorial Zone (EZ)

A narrow dark belt was visible in the southern half of the EZ(S), just to the north of the SEBn. This was visible during the previous apparition,[6] and was described as an EZ(S)B by McKim.[6] It was also visible in subsequent apparitions (see for example ref. 5). It

Table 4. Average visual intensity estimates, 2005/2006

OBSERVER	*Bowen*	*Colombo*	*Gray*	*Heath*	*McKim*	*Apparition average (all obs.)*	*Total no. of obs.*
DATES	2006 Apr 5 to 2006 May 5	2006 Mar 31 to 2006 May 26	2005 Sep 28 to 2006 May 5	2005 Dec 28 to 2006 Apr 4	2005 Dec 14 to 2006 May 30		
The planet							
SPR Cap			4.9 (31)		5.8 (6)	5.1	37
SPR	5.1 (4)	3.4 (4)	4.6 (32)	3.3 (7)	5.0 (14)	4.5	61
SPB			5.6 (32)		5.4 (11)	5.5	43
SSTZ			3.4 (25)		3.6 (12)	3.4	37
SSTB			4.1 (25)		3.8 (3)	4.0	28
STZ		4.1 (4)	3.1 (32)	2.1 (6)	3.7 (12)	3.2	54
STB			4.4 (32)		4.1 (11)	4.3	43
STropZ	4.1 (4)	3.0 (4)	2.4 (32)		3.1 (12)	2.7	52
SEB(S)	4.9 (4)		4.3 (32)		4.9 (15)	4.5	51
SEBZ	3.5 (4)		3.3 (32)		3.7 (13)	3.4	49
SEB(N)	4.9 (4)	3.8 (4)	5.8 (32)	4.6 (7)	5.4 (15)	5.4	62
EZ(S)	1.5 (1)	2.0 (4)	1.4 (32)	1.8 (7)	2.0 (17)	1.6	61
EB	2.9 (4)		3.3 (32)	3.1 (6)	3.3 (14)	3.2	56
EZ(N)			1.9 (32)		2.4 (17)	2.1	49
NTZ	2.2 (3)		3.5 (21)		2.9 (10)	3.3	44
NNTB			4.8 (31)			4.8	31
NNTZ			4.1 (32)			4.1	32
Remainder of n. hemisphere to the n. limb	4.7 (4)	3.4 (4)	5.2 (20)	3.6 (5)	3.4 (7)	4.5	40
The rings							
Ring A1	4.0 (4)	3.4 (4)	4.0(32)	3.0 (7)	3.6 (14)	3.8	61
Encke Complex outer border			7.3 (15)		7.0 (13)	7.2	28
Encke Complex			4.8 (30)	4.0 (3)	3.9 (14)	4.5	47
Encke Complex inner border					6.2 (6)	6.2	6
Ring A2	3.5 (4)		3.1 (32)	1.5 (6)	2.7 (14)	2.9	56
Cassini Divn.	10.0 (4)	7.0 (4)	9.1 (32)	9.6 (7)	10.0 (16)	9.3	63
Ring B1	1.0 (4)	2.5 (4)	1.3 (32)	1 (7)	1.1 (14)	1.3	61
Ring B2	2.5 (4)	3.3 (4)	2.4 (32)	1.7 (5)	2.0 (14)	2.3	59
Divn. B2/B3					3.5 (1)	3.5	1
Ring B3			4.0 (32)		3.0 (13)	3.7	45
Ring C	9.0 (4)	9.0 (3)	7.2 (31)	8.4 (6)	7.1 (16)	7.5	60
Ring C(M)	6.2 (4)	6.0 (4)	5.5 (32)		6.1 (14)	5.7	54
The shadows							
Sh. G on R	10.0 (4)	10.0 (4)	9.2 (32)	10.0 (5)	10.0 (16)	9.6	61
Sh. R on G					8.6 (7)	8.6	7

Notes: Intensities are made on the scale: 0= bright white; 10= black. The number of observations made by each observer is shown in ( ). Colombo and Heath gave intensities only for the SEB as a whole. These have been allocated to the SEB(N) in the above table. Gray recorded different apparition averages for the *p.* and *f.* sides of Ring C (7.0 & 7.4 respectively). The overall average is shown in the table. All values are given to one decimal place.

Table 5. Colour estimates, 2005/2006

Observer	*Colombo*	*Foulkes*	*Heath*	*McKim*	*Colour from digital images assessed by the author*
Dates	2006 Mar 6 to 2006 May 6	2005 Dec 7 to 2006 June 3	2005 Dec 28 to 2006 Apr 4	2005 Dec 14 to 2006 May 30	2005 Sep 23 to 2006 May 30
The planet					
SPR Cap					Light grey
SPR	Yellow	Grey		Orange brown (Nov & Jan)	Dark grey
Zone s. of SPB				Orange brown	Faint reddish colour on some images; otherwise grey
SPB		Dark grey		Orange brown or brown	Dark grey
SSTZ				Yellowish grey	Light grey
SSTB					Grey
STZ				Yellowish grey	Light grey
STB					Warm grey
STropZ	Yellow or yellowish grey	Grey or yellowish grey		Yellowish grey	Greyish white
SEB(S)	Brown or orange	Brown or greyish brown	Grey	Orange grey	Warm grey
SEBZ	Orange or yellow			Orange brown	Dull white or light grey
SEB(N)	Brown	Brown or greyish brown		Orange brown	Warm brown
EZ(S)	Yellow	Yellowish	Grey	Yellow, deep yellow	Yellow or yellow white
EB	Grey			Slight orange brown	Grey
EZ(N)				Slight orange brown, deep yellow	Yellowish white
NTZ				Bluish grey	Blue or turquoise
N. hem.	Yellow	Grey		Grey	Dark grey
The rings & shadows					
Ring A	Yellowish or grey		A1 grey, A2 off-white		
A1		Bluish grey		Bluish grey, grey	Blue or bluish grey
Encke complex				Bluish grey, grey	Blue or bluish grey
A2		Bluish grey		Bluish grey or grey	Blue or bluish grey
Cassini Divn.	Black	Black	Black	Black	Black
Ring B	Yellowish		B1 white, B light grey		
B1		White		White	White
B2		Light grey		Dull white	Light grey
B3				Grey	Light grey
Ring C				Warm grey, to brown grey	Dark grey
Ring C (M)	Black	Grey or black		Brown	Grey
Sh. G on R		Black	Black	Black	Black
Sh. R on G		Black		Black	Black

was only seen visually by Gray. The EZ was divided into the EZ(S) and EZ(N) by a broad grey EB. Only the southern half of the EZ(N) was visible, due to the presence of the rings. Both the EZ(S) and EZ(N) were the brightest zones and were of a similar intensity.

Generally no features were recorded in this region, apart from a light spot in the northern half of the EZ(S) reported by Gray on Jan 31, with a System III longitude of 246°.

Northern hemisphere

Only a small portion of the northern hemisphere was visible during this apparition. Within this was a prominent-but-narrow bright bluish-coloured zone. Some observers described it as turquoise or coral. A strong bluish colour in the northern hemisphere would be a feature of subsequent apparitions (see for example ref. 5).

The latitude of the northern edge of this zone was 44.7°N (see Table 3). However, the southern edge of the zone was not clearly observed. During the early part of the apparition, the southern boundary was marked by the northern edge of the shadows of the rings on the globe (Sh. R on G). Later, it was marked by the northern edge of where the rings crossed the planet. Some observers designated the zone as the NTZ, but this is uncertain.

A darker belt was sometimes detected on the northern edge of this zone and a narrow lighter zone was detected further north, up to the limb shading.

The rings

The rings were well presented to the Earth during this apparition, with an inclination of 18.9° at opposition.

A number of features in the form of broad and narrow radial variations in intensity were detected, especially in high-resolution observations. These features have been recorded in previous and subsequent apparitions. Two typical high-resolution observations are shown in Figure 11. The digital image taken by Peach and the visual observation made by McKim show good agreement.

Ring A

Many observers recorded the darker outer region of this ring (Ring A1) and the narrower, brighter inner region (Ring A2).

A narrow-but-bright outer part of Ring A1 was often recorded. What is often designated as the Encke Complex formed the darker inner part of Ring A1.

The Encke Gap lies at the outer edge of this complex and was recorded in high-resolution images, such as in Figure 11(a), and seen visually by Gray and McKim (Figure 11(b)). A narrow darker region was detected within the complex (Figure 11(a)) and another at its inner edge (Figures 11(a) & (b)). This latter feature, or the contrast effect between Rings A1 & A2, may account for the appearance of what many observers recorded as the Encke Division. However, a true division does not exist here.

High-resolution observations detected the Cassini Division where it was projected in front of the planet.

Ring B

Many observers recorded the broad intensity variations across this ring (comprised, moving inwards, of rings B1, B2 and B3) with the outer B1 being much brighter than the inner B3. Some narrow intensity minima were also recorded, including a narrow minimum at the inner edge of B1 (see Figure 11).

Ring C

This was difficult to detect other than where it crossed the planet (Ring C(M)).On Feb 15, Ring C was recorded to be

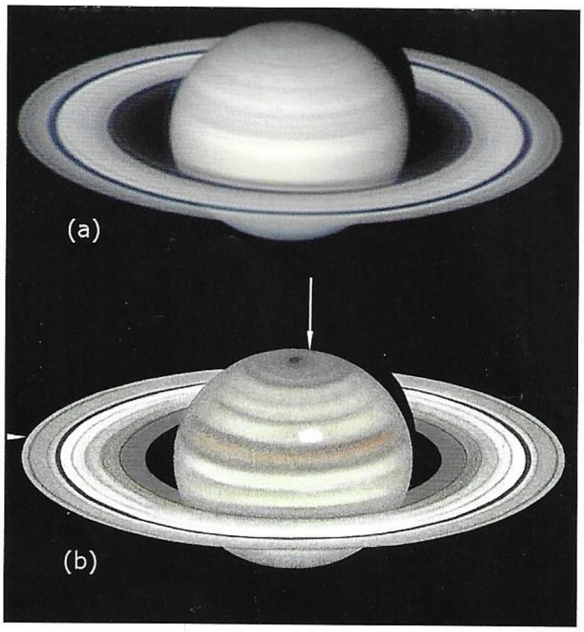

Figure 11. Detail in the rings. **(a)** 2006 Apr 14, 00:04 UT; CM1= 94.5°, CM 2= 21.3°, CM3= 68.1°. *(Image by Peach.)* **(b)** 2006 Mar 2, 23:10 UT; CM1= 244.2°, CM2= 88.7°, CM3= 186.2°. Shows ring detail and the STBn spot No. 1 (arrowed) on the central meridian. *(Drawing by McKim.)*

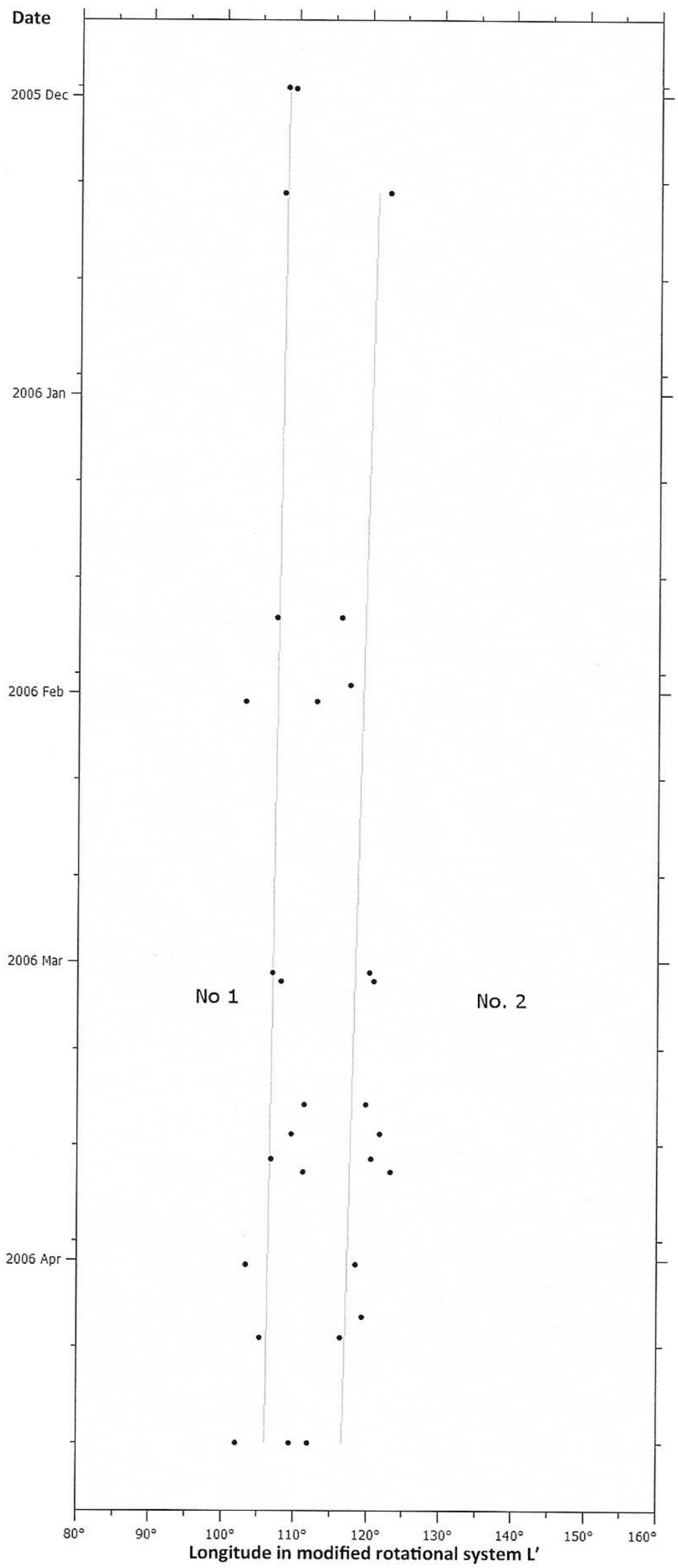

Figure 10. Drift chart for the centre of bright SEBZ spots Nos. 1 & 2 during 2005/2006 in a longitude system drifting at –7.0°/d with respect to System III. The reference date is opposition. The positions (shown by dots) are derived from images taken by Friedman, Go, Meredith, Parker, Peach, Pellier, Tyler, Vandebergh and Yunoki. The solid lines represent the average drift derived from these observations.

brighter S*f* by McKim. Gray systematically recorded the *p.* side of Ring C as brighter than the *f.* side (see Table 4).

On 2006 Apr 28, the *Cassini* spacecraft imaged part of Saturn's C ring (image PIA08191); the result is reproduced here in Figure 12. The dark inner edge of Ring B is shown at the top of the image. The figure also shows Ring C covering bright clouds in the planet's atmosphere.

According to Bryan,[8] the *Cassini* image shows that the bright clouds in the planet's atmosphere were only partially obscured by Ring C. This, he writes, tends to validate a 1993 suggestion that BAA observations of the patchy structure of C(M) were more likely caused by darker areas in the NEB, which had been hidden by the C Ring crossing the globe.[9]

Opposition effect

The opposition effect is where Saturn's rings appear to brighten for a short period around the time of opposition. Many observers recorded the effect at this time, *i.e.* Jan 27 (Maxson, Phillips (Figure 7(a)), Tyler) and Jan 28 (Adelaar (Figure 13), Arditti, Phillips, Pratt, Yunoki).

McKim recorded the rings to be bright on Jan 21, six days before opposition. This effect can also be seen in some observations of the occultation of BY Cancri on Jan 25 (see below) and in Figure 5.

Other ring observations

On Apr 26, images taken by Arditti show the *p.* side of Ring A to be brighter than the *f.* side. This effect was visible in red, green and blue images and hence the colour images derived from these. However, it was not visible in an image taken by Peach on Apr 25, or in other observations made around this time. Whether it was due to the seeing or an example of the so-called bicoloured aspect of the rings is not clear.

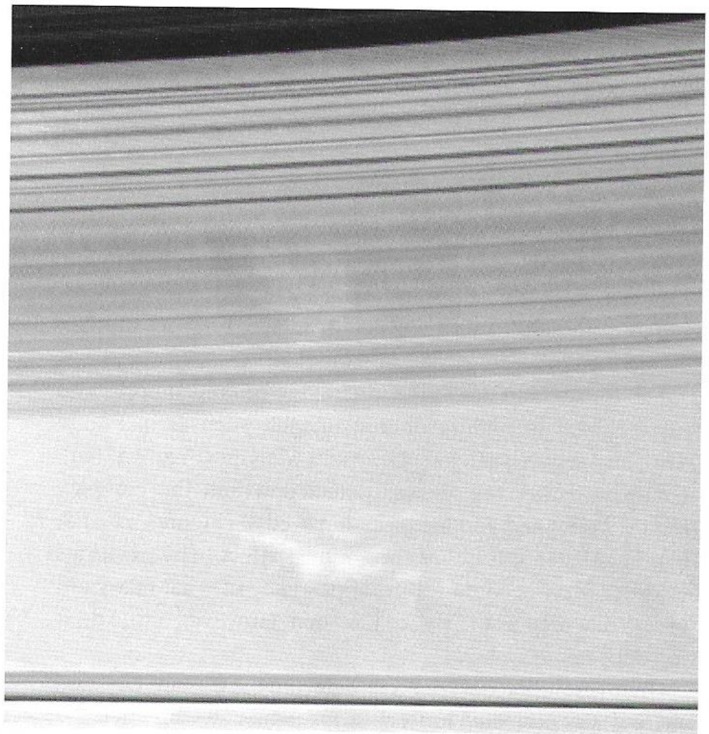

Figure 12. Saturn's C Ring, taken by the *Cassini* spacecraft on 2006 Apr 28. This image was obtained with the wide-angle camera in infrared light, centred at 752nm. *Courtesy NASA/JPL-Caltech*

McKim noted Ring B to be dull from the end of April and into May, but recorded no variations between the *p.* and *f.* sides.

The shadows

The shadow of the globe onto the rings (Sh. R on G) was visible adjacent to the planet's *p.* limb prior to opposition, and to the *f.* limb following opposition. Many images taken very close to opposition

Table 6. Longitudes & drifts for spots

Spot no.	*Description*	*Planetographic lat. (°)*	*L3 (O) (°)*	*DL3 per day*	*DL3 per 30 days*	*Rot. period*	*Dates*	*No. of obs. for drift*	*Average extent in long. (°)*	*No. of obs. for average extent*
On the SPBs										
1	White Spot SPBs	70.9S ± 0.9 (1σ)	169.3 ± 1.1 (1σ)	1.07 ± 0.02 (1σ)	32.07 ± 0.69 (1σ)	10h 40m 13.04s ± 1.06s (1σ)	2005 Nov 19 to 2006 Apr 19	14	13.2±3.6 (1σ)	13
On the STB(N)										
1	White Spot STB(N)	40.4S ± 1.2 (1σ)	170.7 ± 0.5 (1σ)	0.86 ± 0.01 (1σ)	–25.8 ± 0.3 (1σ)	10h 40m 2.3s ± 0.7 (1σ)	2005 Nov 30 to 2006 Apr 19	53	9.0 ± 2.7 (1σ)	47
2	White Spot STB(N)	41.5S ± 0.7 (1σ)	178.1 ± 1.6 (1σ)	0.91 ± 0.02 (1σ)	–27.16 ± 0.6 (1σ)	10h 40m 5.3s ± 1.1 (1σ)	2006 Mar 15 to 2006 Apr 19	7	6.9 ± 1.8 (1σ)	7
On the SEBZ										
1	White Spot SEBZ	28.94S ± 0.63 (1σ)	107.6 ± 0.09 (1σ)	–7.02 ± 0.017 (1σ)	–210.57 ± 0.5 (1σ)	10h 33m 53.15s ± 0.07	2005 Nov 30 to 2006 Apr 19	14	5.3 ± 1.43 (1σ)	9
2	White Spot SEBZ	28.77S ± 0.57 (1σ)	119.4 ± 1.6 (1σ)	–7.03 ± 0.03 (1σ)	–211.0 ± 0.88	10h 33m 52.49s ± 1.37	2005 Dec 11 to 2006 Apr 19	15	5.7 ± 1.24 (1σ)	9

Notes:
L3 (O) is the System III longitude at opposition on 2006 Jan 27. ( ) indicate the estimated opposition longitude for any spot not observed at opposition. DL3 per day is the drift relative to System III, in degrees of longitude per day. DL3 per 30 days is the drift relative to System III, in degrees of longitude per 30 days. All values rounded to two decimal places.

gave the illusion that this shadow was visible adjacent to both limbs (see for example Figure 7(a)). This illusory effect may be due to the dark limb adjacent to the bright rings.

Prior to opposition, the ring inclination with respect to the Earth was further north than the inclination to the Sun (see Figure 1). This allowed part of the Sh. R on G to be seen north of where the rings were projected onto the planet (see for example Figure 4(b)). The width of this shadow then narrowed as the ring inclinations to the Earth and Sun became equal on ~Jan 26 – shortly before opposition. It was suspected as very narrow in an image taken by Phillips on Jan 12.

After opposition, the ring inclination with respect to the Earth was further south than the inclination to the Sun. This allowed the shadow to be visible though ring C(M), as shown in Figures 7(c)–(f). The earliest it was detected in ring C(M) was in an image taken by Peach on Feb 17.

In a few images, such as Figure 11, the ring C(M) appears slightly lighter just south of the southern edge of the Sh. R on G. The reason for this is not clear; it may be a processing artefact.

The satellites

The satellites from Mimas out to Titan were recorded by many observers, and are shown in Figure 14. Iapetus was also observed, but was out of the field of view when this image was taken.

The occultation of BY Cancri

A rare occultation of a star by Saturn and its rings took place on 2006 Jan 25. The star in question was the Delta Scuti-type variable BY Cancri. At the time of the occultation, Saturn's apparent motion in the sky was westwards. The star was predicted to be occulted by the *p.* edge of Ring A at approximately 18:50 UT. It was then expected to be at the position of the Cassini Division from approximately 19:01 until 19:06 UT. Finally, it was predicted to reappear from behind the planet on the *f.* limb close to the south pole, at approximately 20:50 UT. The actual times did vary slightly depending on the location of the observer.

Table 7. Observations of the occultation of BY Cancri on 2006 Jan 25

Observer	*Observational period (UT)*	*Observations*
Arditti	Start of event, with also a series of images taken from 20:50:00–21:21:00.	The star could not be detected 10min before its disappearance at the outer edge of Ring A, either visually or by imaging. However, at this time the seeing was poor and the planet was at a low altitude. A series of images were taken at the time of reappearance, which was on the *f.* limb near the planet's south pole. The star was detected visually at 20:52; 1.5min after the predicted reappearance time for London.
Best	21:49–21:24	A series of images were taken, showing the reappearance of the star. Reappearance was timed at 20:52:25.
Bucharest Astro. Club (Conu & Sonka)	18:23:42–21:13:04	Multiple images were taken throughout the complete event, both at prime focus and with a ×2 Barlow lens. A typical image is shown in Figure 15. The star was still visible at the *p.* edge of Ring A at 18:41:46, but not visible in an image taken at 18:56:52. These observers indicated that the star was barely visible through the Cassini Division in images taken between 19:01:30 & 19:03:54, but this is not certain. The star was visible at the planet's *f.* limb near to the south pole in an image taken at 20:51:20.
Cook	No times provided	Imaged the event, but no sign of the star.
Foulkes	20:50–21:14	Clear skies. A series of images were taken showing the reappearance of the star on the *f.* limb, near to the planet's south pole.
Gray	19:03	Observed visually. The sky was cloudy at the predicted time of the disappearance at the edge of Ring A. There was a brief clearing at 19:03. The star was certainly seen within the Cassini Division at the edge of Ring B (see Figure 16). Increasing cloud prevented further observation.
Heath	18:30–21:07	The seeing was bad at the predicted time of disappearance and the planet's altitude was low. The star was not seen visually. At 20:00 a bright spot was observed in Ring B1, adjoining the globe, which was taken to be the Terby spot. However the star was predicted to be close to this spot at the time. At 21:00 the star was visible, adjoining the limb of Saturn at the *f.* side of the SPR. At 21:02, the star was off the *f.* limb.
Hurst	21:01–22:07	Conditions were initially cloudy. No observations were made of the disappearance. The first glimpse of the star on the *f.* limb near to the planet's south pole was made visually at 21:01. A drawing was made at 21:07.
McKim	18:40–19:08	Visual observation in transparent but unsteady conditions. Nothing observed.
Meredith	21:15:00	An image was taken in variable cloud. By the time of the observation, the star was well clear of planet's south pole.
Parish	18:49–20:47	Visual observation. At 18:49, Saturn was at a low altitude and the star was not detected. From 19:03 to 19:06, the seeing was very poor. The star was suspected in the rings. Alas, no detailed position was provided in the observational report. At 20:47, the star was observed to reappear even though the seeing was poor.
O'Sullivan	19:02:00–21:07:00	Three images were taken over the observation period. The star was separated from the southern limb in the image taken at 20:56:00.
Porter	21:05:00–21:43:00	Visual drawing showing the position of the star at various times, post-reappearance. Seen at the *f.* limb near to the south pole at 21:05, but suspected earlier.
Rogers	20:50–21:05	Visual observations commenced 5min before the predicted disappearance time and the star could not be seen, probably because it was too faint and very close to the bright rings. However, reappearance was observed, predicted at 20:50. Here, the star was suspected within a minute of that time and definite by 20:55, looking about as bright as Tethys. It was then lost as frost formed on the telescope.
Sharp	20:51:45–20:55:30	Three images were taken, showing the reappearance of the star on the *f.* limb near to the planet's south pole (see Figure 17).
Tyler	21:05:00 & 21:31:00	Disappearance was not observed. Two images were taken after reappearance, showing the star separated from the planet.

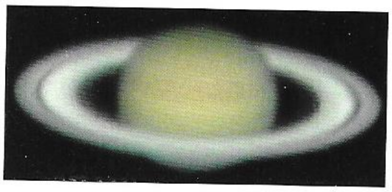

Figure 13. Opposition effect. 2006 Jan 28, 00:33 UT; CM1= 25.5°, CM2= 246.3°, CM3= 24.7°. *(Image by Adelaar)*

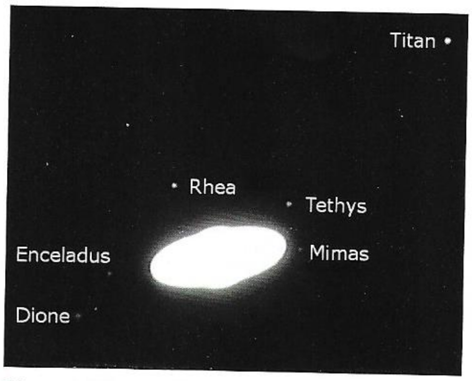

Figure 14. The satellites, imaged 2006 Jan 26 at 22:11 UT. The original image has been enhanced slightly to show the fainter satellites. *(Image by Cooper)*

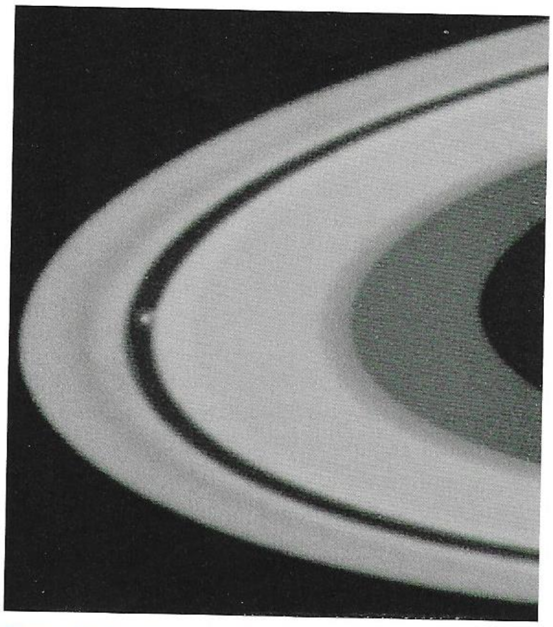

Figure 16. BY Cancri, visible through the Cassini Division. 2006 Jan 25; 19:03 UT. *(Drawing by Gray)*

At the start of the occultation, Saturn was low in the sky for western European observers, including those in the UK. For observers much further east, the start of the occultation would occur with the planet substantially higher.

A number of observers were able to record this occultation, both visually and by digital imaging. All observations are summarised in Table 7. The entire occultation was imaged by the Bucharest Astronomy Club, but under variable seeing (see Figure 15 and notes in Table 7).

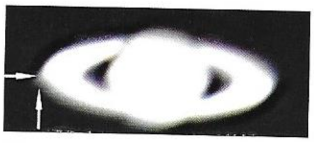

Figure 15. BY Cancri (arrowed) at the *p.* edge of Ring A shortly before disappearance. 2006 Jan 25; 18:39:30 UT. *(Image by Conu & Sonka, Bucharest Astronomy Club)*

The most interesting observation was made by Gray, who observed the star when it was visible within the Cassini Division (Figure 16). The Bucharest Astronomy Club noted that the star may have been recorded in images taken (detailed in Table 7), but these observations are less certain. The star was suspected to be visible through the rings by Heath and Parish.

The reappearance of the star close to the planet's south pole was recorded by several observers, in varying levels of seeing.

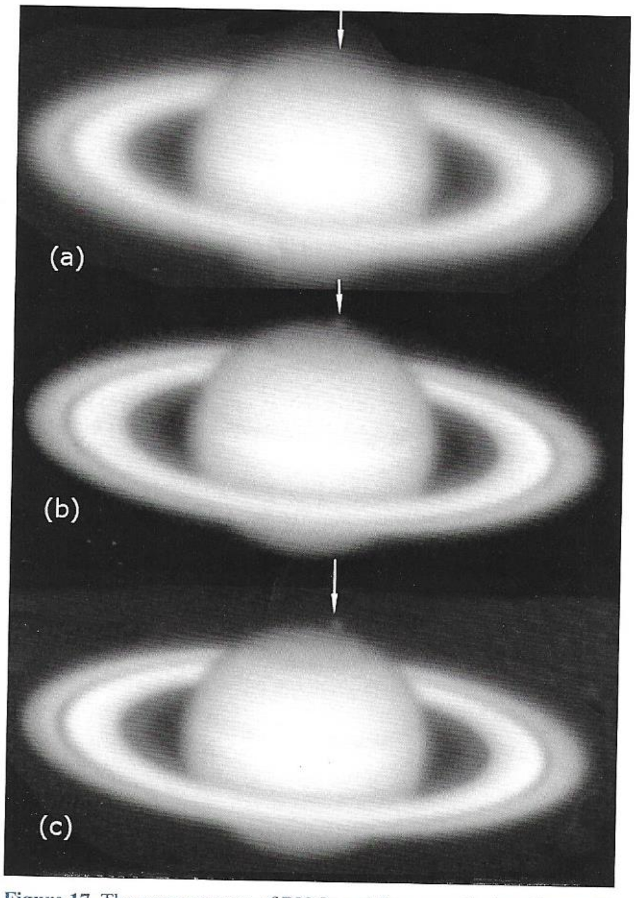

Figure 17. The reappearance of BY Cancri from occultation. Star positions marked by arrows. **(a)** 2006 Jan 25; 20:51:45 UT. **(b)** 2006 Jan 25; 20:53:45 UT. **(c)** 2006 Jan 25; 20:55:30 UT. *(Images by Sharp)*

Report sequencing

This report fills the one remaining gap between the series of Saturn apparition reports that ended with 2004/2005,[6] and a new series that began with 2006/2007.[5]

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