Saturn in 2002–2003

Richard McKim

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

Saturn's rings were open to their maximum extent upon the southern face. Significant new spot activity began in the South Tropical Zone and the South Equatorial Belt Zone. The STropZ activity took the form of small white spots at Saturnicentric latitude –35°, with a mean drift rate of +0.5°/day with respect to System III. White spots in the SEBZ showed a drift rate of –8.0°/day versus System III, while there was continuing evidence for a relatively slow drift in the S. Equatorial Current. A historical survey of STropZ activity is included in an Appendix, which includes previously unpublished BAA data for the 1971–'72 apparition.

Introduction

Saturn was at opposition on 2002 Dec 17, when the sub-Earth latitude (D_e) was –26.6°. During the apparition D_e attained its maximum figure of –26.7° for this presentation of the south face of the rings. Solar conjunctions took place on 2002 Jun 9 and 2003 Jun 24, while perihelion would be reached between this apparition and the next, on 2003 Jul 26. The planet was high in Northern hemisphere skies, with a declination of +22° at opposition. Data covered the period 2002 Aug 17 (Foulkes) to 2003 May 3 (Niechoy).

The *Cassini* spacecraft was still *en route* for Saturn.[1] David Graham and Damian Peach wrote a useful Interim Report, 'Spots on Saturn in visual wavelengths',[2] while a short note also appeared in the Council report.[3] Images such as those in Figure 1 were secured by the Hubble Space Telescope (HST).[4]

Newly available software enabled the rapid stacking and enhancement of images, resulting in an increase in quality of the results submitted, and in the number of contributors: see Table 1 for a list. The 'webcam revolution' has been described elsewhere.[5,6] Several animated images were also received, which demonstrated the objective reality of small details that rotated with the planet. Peach made use of a long sojourn on Tenerife to secure a large number of exquisite images. A few new visual observers contributed for the first time.

A 2002–'03 report by the Association of Lunar and Planetary Observers (ALPO, USA) was published.[7] Online archives of images were maintained by ALPO Japan (JALPON)[8] and the International Outer Planets Watch.[9] No report was published by the Unione Astrofili Italiane (UAI), but its online Saturn archive begins with the 2002–'03 apparition.[10]

The present report continues the narrative from 2001–'02.[11] Up to the previous opposition we used System I (844.3°/day) and II (812.0°/day) longitudes for equatorial and non-equatorial features, respectively. For comparison with present-day reports we now replace System II by System III (810.8°/day, or 10h 39m 22s), as explained in the BAA *Handbook*.

The globe

Introduction

One Saturnian year (29½ terrestrial years) ago, the general arrangement of the belts was extremely similar to their pattern in 2002–'03. In 1972–'73 J. B. Murray was able to observe from Pic du Midi with the 1.07m Cassegrain.[12] Figure 2 offers an interesting comparison with the 2002–'03 drawings (Figures 3, 6–8, 13).

In 2002–'03, the relative blandness of the globe to visual inspection, as noted in the last few years, continued. However there were numerous faint or narrow belts to be captured by imaging. Since 2001–'02 there were some intensity changes in minor features (see Table 2), but otherwise the appearance was much the same. The dark SPC crowned the inverted telescopic image, but the surrounding SPR remained a faded light halftone. There were also slight latitude variations (Table 3). In particular, the S. edges of both the S. S. Polar Belt and the Equatorial Band lay significantly further south than last year. General nomenclature was illustrated in our last report.[10]

Colours

The SPC was dark grey according to Foulkes, McKim and Phelps; however, a

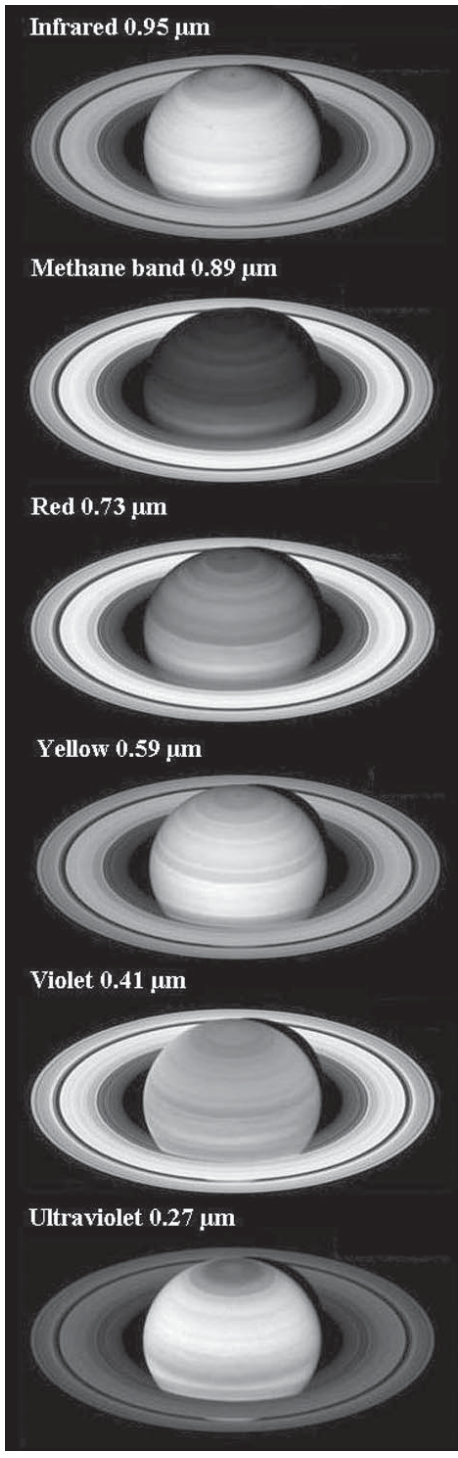

Figure 1. 2003 Mar 7. HST WFPC2 images with different filters. Infrared (top image) 0.95µm, methane absorption band 0.89µm (hence the darkness of global features); red 0.73µm; yellow 0.59µm; violet 0.41µm and ultraviolet 0.27µm. *(NASA & E. Karkoschka (University of Arizona).*

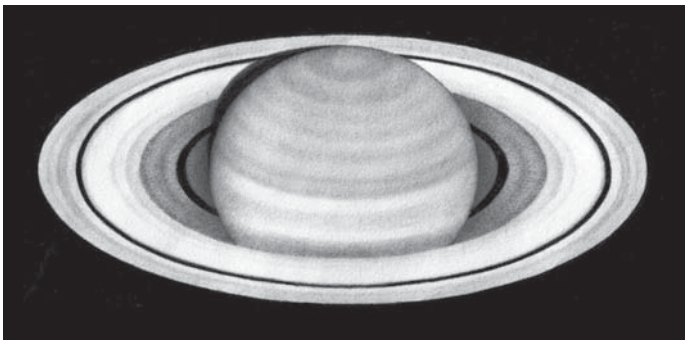

Figure 2. 1973 Sep 11, 05:10UT, 1.07m Cass., ×725, *J. B. Murray*. Seeing I. Drawing made at Pic du Midi Observatory one Saturnian year prior to 2002–'03, showing many belts, fine ring divisions (including details upon ring C), and material interior to Ring C ('Ring D'), the latter also being visible on Sep 2, 3 and 10.

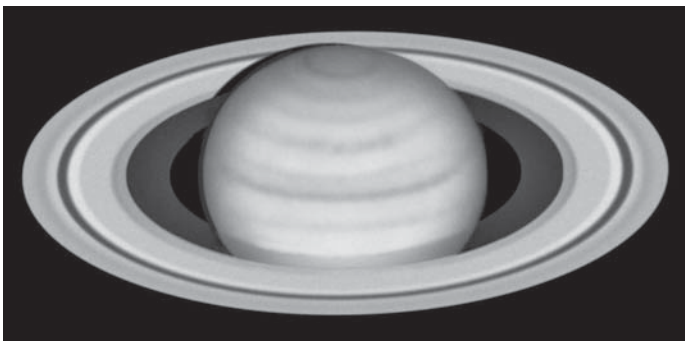

Figure 3. 2002 Sep 3, 04:00UT, 415mm DK Cass., ×348, ω_1= 118°, ω_3= 001°, *D. Gray*. Seeing II. Note the darker, spotted section of the STB. Compare with Figure 2 from one Saturnian year earlier. (Gray's drawings were made using commercial software.)

greenish tint was apparent to Frassati (Mar 10), and contrarily a brownish colour was reported by Tan (Jan 20, Mar 10). The lighter SPR at the north edge of the SPC looked greenish to Frassati (Mar 10) and Jamison (Dec 29), but yellowish-brown to Graham (Jan) and slightly brownish to McKim (Nov–Mar), and Tan (Jan 10, Mar 10). The SPB was described as a 'greenish collar' to the SPR by Tan, and Frassati shows this greenish tint in all the zones south of the STeZ. Gray did not make colour estimates.

The STeZ and STropZ appeared pale yellowish to almost all observers. Peach noted on Feb 11 that he could no longer trace the green tint in the STropZ that he had witnessed since October. All observers agreed that the SEB was brown or reddish-brown, that the EZ(S) was strongly yellow, and that the EZ(N) appeared more white than yellow.

The HST filter series taken on 2003 Mar 7 (Figure 1) reveals subtle colour contrasts.

South Polar Region

Several observers considered the SPC darker than in 2001–'02. A tiny dark circular SSPC located within the SPC (also centred upon the S. pole) was even more widely reported and imaged than in 2001'02 (Figures 4, 9–12, 14). It was more difficult to see visually, but Gray showed it on Sep 23 and Oct 30 and McKim saw it on Jan 15 (Figure 13) and Feb 14 and 24. Phelps agreed with McKim that it was the darkest feature upon the globe. From Figure 1 we note that the intensities of the SSPC and its surroundings were reversed in the ultraviolet waveband.

The SSPC was surrounded by a light, narrow zone

Figure 4. 2002 Oct 7, 11:26UT, 355mm SCT, SBIG ST-5c CCD camera at F/27, ω_1= 287°, ω_3= 101°, *E. A. Grafton*. Note the SSPC, STropZ white spot near the CM, and Encke's Division. Ring C shows a division near its centre, which the brightened inset helps to show.

upon the best images (as upon the original of Figures 11). The SPC had a broad dark belt, the SSPB, at its N. edge. As in 2001–'02, the adjacent SPR was only slightly shaded. It was bounded by a fairly dark SPB.

North of the SPB, the narrow SSSTB remained visible, and it was often more prominent than the narrow and faint SSTB. Figures 12 and 14 show all of these belts particularly well.

South Temperate Zone

Most white spot activity during 2002–'03 took place in the STropZ (see below), but a light patch in the STeZ was also seen by Gray on Sep 1. Upon images, the STeZ looked marginally lighter than the STropZ, but most visual observers recorded them equal or the STropZ as slightly lighter.

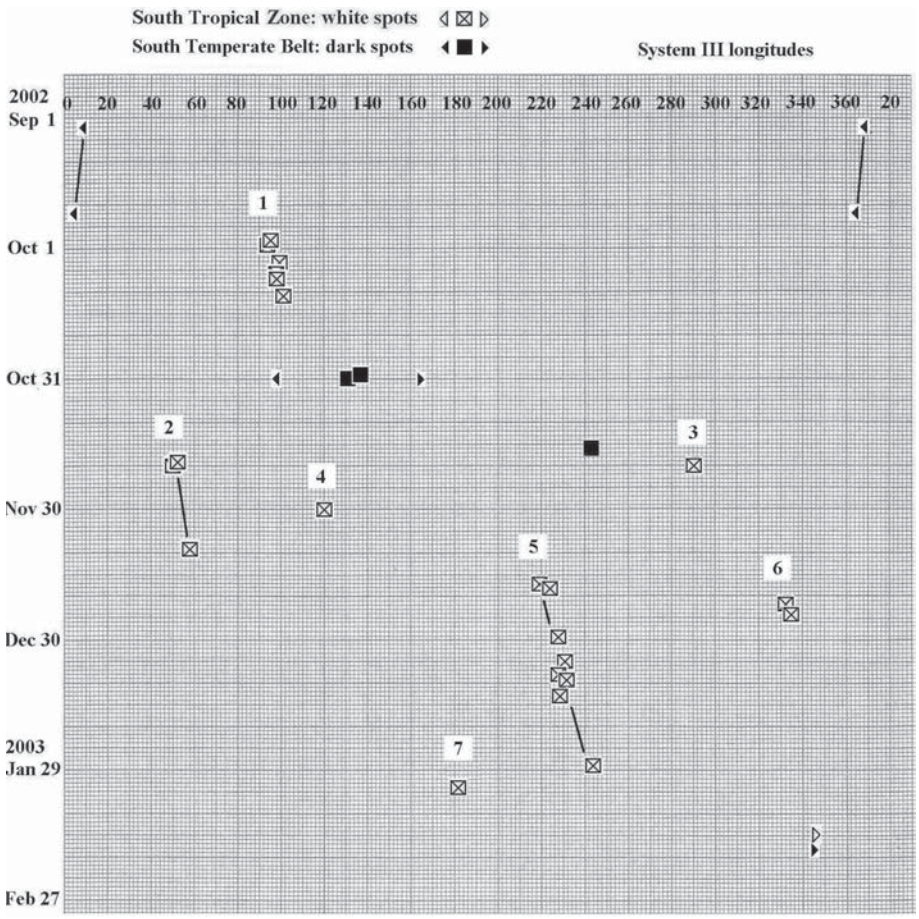

Figure 5. Longitude chart of the STropZ white spots and STB dark spots, in System III. *R. J. McKim*.

South Temperate Belt

The STB was of similar width and intensity to the SSSTB and SSTB. Gray found some darker sections. Exceptionally he found the belt knotty around the CM on Sep 3 (Figure 3).The tentative period of one dark section (according to Gray's CM transits) can be quoted. See also Figure 5.

Spot	*Limiting dates*	*No. obs.*	*Limiting longitudes*	$\Delta\lambda_3$ *(°/day)*
DS1p	Sep 3–Sep 23	2	007–003	–0.170

STB period: 10h 39m 30s

South Tropical Zone

White spot activity broke out at the N. edge of the STB. Latitude measurements by Peach give an average Saturni*graphic* latitude of –41.3°, or Saturni*centric* latitude –35.0°. As in 2001–'02[11] the STropZ was divided by a thin and faint S. Tropical Belt, perhaps best seen during Nov–Jan during the period of spot activity (which occurred between the STB and STropB). But sometimes the STropB did not appear even upon the best images; Legault's of Jan 5, or Peach's of Feb 19, for instance (Figures 11, 14).

Images showing spots were provided by Grafton (Figure 9), Kumamori (Figure 12), Parker, Peach (Figure 10), and Wu, while Gray and Parker made some visual sightings. Figure 5 offers a plot of longitudes in System III, the spots being numbered in order of appearance. Several images of these features were given in the Interim Report.[2] We can recognise seven different STropZ white spots in Figure 5, only some of whose rotation periods can be derived, as some existed for one day only.

The first sighting of a white spot this apparition was of 'WS1' (Figure 5) by Grafton on Sep 29 when a faint white oval was imaged close to the CM. Next day Grafton's image showed it extremely faint when 40° *p*. the CM, but it was more conspicuous when close to the CM to the same observer on Oct 7 (Figure 4). Three further sightings near the CM by Parker (Oct 4, 8 and 12) complete its history. Although its track if extended would coincide closely with spot WS4 imaged on one date only (Nov 30) by the HST, it was not imaged by Peach on Oct 22, so such an extension in lifespan is not possible. On Oct 31, Gray noticed a brightening of the zone in the longitudes *p*. the track of the spot. Spot WS2 showed a similar positive drift in System III; it was also imaged from Pic du Midi on Nov 25.[2]

Spot 'WS5' was the longest-lived and most conspicuous white spot. From Dec 18 up till Jan 4 its longitude increased at a similar rate to WS1, but between Jan 4 and 12 its longitude failed to increase; after that, the drift in increasing longitude continued.

Spot	*Limiting dates*	*No. obs.*	*Limiting longitudes*	$\Delta\lambda_3$ *(°/day)*
WS1c	Sep 29–Oct 12	6	095–102	+0.512
WS2c	Nov 19–Dec 9	3	051–060	+0.435
WS5c	Dec 16–Jan 28	8	219–244	+0.611
WS6c	Dec 22–24	2	332–335	(+1.69)
Average:				+0.519

STropZ average period (omitting WS6): 10h 39m 47s

Spot WS6 (Figures 9, 10) was observed over only a brief interval. Spot WS5 (Figure 9) was the largest and brightest STropZ spot of the apparition, discovered in HST images on Dec 16, with Grafton clearly imaging it till about 40° past the CM on Dec 22.

After Peach's observation of WS5 on Jan 28, despite many superb images throughout February and March, no further spot activity was detected, save one visual sighting by Gray on Feb 1, marked WS7 on the chart.

STropZ activity has often been witnessed in the past, but no single historical summary exists. The writer therefore collected the available reliable information in Appendix I, which conveniently includes a discussion of unpublished BAA data from 1971–'72.

South Equatorial Belt

As in 2001–'02 the SEB was widely double. The S. component was slightly variable in intensity with longitude: Gray caught one dark spot at the CM on Feb 1, and a number of Peach's images show darker sections. The SEB(N) was the wider and darker component, and was sometimes resolved into two belts, but some fine images show it as definitely single. Some small, short-lived dark features appeared at the N. edge of the SEB(N). For example, Phelps saw SEB(N) spots on Oct 18–19, and McKim on Nov 6 found a SEB(N)

Table 1. Observers

Observer	*Location(s)*	*Instrument(s)*
S. Beaumont	Windermere, Cumbria	203mm SCT
N. D. Biver	Versailles, Paris, France	256mm refl.
N. D. Bryant	Glasgow	254mm SCT
E. Colombo	Milan, Italy	152mm refl.
E. Y. Crandall	Winston–Salem, NC, USA	254mm refl.
M. Foulkes	Hatfield, Herts.	203mm SCT & 254mm refl.
(with P.Carter)	Tewin, Herts.	254mm SCT
M. Frassati	Crescentino (VC), Italy	203mm SCT & 318mm refl.
E. A. Grafton	Houston, TX, USA	356mm SCT
D. L. Graham	Brompton on Swale, N. Yorks.	235mm MKT
	Ripon, N. Yorks.	152mm MKT
D. Gray	Spennymoor, Co. Durham	415mm DK
P. T. Grego	Rednal, Birmingham	152mm OG
A. W. Heath	Long Eaton, Notts.,	203mm SCT & 254mm refl.
T. Ikemura	Nagoya, Japan	310mm refl.
E. Jamison	[not stated] USA	130mm & 180mm OGs
S. Keene	Columbus, OH, USA	333mm refl.
T. Kumamori	Sakai City Obsy., Oasaka, Japan	600mm Cass.
T. Legault	France	305mm SCT
R. J. McKim	Upper Benefield, Northants.	410mm DK
F. J. Melillo	Holtsville, NY, USA	203mm SCT
C. E. Meredith	Manchester	203mm SCT & 215mm refl.
M.P. Mobberley	Bury St Edmunds, Suffolk	355mm refl.
D. M. Moore	Phoenix, AZ, USA	250mm refl.
Y. Morita	Hiroshima, Japan	250mm refl.
E. Ng & A. Chu	Hong Kong, China	254mm refl.
D. Niechoy	Göttingen, Germany	203mm SCT
D. C. Parker	Miami, FL, USA	410mm refl.
P. W. Parish	Rainham, Kent	152mm OG
D. A. Peach	Costa da Silencio, Tenerife, Spain	279mm SCT
C. E. Pellier	Bruz, France	178mm MKT
I. S. Phelps	Warrington, Cheshire	114mm refl.
M. Pugh	Caparica, Portugal	127mm OG
J. R. Sanchez	Cordoba, Spain	279mm SCT
R. W. Schmude	Barnesville, GA, USA	102mm OG
W–L. Tan	Singapore	254mm DK
G. Wu	Morgantown, WV, USA	235mm SCT

Abbreviations: SCT= Schmidt–Cassegrain; DK= Dall–Kirkham Cassegrain; MKT= Maksutov–Cassegrain; OG= refractor ('Object Glass'); Refl.= reflector.

Table 2. Visual intensity estimates, 2002–'03

Feature	*SB*	*MF*	*MFr*	*DGy*	*AH*	*RM*	*CM*	*IP*	*RS*	*Ave.*	*No.*
SSPC	–	–	–	–	–	7.0	–	5.5	–	6.2	3
SPC	–	4.8	6.0	5.0	4.1	5.4	–	5.0	5.3	5.1	88
SSPB	–	4.9	–	5.7	–	5.9	–	–	–	5.5	40
SPR	4.3	4.0	–	4.3	3.1	4.0	5.0	3.5	–	4.0	57
SPB	–	–	–	4.9	–	4.7	–	5.0	–	4.9	44
SSTeZ	–	–	–	3.5	–	–	–	–	–	3.5	33
SSTB	–	–	–	4.5	–	–	–	–	–	4.5	33
STeZ	4.0	3.1	4.0	2.4	2.1	3.4	3.5	2.5	3.2	3.1	98
STB	–	–	–	4.2	–	3.8	–	–	4.0	4.0	35
STropZ	3.0	2.9	3.0	2.7	–	3.4	–	2.5	3.1	2.9	86
SEB(S)	–	4.5	4.5	5.0	–	4.7	–	5.0	–	4.7	63
SEBZ	–	3.5	–	4.4	–	3.9	–	4.0	–	4.0	48
SEB(N)	4.7	5.0	4.5	5.8	4.7	5.2	4.8	6.0	4.3	5.0	101
EZ(S)	1.7	1.5	1.5	2.2	1.5	1.7	1.0	2.0	2.3	1.7	101
EB	–	3.2	–	3.3	2.2	3.2	–	3.5	3.5	3.2	70
EZ(N)	–	1.5	–	1.5	–	1.6	–	2.0	–	1.6	77
Ring A1	3.0	3.9	3.0	4.3	3.0	3.7	4.0	4.5	3.1	3.6	99
Encke's Divn.	–	8.0	–	7.5	–	6.2	–	5.0	–	6.7	24
Encke Complex	–	–	–	5.2	3.7	3.9	4.5	5.5	–	4.6	56
Ring A2	–	3.5	–	3.1	1.9	2.8	–	2.5	–	2.8	70
Cassini's Divn.	6.7	10.0	8.0	9.3	10.0	10.0	10.0	9.2	8.0	9.0	99
Ring B1	1.0	1.0	1.2	1.2	1.0	1.2	1.0	1.0	2.0	1.2	100
Ring B2	–	3.2	2.5	2.5	1.5	2.9	1.2	3.0	2.6	2.4	91
Ring B3	–	–	–	4.0	–	2.7	–	–	–	3.4	54
Ring C	–	8.0	7.0	6.9	8.3	7.8	8.2	8.5	8.5	7.9	110
Ring C_m	7.0	6.9	6.0	4.2	8.0	6.5	8.0	8.0	7.1	6.8	100
ShRG	–	–	–	7.7	–	–	–	–	–	7.7	9
ShGR	8.0	10.0	8.0	–	10.0	10.0	10.0	9.8	10.0	9.5	65
Total used	30	246	13	844	162	451	21	32	55		1,854

Key to observers: SB, Beaumont; MF, Foulkes; MFr, Frassati; DGy, Gray; AH, Heath; RM, McKim; CM, Meredith; IP, Phelps; RS, Schmude.

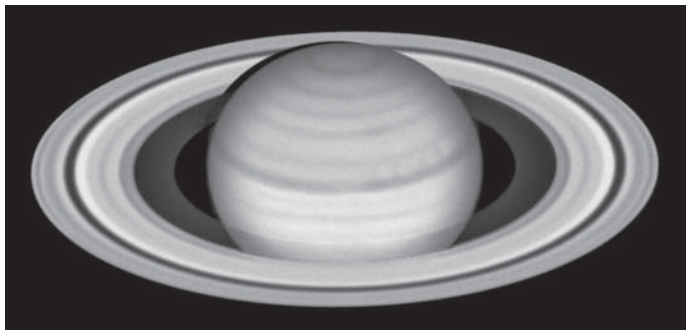

Figure 7. 2002 Nov 17, 21:50UT, 415mm DK Cass., ×348, ω_1= 353°, ω_3= 218°, *D. Gray*. Seeing I–II. Note Encke's Division as well as three belts in the EZ, and the complex lighter SEBZ *f*. the CM.

condensation near the CM, with the SEB mottled on Feb 17 and 21. Colombo saw a SEB(N) projection into the EZ(S) on Feb 18.

Images showing two white spots in the SEBZ between the belt's components were provided by Grafton and Parker; these features were not seen visually. From latitude measurements by Peach, the average Saturni*graphic* latitude was –28.3°: Saturni*centric* latitude –23.2°. The spots were separated by about 14° in longitude.

Spot	*Limiting dates*	*No. obs.*	*Limiting longitudes*	*$\Delta\lambda_3$ (°/day)*
WS1c	Oct 7–12	3	118–082	–7.53
WS2c	Oct 8–12	2	100–067	–8.37
Average:				–7.95

SEBZ average period: 10h 33m 10s

WS1 was slightly more prominent than WS2, and Sanchez–Lavega noted upon an emailed drift chart[13] that it had been recorded by the HST on Sep 21. Images at these longitudes by Peach demonstrated that the spots had disappeared by Oct 16. Another small SEBZ white oval was captured by Peach on Nov 12 and Grafton on Nov 14. Gray sketched further SEBZ activity on Nov 17 as a chain of spots (Figure 7). Grafton imaged another spot there on Nov 20, and finally Biver sketched activity there on Feb 15.

Equatorial Zone

As noted earlier, the EZ(S) was strongly yellow, perhaps more so than in recent years, while the EZ(N) was lighter and whiter. The difference between the two halves of the zone (divided by the EB) is especially marked in UV light (Figure 1).

A few images show very small scale white spot activity, and Gray took a transit of a small bright spot in the EZ(S) (Aug 27) and in the EZ(N) (Sep 2). Keene caught a tiny EZ(S) oval at the SEB N. edge on Sep 29. An array of dark streaks upon the EZ(S)B and light patches in the EZ(S) was imaged by Peach on Dec 14/15 and by the HST on Dec 17, and a tentative rotation period can be derived. Other dark festoons crossing the EZ(S) from the EZ(S)B to the EB were tracked by Peach on Dec 22 and 24 (Figure 10).

Spot	*Limiting dates*	*No. obs.*	*Limiting longitudes*	*$\Delta\lambda_3$ (°/day)*
WS1c	Dec 15–17	2	201–214	+6.7

EZ(S) period: 10h 18m 55s

This is a slow period for the Equatorial Current, but it continues the trend witnessed since 1994–'95, during which even *ca.* +10°/day has been common.

As in 2001–'02, the thin and very faint EZ(S)B lay close to the SEB and was now nearly invisible. The broad dusky EB remained close to the equator, and appeared more slightly variable in latitude from the images, while a thin dusky EZ(N)B (darker than the EZ(S)B) was located in the N. half of the zone.

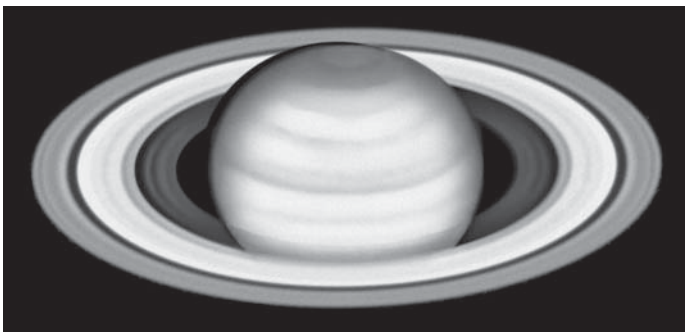

Figure 6. 2002 Oct 31, 01:30UT, 415mm DK Cass., ×348, W25 red filter, ω_1= 043°, ω_3= 146°, *D. Gray*. Seeing I–II. Note the well-marked details within ring C and the ring's greater brightness on the *p*. side, as well as other fine ring details.

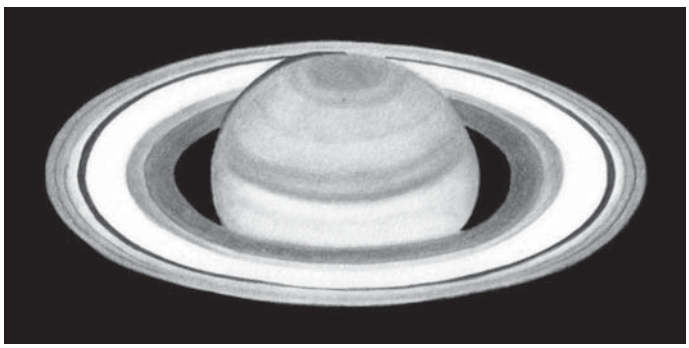

Figure 8. 2002 Nov 28, 21:30UT, 410mm DK Cass., ×410, ω_1= 270°, ω_3= 127°, *R. J. McKim*. Seeing II–III. Encke's Division and Encke Complex; SPB, STB, double SEB.

Figure 9. 2002 Dec 22, 05:56UT, 355mm SCT with SBIG ST-5c camera at F/27, ω_1= 188°, ω_3= 342°, *E. A. Grafton*. Near-opposition image showing STropZ white spot and SSPC.

Figure 10. 2002 Dec 24, 00:48UT, LRGB image, 279mm SCT and SBIG ST-5c camera at F/22, ω_1= 256°, ω_3= 351°, *D. A. Peach*. SSPC; small bright spot in STropZ *p*. the CM; festoons between EZ(S)B and EB.

The rings

The ring features have been fully described in recent reports.[11,14,15] At a maximum southern tilt this apparition, the Cassini Division was still *just* interrupted by the S. pole of the planet, as can easily be verified by calculation. The shadow of the globe on the rings generally extended very slightly beyond the Cassini Division onto ring A.

Table 3. Saturnicentric latitudes, 2002–'03

Feature	*EG*	*TL*	*DAP*	*Average*
SSPCn	–88.4	–88.4	–89.0	–88.6
SSPBs	–77.9	–	–78.4	–78.2
SSPBn	–72.7	–72.6	–73.2	–72.8
SPCn	–72.7	–72.6	–73.2	–72.8
SPRn	–63.0	–62.0	–63.0	–62.7
SPBs	–63.0	–62.0	–63.0	–62.7
SPBc	–60.6	–60.4	–61.2	–60.7
SPBn	–58.2	–58.9	–59.4	–58.8
SSSTBs	–55.6	–55.2	–55.6	–55.5
SSSTBn	–53.8	–53.4	–53.4	–53.5
SSTBs	–49.7	–48.3	–49.3	–49.1
SSTBn	–47.0	–46.1	–46.8	–46.6
STBs	–42.4	–42.6	–42.1	–42.4
STBc	–41.2	–41.0	–40.6	–40.9
STBn	–39.9	–39.5	–39.1	–39.5
STropBs	–	–	–34.2	–34.2
STropBn	–	–	–32.1	–32.1
SEB(S)s	–28.4	–30.7	–28.7	–29.3
SEB(S)n	–25.2	–25.6	–25.2	–25.3
SEB(N)s	–22.4	–22.2	–21.6	–22.1
SEB(N)n	–15.5	–16.4	–15.4	–15.8
EZ(S)Bs	–12.7	–13.3	–12.0	–12.7
EZ(S)Bn	–11.1	–11.9	–10.4	–11.1
EBs	–7.3	–8.8	–6.2	–7.4
EBc	–4.7	–5.6	–3.9	–4.7
EBn	–2.1	–2.4	–1.6	–2.0
EZ(N)Bs	+2.6	+2.9	+2.8	+2.8
EZ(N)Bn	+4.9	+5.1	+5.4	+5.1
Total	98	20	119	237

Key to observers: EG, Grafton (the best 6 images); TL, Legault (one image); DAP, Peach (the best 6 images). All data were reduced by McKim.

Figure 11. 2003 Jan 5 (time not stated), 305mm SCT, Philips Vesta Pro camera, *T. Legault*. Many belts, but no spot activity. Three intensity minima within ring A. The brightened inset clarifies details within ring C.

Mobberley on Sep 28 glimpsed the N. globe through the Cassini Division, and as at the previous opposition, others were able to confirm this effect. For example, the HST images of Mar 7 (Figure 1) also show the N. hemisphere through the division, the contrast being strongest in the UV where the rings have the lowest albedo relative to the globe: this strip of N. hemisphere can be seen in violet and less clearly in yellow, but not at all in the longer wavelengths.

The highest resolution images by Legault (Figure 11) and Peach clearly show a dusky band between the Encke Gap and the inner edge of the Encke complex in ring A, so that there were actually three such intensity minima in the ring. (See also Figure 2.) Peach on Dec 7 made a brightness scan from his image, which nicely shows two minima in ring A as well as the intensity 'ripples' of the B ring, and the uneven brightness of ring C: see Figure 15.

There were again a few visual reports of spokes in ring B, but none were confirmed, and there were no spokes visible in the many excellent images. Phelps reported seeing the Terby White Spot on Sep 22–23, and Heath saw it adjacent to the ShGR on Feb 5.

To Gray the *p*. ansa of ring C was again generally slightly lighter than the *f*. one. Ring C looked merely greyish to Heath and McKim, but it was brown to Phelps, while Gray again saw a coffee or copper-brown tint, and considered that the ring had become more

Figure 12. 2003 Jan 12, 09:38UT, 600mm Cass., with Sony DCR-TRV900 camera, ω_1= 050°, ω_3= 215°, *T. Kumamori*. STropZ white spot approaching CM; SSPC; SSSTB and SSTB clearly visible between STB and SPB; fine ring details.

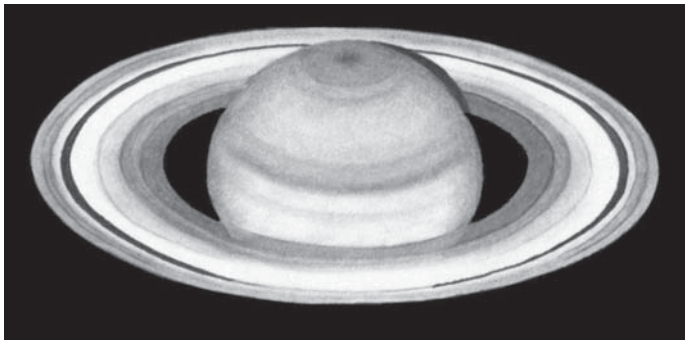

Figure 13. 2003 Jan 15, 19:30UT, 410mm DK Cass., ×410, ω_1= 050°, ω_3= 101°, *R. J. McKim*. Seeing II. Complex details upon rings A and B; SSPC visible in centre of SPC.

Figure 14. 2003 Feb 19, 19:48UT, LRGB image, 279mm SCT and SBIG ST-5c camera at F/22, ω_1= 091°, ω_3= 048°, *D. A. Peach*. Many minor belts extremely well defined, but no spot activity.

obviously redder over the last three apparitions. However, the increasing sub-Earth latitude might also explain this impression. Professional studies using HST images have been published,[16,17] and these indicate that there is no change of colour with D_e, although there is a small variation with phase angle.

On Oct 31 in superb seeing conditions Gray (Figure 6) was astonished to see several fine details upon ring C, these being especially pronounced when using a W25 red filter. There was a dark division nearer to the outer edge, while a lighter annulus lay just inside it, and further detail within that. In red light, these details appeared much more clearly on the *p*. side, but with a W58 green filter the ansae looked equal in brightness. These fine details are confirmed in the best images of Grafton (Figure 4, inset), Kumamori, Legault (Figure 11, inset), Ng and Peach as well as by the HST images (Figure 1). Biver also saw the division visually. Compare these details with Murray's 1973 view (Figure 2).

Ring C crossing the globe (C_m) was unusually light according to Gray's estimates (Table 2), but most observers considered it insignificantly different from 2001–'02.

Heath made no sightings of the bicoloured aspect of the rings (whose objective reality and interpretation we discussed in our last report.[11]). Schmude looked for the effect and never saw it, but Frassati reported seeing the inner part of ring B darker and more intensely brown on the *p*. side on Jan 14 and 24, while Gray's observation of ring C on Oct 31 was cited above.

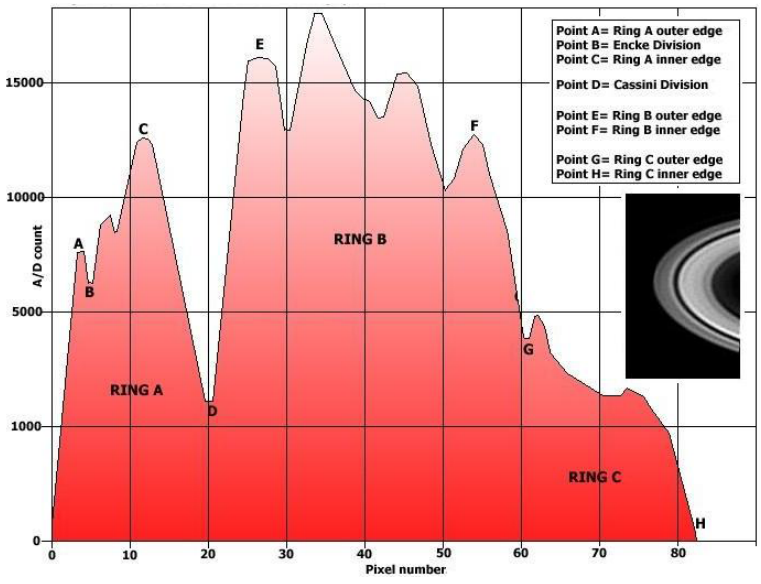

Figure 15. A brightness profile of the rings made from a monochrome image (inset) on 2002 Dec 7, 01:59UT, 279mm SCT & SBIG ST-5c camera at F/22. *D. A. Peach*.

None of our observers reported seeing an inner D ring,[12] but no-one had access to an adequate mountain-based telescope of more than 60cm diameter. Today, J. B. Murray interprets his 1973 sightings (Figure 2) as the blending together of the very tenuous strands of ring material lying within the orbit of ring C, into an apparently single telescopic feature.[18]

The ShRG was hidden by the rings for nearly all the opposition but Gray recorded it through the crepe ring crossing the globe as a darker sliver at its N. boundary from Feb 1 till his final observation on Apr 22: at those times, D_e exceeded D_s.

The satellites

On 2002 Dec 15 Tethys was predicted to occult the 9th magnitude star TYC 1310-02435-1 upon a track that crossed southern UK and France.[19] In the event the actual eclipse track was marginally different, missing the Pic du Midi Observatory, but positive results were obtained from Belarus, Japan and Poland. No positive observations were communicated to the Section.

Occultation of the Crab Nebula

Around New Year the unusual close approach of Saturn to Messier 1 – the Crab Nebula – was witnessed by Grego (Jan 5) and Jamison (Dec 29), though the nebula's surface brightness was too low for Foulkes & Carter to spot it on the night of Jan 4–5, when the planet actually passed across it.

Acknowledgment

I thank Dr John B. Murray for a copy of his original drawing that appears in Figure 2.

Address: 16 Upper Main Street, Upper Benefield, Peterborough PE8 5AN. *[richardmckim@btinternet.com]*

References and notes

1 Initial *Cassini* atmospheric results are reported in: C. Porco *et al*., '*Cassini* imaging science: initial results on Saturn's atmosphere', *Science*, **307**, 1243–1247, (2005)
2 D. L. Graham & D. A. Peach, *J. Brit. Astron. Assoc*., **113**(6), 322–324 (2003). Unusually, Saturni*graphic* latitudes (L) for spots were quoted in this Interim Report. These are related to the Saturni*centric* latitudes (C) used in most other BAA Saturn reports by the formula Tan C = Tan L/ $(1.12)^2$. See A. F. O'D. Alexander, *The Planet Saturn*, Faber & Faber, 1962, p. 450.
3 D. L. Graham, *J. Brit. Astron. Assoc*., **113**(5), 286 (2004)
4 The HST website: **http://hubblesite.org/newscenter/archive/releases/solarsystem/saturn**
5 R. J. McKim & J. H. Rogers, 'Obituary: Donald C. Parker, 1939–2015', *J. Brit. Astron. Assoc*., **125**(3), 177–178 (2015)
6 R. J. McKim, 'The great perihelic opposition of Mars, 2003', *ibid*., **120**(5), 280 -295 (2010)
7 J. L. Benton, *J. Assoc. Lunar Planet. Obs*., **48**(2), 24–40 (2006)
8 The ALPO Japan website: **http://alpo-j.asahikawa-med.ac.jp/Latest/Saturn.htm**
9 The IOPW website: **http://www.pvol.ehu.es**
10 The UAI website archive: **http://pianeti.uai.it/archiviopianeti/**
11 R. J. McKim, 'Saturn in 2001–2002', *J. Brit. Astron. Assoc*., **126**(6), 355–360 (2016)
12 J. B. Murray, *ibid*., **89**, 250–255 (1979)
13 Email from A. Sanchez–Lavega to D. L. Graham, 2002 Dec 12

14 R. J. McKim, 'Saturn in 1999–2000', *J. Brit. Astron. Assoc.*, **126**(3), 169–177 (2016)
15 R. J. McKim, 'Saturn in 2000–2001', *ibid.*, **126**(4), 238–243 (2016)
16 J. N. Cuzzi, R. G. French & L. Dones, 'HST multicolour (255–1042nm) photometry of Saturn's main rings', *Icarus*, **158**, 199–223 (2002)
17 F. Poulet, J. N. Cuzzi, R. G. French & L. Dones, 'A study of Saturn's phase curves from HST observations', *ibid.*, **158**, 224–248 (2002)
18 J. B. Murray, *pers. comm.* (2015)
19 Tethys occultation predictions were contributed to the Section by Jon Harper.
20 T. W. Webb, 'The Planet Saturn', *The Intellectual Observer*, **9**, 254–256 (1866)
21 Samuel Vince, *A Complete System of Astronomy*, vol. **1**, Cambridge, 1797, p. 233
22 R. J. McKim, 'Saturn in 1994–'95', *J. Brit. Astron. Assoc.*, **124**(3), 142–150 (2014)
23 R. J. McKim, 'Great White Spots on Saturn: Current and historical observations', *ibid.*, **121**(5), 270–273 (2011)
24 A. F. O'D.Alexander, *op. cit.*, p.153
25 W. Lassell, *Mon. Not. R. Astron. Soc.*, **18**, 231 (1858)
26 T. E. R. Phillips, *J. Brit. Astron. Assoc.*, **21**, 323–326 (1911)
27 T. E. R. Phillips, *ibid.*, **44**, 29–31 (1933)
28 J. H. Shears & R. M. Baum, 'Limb projections on Saturn', *ibid.*, **123**(3) 151–152 (2013)
29 E–M. Antoniadi, 'La Planète Saturne', *Bull. Soc. Astron. France*, **44**, 1–11 (1930)
30 J. H. Moore, *Proc. Astron. Soc. Pacific*, **51**, 274 (1939). These results were described in *The Observatory*, **63**, 58–59 (1940), and later in Alexander, *op. cit.*, p 389.
31 A. F. O'D. Alexander, *op. cit.*, p. 405
32 E. J. Reese, 'Recent photographic measurements of Saturn', *Icarus*, **15**, 466–479 (1971). [These data are also tabulated in the 1969–'70 ALPO report: J. L. Benton, *JALPO*, **24**(1–2), 27–35 and (5–6), 89–90 (1973).]
33 A. W. Heath, *J. Brit. Astron. Assoc.*, **87**, 258–294 and 294–299 (1977)
34 A. W. Heath, *ibid.*, **88**, 168–179 (1978) and **89**, 155–168 (1979)
35 D. L. Graham & D. A. Peach, *ibid.*, **114**, 65–67 (2004). STropZ drift-rates quoted in this Interim Report will be succeeded by those in R. J. McKim, 'Saturn in 2003–2004', *ibid.*, *in press* (2017).
36 J. K. Beatty, B. O'Leary & A. Chaikin, *The New Solar System*, Cambridge University Press, 1981, p. 119
37 BAA *Circular* No. 536 (1971 Sep 22)
38 A. W. Heath, 'Saturn, 1971–'72', *J. Brit. Astron. Assoc.*, **87**, 82–85 (1976). Heath's predecessor did not respond to enquiry about other missing records.
39 *The Astronomer*, **8**, Nos. 90–92 (1970–71)
40 J. L. Benton, *JALPO*, **24**(7–8), 139–147 (1973)

Appendix: Ground-based observations of STropZ activity, with a special report on 1971–'72

Historical survey up to 2003

Here we try to collect all the ground-based data up to 2003 in one place. This includes references in Alexander's book,[24] historical references not listed by him, and the work of the Section since Alexander's book was published (1962).

Looking at earlier spots in the STropZ we find nothing before 1858, though the Revd T. W. Webb (in a long, serialised paper[20]) gives us a tantalising reference to an observation by Cassini & Fato in 1683 who saw a bright streak, 'suggestive of rotation', on two dates. Webb's likely source, Vince's *A Complete System of Astronomy*,[21] gave no location for the object. Online copies of *Phil. Trans.* and *J. des Scavans* do not help, nor does Alexander mention this early activity, except by omission, and it is possible it was merely a lighter zone.

Webb also stated that Busch and Luther on 1848 Sep 9 and 10 saw a bright round spot near the S. limb: again no source was given. As the rings were then edgewise, this must have been some high latitude feature akin to the bright spot imaged in 1994 at Pic du Midi.[22]

On 1858 Jan 11 and 14 the Revd W. R. Dawes twice saw a light southern spot, leading to an apparent period of 10h 24.3m.[23,24] However, closer inspection shows that on both occasions the spot had already crossed the CM by different amounts, leaving a range of error. Given its latitude (estimated by Dawes) at *ca.* –40° it most likely lay in the southern STropZ. On 1858 Apr 17, W. Lassell[25] described another specific light area south of the SEB, but did not follow up the sighting. These were the first spots to be seen in the STropZ.

Very few of the older BAA reports mention white spot activity in the STeZ or STropZ. For the S. *Temperate* Zone the writer found observations by the Revd T. E. R. Phillips in 1910–'11.[26] Phillips did not determine any period at the time, but his later re-examination of the data[27] yielded 10h 36.8m for one spot (and *ca.* 10h 36m for another). His drawing of 1910 Aug 21[26] shows a large STeZ white oval followed by dusky shading. (The STB at that epoch was unusually conspicuous, and the STropZ a little shaded, with a single broad SEB.)

M. Maggini also saw bright spots in 1910–'11, and both observers saw them irradiating at the limb, implying high altitude. (Maggini's drawing of 1910 Sep 29 has been conveniently illustrated (in a different context) by J. H. Shears & R. M. Baum.[28]) E–M. Antoniadi's 1930 review[29] is silent about these latitudes.

Ground-based spectroscopic measurements were made by J. H. Moore at Lick Observatory.[30] Moore's results, obtained in 1936–'37 with the rings edgewise, showed the period increased with latitude, but the result for latitude ±42° (only 1.08 times the equatorial period) seems too short.

On 1941 Sep 16 and 22 Camichel at Pic du Midi photographed a white STropZ spot near latitude –40°.[31]

The next favourable presentation of the S. hemisphere occurred in the mid 1960s to late 1970s. During 1969–'70 and 1970–'71, E. J. Reese and others at New Mexico State University photographed a small white spot in the SSTeZ (at mean Saturni*graphic* latitude –57.3°, or Saturni*centric* latitude –51.2°) which showed a mean period of 10h 36m 28s.[32] This was too delicate a feature to have been detected by Section members. But in 1971–'72 short-lived activity was detected by Saturn Section members: see below.

Observations in the succeeding years were less numerous, with negligible activity in the STropZ in 1973–'74 and 1974–'75.[33] A small bright SSTeZ white oval was seen by the BAA in 1976–'77; in 1977–'78 there was slight activity in the STeZ and STropZ.[34] In 1994, the Pic du Midi observers imaged a white spot at high latitude[22] which drifted at –3.5°/day in System III with a period (10h 36m 37s) close to Reese's spot. In several of the post-1994 apparitions, BAA observers followed less conspicuous ovals in the STropZ, and occasionally in the STeZ. The former are tabulated below.

In the present 2002–'03 apparition, the small STropZ white spots

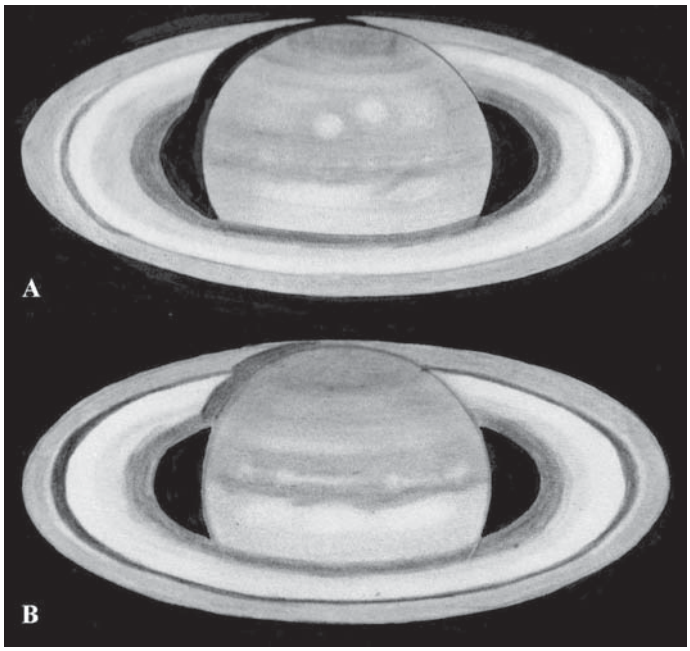

Figure 16. (A) 1971 Sep 18, 23:30UT, 318mm refl. ×432, ω_2= 194°, *A. Appleyard*. Seeing II. Two white spots are in the STropZ. The SEBZ was also noted as active, and there is also a white spot in the EZ(S).
(B) 1971 Oct 27, 22:10UT, 318mm refl. ×432 & ×540, ω_2= 140°, *A. Appleyard*. Seeing I–II. The STropZ was mottled by lighter streaks, the *f.* end of one being at the CM. SEBZ activity consisted of well-defined spots and streaks.

Table 4. Activity in the STropZ in 1971–'72

Date	*Observer*	*Instrument and notes*	λ_2 (°)
Sep 5	D. Gray	254mm refl., 03:00–05:00UT; STropZ mottling suspected	(137)
Sep 7	D. A. Allen	60-in Cass., Mount Wilson; 13:25UT; No activity in STropZ.	(280)
Sep 10	Allen	100-in refl., Mt Wilson; 12:55UT; No activity in STropZ.	(179)
Sep 12	A. Appleyard	318mm refl., 00:30UT; STropZ mottled adjacent to SEB	(303)
Sep 12	W. J. Wilson	216mm refl., 00:05–01:05UT; 'Suspect uneven shading' in STropZ	(320)
Sep 12	T. J. C. A. Moseley	370mm refl., STropZ ws, rough CMT estimate 03:25UT.	042
Sep 17	P. B. Doherty	254mm refl., STropZ shown mottled.	
Sep 18	Appleyard	STropZ (N) ws CMT 23:24UT.	190
Sep 18	Appleyard	STropZ (S)/STB ws CMT 23:50UT.	205
Sep 19	Appleyard	23:30UT; STropZ ws *f.* CM	(286)
Sep 19	Doherty	24:00UT; (the above) STropZ ws at or near CM.	302
Sep 20	Doherty	Narrow bright strip in STropZ	
Sep 21	Appleyard	23:30UT; STropZ ws est. 1½ hours *f.* CM.	(110)
Oct 1	Doherty	STropZ mottled.	
Oct 2	F. J. Acfield	254mm refl., 03:00UT; STropZ blank in excellent seeing.	(069)
Oct 3	A. W. Heath	305mm refl., 00:45UT; Apparent wisps crossing STropZ.	(085)
Oct 4	J. B. Murray[39]	1.07m Cass., Pic du Midi, 22:50–23:50UT; no spot activity.	(204–238)
Oct 5	Appleyard	23.10UT; Two vague white STropZ patches on *f.* side.	(308)
Oct 5	Doherty	Narrow bright strip in STropZ	
Oct 7	Doherty	STropZ mottled.	
Oct 8	G. E. Satterthwaite	127mm OG, Selsey, 23:00 UT; SEB S. edge irregular *f.* CM	(134)
Oct 8	Murray[39]	02:15–02:45UT; Perfect seeing; no spot activity.	(236–253)
Oct 14	Appleyard	22:45UT; Vague STropZ white ovals suspected on f. side.	(042)
Oct 19	Doherty	Narrow bright strip in STropZ.	
Oct 22	D. B. Taylor	254mm OG, Dundee; 21:45UT; STropZ ws shown *p.* CM.	000
Oct 22	Appleyard	22:00–23:10UT; STropZ mottled	(034)
Oct 27	Appleyard	22:10UT; STropZ mottled; *f.* end STropZ light streak at CM.	140
Oct 29	C. J. R. Lord	152mm OG; 01:30UT; STropZ diffuse mottlings.	(345)
Oct 30	Gray	00:10–01:30UT; Indefinite light patches in *p.* half of STropZ/STeZ.	(060)
Nov 19	Appleyard	'The whole of this zone appeared to be in turmoil with unresolved [light] streaks seen.' Broken STB suspected.	
Nov 23	J. Nash	215mm refl., 22:20UT; widening of SEB(S) at CM.	(113)
Dec 15	Lord	STropZ 'very mottled at times'.	
Dec 16/17	Appleyard	23:45–00:45UT STropZ turbulent; light areas on *f.* side.	(127)
Jan 11	Lord	STropZ 'patchy and mottled'. Drawing 22:00UT shows *f.* end of light area just *f.* the CM.	297
Feb 8	Lord	STrop Z 'interrupted.' Drawing 21:00UT shows *f.* end light area just *f.* the CM.	326
Feb 9	Doherty	STropZ mottled.	
Mar 4	R. de Terwangne	203mm SCT; Drawing hints at vaguely lighter area *p.* CM.	
Mar 20	F. Nardone & R. O'Reilly	370mm refl., Drawing 21:25UT shows STropZ ws a very long way *p.* the CM; 21:30UT another ws at CM.	136
Mar 21	Nardone	254mm OG, Armagh; Drawing 19:45UT shows STropZ ws a long way *p.* the CM; ws not visible by 20:50UT.	(168)

Moseley sometimes observed with O'Reilly & Nardone; Appleyard likewise with M. Wardley.

showed drift rates of +0.52°/d in System III, and +0.30°/30d in 2003–'04.[35] The *Voyager* wind profile[36] shows that the expected velocity for the STropZ decreases roughly linearly with increasing latitude away from the System I rate of the SEB up to the STB mean latitude of –37°, where it has already fallen to the System III 'core' period. STropZ spots lying closer to the SEB, such as in 1997–'98, would be expected to have a shorter period (or more negative drift) than those adjacent to the STB. This seems in general to be the case if we arrange recent data in order of descending latitude:

Apparition	*STropZ white spots mean latitude (*)*	*Mean drift rate* $\Delta\lambda_3$ *(°/day)*
2003–'04[35]	–37	+0.30
2002–'03	–35	+0.52
2000–'01	–35	+0.16
1998–'99	–34	–1.62
1996–'97	–34	–1.01
1997–'98	–33	–1.18

*In 2000–'01, 2002–'03 and 2003–'04 the spots lay in the southern part of the zone. Otherwise the latitude of the centre of the STropZ has been quoted for the larger, more diffuse objects seen in other years.

The 1971–'72 BAA observations

The discovery of a STropZ white spot on 1971 Sep 12 by Terry Moseley from Belfast (370mm refl., with two other observers) together with activity in the EZ was announced by the then Director (G. E. Satterthwaite) in a BAA *Circular*.[37] Subsequently another STropZ spot was seen on Sep 18 by Alan Appleyard from Sheffield (318mm refl.).

Moseley did not send any drawing, but we publish Appleyard's of Sep 18 for the first time (Figure 16A), showing two objects, one in the northern STropZ and another, closely following, in the southern STropZ. Satterthwaite failed to mention that the timings he quoted from Moseley were rough estimates made over 45 minutes away from CM passage. WinJUPOS data (and here we revert to System II longitudes) show that (contrary to what Satterthwaite wrote) Moseley and Appleyard had seen *different* spots.

At the time of publication of the BAA 1971–'72 Section Report (by A. W. Heath),[38] the original observations had been misfiled by the previous Director (Satterthwaite), and Heath's report (which mentions only the EZ activity) is based on the work of a subset of those original observers who had resubmitted data. Later discovery of the originals enabled this more comprehensive summary.

The activity was short-lived, with negative reports in *The Astronomer* magazine,[39] while the ALPO report[40] does not add anything. Moseley's original spot was not seen again. Heath (305mm refl.) could not see any spots in excellent seeing on Oct 3 at a somewhat higher longitude to Moseley, but some lineaments were sketched crossing the zone from N. to S., representing other imperfectly resolved STropZ details.[40] Throughout 1971–'72, many observers made a significant number of comments about STropZ mottling: too many to be dismissed.

In fact, activity had broken out in two different longitudes on Sep 12, as we can see from Table 4: both Appleyard and Wilson saw the STropZ mottled three hours prior to Moseley's discovery. We have included significant negative observations, and some notes where no UT time is available. It will be clear whether the feature's longitude was measured or not, for we give the System II CM longitude at the time stated in brackets, and actual longitudes of features without brackets (ws= white spot).

Plotting the data in System II does not yield any rotation periods (due to the lack of actual transits) but suggests about eight different STropZ features existed, with small or zero drifts:

Feature

1 Not present Sep 7 (Allen). Seen Sep 12 (Appleyard/Wilson) and Sep 19 (Doherty/Appleyard).
2 Seen Sep 12 (Moseley). Not seen again.
3 Not present Sep 10 (Allen). Seen Sep 18 (Appleyard and Wardley's N. STropZ spot) and Sep 21 (Appleyard). Both it and Appleyard's Sep 18 S. STropZ spot had gone by Oct 4 (Murray).
4 Not present Oct 2 (Acfield). Seen Oct 3 (Heath) and Oct 14 (Appleyard).
5 Seen Oct 5 (Appleyard/Doherty), Oct 22 (Taylor/Appleyard) and Oct 29 (Lord).
6 Seen Oct 30 (Gray).
7 Seen Jan 11 (Lord) and Feb 8 (Lord).
8 Seen Mar 20 (Nardone/O'Reilly) and Mar 21 (Nardone).

Features 2, 3 and 8 were the most prominent; feature 5 showed the best accord in longitudes.

In addition to this STropZ activity there were several conspicuous white ovals in the EZ(S) which were announced at the time;[37,39] there were several sightings by other observers, but we do not deal further with them here except to note that their period must have been close to System I. (Heath's drawing[38] shows *three* such ovals.)

Appleyard drew many details in the SEBZ: another white spot outbreak. His drawings of 1971 Sep 18 and Oct 27 (Figures 16A, B) show this activity well, recalling the SEBZ activity in 2002–'03. These spots too were confirmed by other observers during 1971–'72, so that apparition showed the same latitudinal range of activity as the present one.

Received 2015 May 30; accepted 2015 September 3