Saturn in 2001–2002

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A report of the Saturn Section. Director: M. Foulkes

Saturn's atmosphere remained quiet, the only activity being small irregularities within or at the N. edge of the S. Equatorial Belt, and in the Equatorial Band. No rotation periods could be derived for these small, transient features. On the other hand, there were obvious intensity changes in the far south: the tiny dark area at the extreme S. pole (SSPC) was more constantly present, and at high resolution was seen to be surrounded by a narrow light zone. The south face of the rings was displayed nearly to its maximum effect during the current presentation. The various occultations of the planet and its satellites by the Moon were further highlights of the apparition.

Introduction

Saturn was at opposition on 2001 Dec 3, when the sub-Earth latitude was –25.9°. During the period of observation this quantity attained –26.4°, a shade less than the maximum figure of –27.0° that would be reached for the presentation of the south face of the rings, during 2002–'03. Solar conjunctions were on 2001 May 25 and 2002 Jun 9, and our data span 2001 Jul 29 (Gray) till 2002 Apr 23 (McKim). The planet's declination at opposition was +20°: very favourable for north temperate observers. The writer experienced many clear nights, but seeing for visual work was less favourable than during the previous winter's observing season. This was also the experience of some other observers.

Many high quality images were taken. Among the new contributors we have Grafton's fine work: his images achieved the highest resolution of all those submitted. Akutsu again contributed infrared images; their appearance is very similar to those of 2000–'01. No groundbased image revealed much in the way of spot activity. No images were taken with the HST, but a superb infrared image by the VLT was published (in false colour) on the front cover of the *Journal*.[1] The number of visual contributors declined in 2001–'02, but several of these observers obtained long series: Foulkes observed on 39 nights, and Gray on 45. The *Cassini* spacecraft continued on its long journey: its first results would be received during the following apparition.[2]

A short summary of this apparition appeared in a Council report.[3] The present report continues from that for 2000–'01.[4] Accounts of the 2001–'02 apparition have been published by the Association of Lunar and Planetary Observers (ALPO)[5] and Unione Astrofili Italiane (UAI).[6] An International Outer Planets Watch website[7] was launched; together with the ALPO Japan website[8] this has proved an excellent source of Saturn images. Finally, Henshaw discussed his extensive naked eye magnitude data from 1971 to 2001.[9]

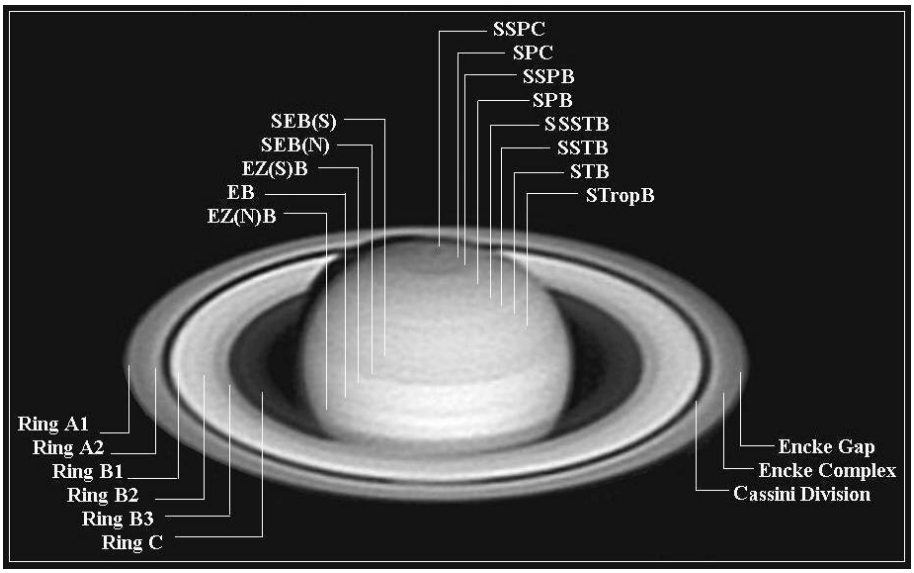

Figure 1. Saturn nomenclature (image by Grafton, Figure 3). South is uppermost in all illustrations unless otherwise stated.

The globe

General

The appearance was very similar to 2000–'01, with a general lack of fine detail apparent to visual observers: with the dusky SPC, the SEB and EB being the only glaringly obvious features. Spot activity was minimal. Upon the best images, however, subtle changes were clearly shown. With increasing altitude of the Sun above the S. hemisphere of the planet, Saturn's atmosphere appears to have become more and more differentiated into belts and zones, some of which were extremely narrow. Thus the SEB(N) component was itself closely double this time, a STropB was sometimes present, the elusive SSSTB remained visible from last year, while the SSPC was now more often visible. On the best images no fewer than 12 belts could be resolved. Figure 1 is labelled to illustrate belt and ring details.

Colours

Few visual colour estimates were received, and unfortunately none were made by Gray: the colour images speak for themselves, but those presented here were derived by several different synthetic processes that might produce a bias towards one colour. No unusual colours were reported. The SPC appeared visually grey to Foulkes and McKim, and blue-grey or blue-green to Peach. The STeZ-STropZ showed the usual yellowish tint, while the SEB was brown or reddish-brown. The EZ(S) was yellow or yellowish-

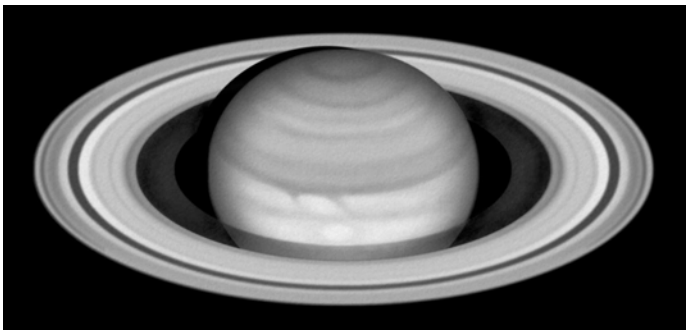

Figure 2. 2001 Aug 5d 03:50UT, 415mm DK, ×348, ω_1= 114°, ω_2= 286°, drawing by *D. Gray*. White spot activity in the EZ; darker section of STB; many fine ring subdivisions seen including the Encke Gap.

Figure 3. 2001 Sep 16d 11:43UT, 356mm SCT, RGB image with ST6 CCD camera at f/68, ω_1= 213°, ω_2= 097°, *E. A. Grafton*. Note the SSPC and slightly eccentric SSPB; small light patches between the two components of the SEB(N) *p.* the CM; many minor belts; Encke's Gap visible. Note the presence of part of the ShRG seen through the *f.* side of C_m.

white, being the most obviously yellow part of the globe; the EZ(N) was white or nearly so. Foulkes found the EB grey.

South Polar Region

The S. limb was capped with a dusky SPC. The SPC had a darker northern rim (the SSPB). The latter looks noticeably eccentric in two of Grafton's images (Sep 16, 17: Figure 3), while Biver drew the SSPB as eccentric on Aug 11 and Dec 23. Upon Di Sciullo's Jan 20 image (Figure 8) it looks slightly flattened upon the *f.* side; furthermore, at the eyepiece Di Sciullo found the lighter area within the SPC eccentric on Jan 20, but the effect was effaced by image-stacking. The Central Meridian longitudes (System II) for these observations all lay within 97–185°, and the Aug 11 (CM= 112°) and Sep 16 (97°) records agree rather closely in both date and longitude.

At the centre of the cap the tiny dark spot (SSPC) was now more or less constantly visible. Grafton's images (Figures 3, 5) show it

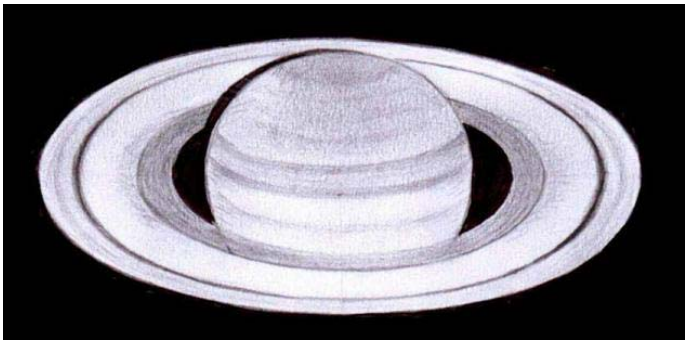

Figure 4. 2001 Nov 4 22:50UT, 215mm refl., ×354, ω_1= 023°, ω_2= 147°, drawing by *C. E. Meredith*. Several minor belts seen; Encke complex visible.

especially well, and Gray was able to record it visually on Mar 13. The area close to the SSPC was lighter in several images, and this light zone was especially well captured by a Pic du Midi (1m Cass) image on Dec 16, when there was a narrow belt at the outer edge of the zone midway between SSPB and SSPC.[7] On Aug 17 Peach saw the light zone visually, and it was caught in the best images, as Figure 5 best illustrates.

Figure 5. 2001 Nov 19d 06:39UT, 356mm SCT, RGB image with ST6 CCD camera at f/68, ω_1= 076°, ω_2= 060°, *E. A. Grafton*. SSPC; white zone adjacent to SSPC; SSSTB visible between SPB and SSTB; small light patches between the two components of the SEB(N) *f.* the CM; Encke's Gap resolved.

Table 1. Observers

Observer	*Location(s)*	*Instrument(s)*
T. Akutsu	Tochigi, Japan	320mm refl.
G. W. Austin	Ampthill, Bedford	203mm SCT
S. Beaumont	Windermere, Cumbria	203mm SCT
N. D. Biver	Versailles, Paris, France	256mm refl.
G. Boots & C. Wooldridge	Worthing, W. Sussex	125mm MKT & 203mm refl.
E. Colombo	Milan, Italy	152mm refl.
M. Foulkes	Hatfield, Herts.	254mm refl.
(with P. Carter)	Tewin, Herts.	203mm SCT
M. Frassati	Crescentino (VC), Italy	203mm SCT
M. V. Gavin	Worcester Park, Surrey	305mm SCT
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
D. Hatch	Brampton, Cambs.	152mm OG
A. W. Heath	Long Eaton, Notts.	203mm SCT & 254mm refl.
T. Ikemura	Nagoya, Japan	310mm refl.
N. D. James	Chelmsford	300mm refl.
D. Joye	Saclay, Paris, France	203mm SCT
H. W. McGee	Clandon, Surrey	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.
	Chelmsford	490mm refl.
D. Niechoy	Göttingen, Germany	203mm SCT
D. C. Parker	Miami, FL, USA	410mm refl.
D. A. Peach	King's Lynn, Norfolk & Chatham, Kent	305mm SCT
I. S. Phelps (with L. M. Phelps)	Warrington, Cheshire	114mm refl.
J. H. Rogers	Linton, Cambs.	254mm refl.
M. Di Sciullo	Coconut Creek, FL, USA	254mm refl.
W-L. Tan	Singapore	279mm SCT
J. Taylor	Hurst Green, London	222mm refl.
D. W. Wright	Caterham, Surrey	83mm OG

Abbreviations: SCT= Schmidt–Cassegrain; DK= Dall–Kirkham Cassegrain; MKT= Maksutov–Cassegrain; OG= Refractor (Object Glass); refl= Reflector.

North of the SSPB there was a halftone zone, the S. polar region (SPR), which was not as dark as in some recent years but somewhat darker than the Temperate and Tropical Zones. Its N. edge was marked by the S. Polar Belt (SPB). Formerly conspicuous, the SPB had also faded over the past few apparitions, and remained less dark throughout 2001–'02. A narrow belt just N. of the SPB has again been called the S. S. S. Temperate Belt here. Best seen on images, the SSSTB was also caught by Gray visually on Dec 10.

S. S. Temperate Belt and Zone

The SSTB remained thin and was especially difficult to see visually (Figures 1–9). It was shown on the best images. The SSTeZ was a little fainter than the STeZ.

South Temperate Zone

The light STeZ was without detail.

South Temperate Belt

The STB was thinner and at slightly higher latitude than in 2000–'01, and looked featureless upon all images. Gray saw the *p*. end of a darker section on Aug 5 (Figure 2).

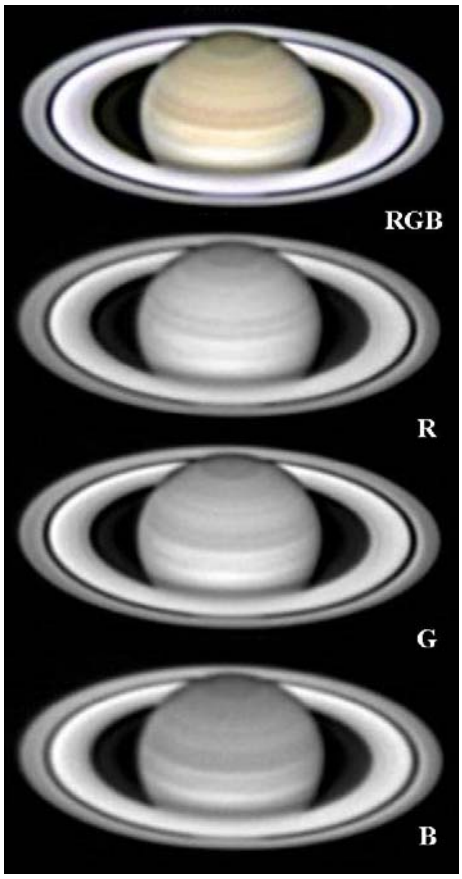

Figure 6. 2001 Dec 9d 02:52UT, 410mm refl., ST9E camera at f/46, RGB, R (630nm), G (540nm) and B (445nm) images, ω_1= 271°, ω_2= 334°, *D. C. Parker*. The SSTB is hardly visible between the SSSTB and STB. Subtle colour contrasts are apparent from the filtered images. The STB, SEBZ and EZ(S) are all relatively darker in blue light.

South Tropical Zone

No white spot activity was reported. The zone was often a little less bright than the STeZ. At high resolution a thin belt was sometimes imaged at the centre of the zone (Grafton, Sep 16, Nov 19; Parker, Oct 7): the STropB. It was certainly not present upon every excellent image, however (*e.g.*, Parker, Dec 9; Di Sciullo, Jan 20).

South Equatorial Belt

As in 2000–'01 the SEB was broad with the N. component wider and darker. The best images (Grafton (Figures 3, 5), Pic du Midi[7]) showed the SEB split into three belts: the northernmost two we assume represent the narrowly separated components of the SEB(N). Together, their width was higher than the SEB(N) in 2000–'01. These components were either equal in intensity, or the northernmost one was the darker. The same SEB(N) splitting had been observed at several apparitions during the 1970s.

Throughout 2001–'02 there were some tiny details associated with the SEB, but they were never prominent or long-lived. Grafton's images of Sep 16 (Figure 3) and Nov 19 (Figure 5) show small irregular light patches between the two components of the SEB(N). A few minute irregularities on the N. edge of the SEB are apparent upon some of Grafton's best images (Sep 16, 17, Oct 18, Nov 7, 19) while two are projecting into the EZ upon Ikemura's image of Nov 19. Meredith suspected an irregular N. edge to the SEB on Dec 2; Frassati saw projections on Jan 12, as did Gray on Aug 5 (Figure 2) and McKim suspected them on Feb 28. Peach reported darker areas within the SEB on Aug 17, as did McKim on Nov 26, Niechoy on Jan 13/14 and Mar 1, and Beaumont on Feb 14.

Equatorial Zone

This looked exactly as in the 2000–'01 apparition, with light yellow EZ(S), broad dusky EB and marginally lighter and whiter EZ(N). Two difficult thin belts, the EZ(S)B and EZ(N)B lay either side of the EB, close to the SEB and to C_m, respectively. The former of these was extremely faint, and visible only upon the best images.

Obvious condensations upon the faint EZ(S)B were shown upon a Pic du Midi (1m Cass.) image of Dec 16.[7] Suggestions of structure in the EZ(S), EZ(S)B and EB were sometimes caught by the best images of our members, with Parker showing the latter two uneven near the CM in Figure 6. Gray on Aug 5 (Figure 2) found a small EZ(S) white oval between two SEB(N) projections as well as a small oval in the EZ(N). However, such observations were exceptional.

N. hemisphere

Completely hidden by the rings, the N. hemisphere was nonetheless responsible for brightening the Cassini Division as it crossed the globe upon the best images.

The rings

General

The last two reports fully described the appearance of the widely open rings. The Encke Gap (Figures 2, 3, 5, 8 and 10) and Encke Division in ring A were well seen together with the various subdivisions in ring B. This apparition the Cassini Division on the southern side of the ring ellipse continued to be interrupted by the S. pole of the planet.

Under the best conditions it was again possible for observers to see the division between rings B and C, and the division was

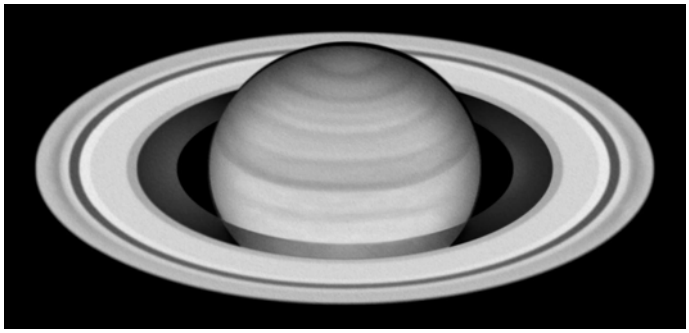

Figure 7. 2001 Dec 10d 21:50UT, 415mm DK, ×348, ω_1= 342°, ω_2= 348°, drawing by *D. Gray*. Compare with the previous day's images in Figure 6.

Table 2. Visual intensity estimates, 2001–'02

Feature	*SB*	*MF*	*MFr*	*DGy*	*AH*	*RM*	*CM*	*Ave.*	*No.*
SPC	4.2	4.8	5.5	4.8	–	5.0	5.5	4.8	113
SSPB	–	–	–	5.5	–	–	–	5.5	44
SPR	–	–	4.5	4.2	–	3.8	3.0	3.9	51
SPB	–	–	–	5.2	–	4.2	3.5	4.3	48
SSTeZ	–	–	3.6	3.6	–	–	3.0	3.4	47
SSTB	–	–	–	4.6	–	–	3.5	4.0	46
STeZ	3.1	3.0	3.2	2.7	3.0	3.3	3.0	3.0	128
STB	–	–	3.6	4.0	–	3.8	3.5	3.7	48
STropZ	3.1	2.9	2.9	2.6	2.5	3.2	3.0	2.9	120
SEB(S)	–	–	4.2	5.3	–	4.6	5.0	4.8	67
SEBZ	–	–	3.6	4.7	–	4.6	4.0	4.2	67
SEB(N)	4.4	4.9	4.4	5.8	4.8	4.7	5.0	4.8	129
EZ(S)	1.2	1.5	1.8	2.0	1.5	1.4	0.5	1.4	129
EB	–	3.0	2.8	3.4	2.9	3.0	–	3.0	79
EZ(N)	–	1.4	1.8	1.2	–	1.3	0.5	1.2	81
Ring A1	3.0	3.9	3.0	4.2	3.0	3.3	3.0	3.3	125
Encke's Divn.									
	–	–	–	7.4	–	–	–	7.4	4
Encke complex									
	–	–	–	4.9	4.3	4.2	4.0	4.4	59
Ring A2	–	3.5	2.8	3.1	2.0	3.1	–	2.9	82
Cassini's Divn.									
	6.2	10.0	8.5	8.8	8.5	10.0	10.0	8.8	118
Ring B1	1.0	1.0	1.2	1.3	1.0	1.2	1.0	1.1	128
Ring B2	–	3.0	2.8	2.5	1.6	2.2	2.0	2.4	105
Ring B3	–	4.5	–	3.8	–	3.6	–	4.0	59
Ring C	–	7.8	8.0	7.0	8.2	7.2	8.0	7.7	125
Ring C_m	6.6	6.7	6.2	4.4	8.0	7.3	–	6.5	124
ShRG	–	–	–	6.6	10.0	8.5	–	8.4	12
ShGR	7.9	10.0	9.5	–	10.0	10.0	–	9.5	70
Total used	102	460	20	1136	132	339	19		2208

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

Table 3. Saturnicentric latitudes, 2001–'02

Feature	*EG*	*DP*	*MDS*	*Average*
SSPCn	−87.6	−87.3	−87.1	−87.3
SSPBs	−77.7	−78.8	−77.8	−78.1
SSPBn	−72.0	−73.4	−71.4	−72.4
SPCn	−72.0	−73.4	−71.4	−72.4
SPRn	−63.8	−63.4	−63.8	−63.7
SPBs	−63.8	−63.4	−63.8	−63.7
SPBc	−62.0	−62.2	−62.5	−62.2
SPBn	−60.1	−61.0	−61.2	−60.8
SSSTBs	−56.1	−57.9	−55.1	−56.4
SSSTBn	−53.4	−54.0	−52.8	−53.4
SSTBs	−48.7	−48.2	−49.5	−48.8
SSTBn	−46.1	−47.1	−46.9	−46.7
STBs	−42.1	−42.2	−42.8	−42.4
STBc	−40.6	−40.4	−41.0	−40.7
STBn	−39.2	−38.6	−39.3	−39.0
STropBs	−34.6	−34.7	–	−34.6
STropBn	−33.0	−32.4	–	−32.7
SEB(S)s	−28.7	−28.0	−29.4	−28.7
SEB(S)n	−25.4	−24.2	−25.8	−25.1
SEB(N)s	−22.9	−21.3	−22.2	−22.1
SEB(N)n	−16.2	−15.3	−16.8	−16.1
EZ(S)Bs	−12.6	–	−12.8	−12.7
EZ(S)Bn	−10.7	–	−11.0	−10.8
EBs	−6.2	−6.2	−6.4	−6.3
EBc	−4.1	−3.6	−4.0	−3.9
EBn	−2.0	−1.0	−1.7	−1.6
EZ(N)Bs	+2.5	–	+2.2	+2.4
EZ(N)Bn	+5.7	–	+4.2	+5.0
Total	101	34	21	156

Key to observers: EG, Grafton (the five best images); DP, Parker (the two best images); MDS, Di Sciullo (one image only).
All data were reduced by McKim. Measures from drawings were in close accord, but from this opposition onwards they were no longer needed to support the imaging work.
Note: The SEB(N) was sometimes double, but we have amalgamated the two components in Table 3.

Figure 8. 2002 Jan 20d 01:16UT, 250mm refl., synthetic colour image with Starlight Xpress HX-916 CCD camera at f/75, ω_1= 036°, ω_2= 185°, *M. Di Sciullo*. (True Technologies cyan and yellow dichroic filters; magenta component extrapolated through averaging/reduction of cyan and yellow data.) Numerous belts; fine ring details.

Figure 9. 2002 Feb 16d 18:35UT, 305mm SCT, LRGB image with SBIG ST-5c camera at f/22, ω_1= 040°, ω_2= 013°, *D. A. Peach*. The SSTB appears to have recovered its intensity somewhat. The SEB(N) is much darker than the SEB(S).

also caught by C. J. R. Lord (25cm refl.) visually on Oct 6.[10]

Peach again found ring C brighter with a W21 filter, indicating a warm tint. To most observers it looked grey, though on Dec 11 Heath felt it was purplish. Gray compared the brightness of the ansae of ring C on 45 nights: the *p.* ansa was up to 0.75 units brighter than the *f.* one on 37 nights; they were equal on only three nights and the *f.* ansa was marginally brighter on only five. This is a similar result to recent apparitions. (See also the comments concerning the bicoloured aspect of the rings, below, which may be relevant here.)

Biver's drawings and Grafton's best images (Figure 1) show a well-marked division close to the centre of ring C. (This feature would be better seen at the following opposition.)

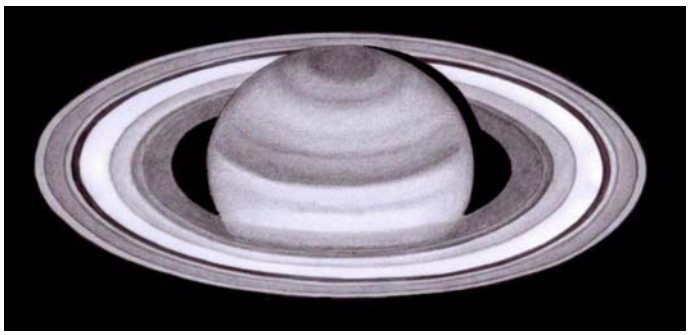

Figure 10. 2002 Feb 28d 18:20UT, 410mm DK Cass., ×410, ω_1= 081°, ω_2= 028°, drawing by *R. J. McKim*. Note the Encke Gap and other minor ring subdivisions.

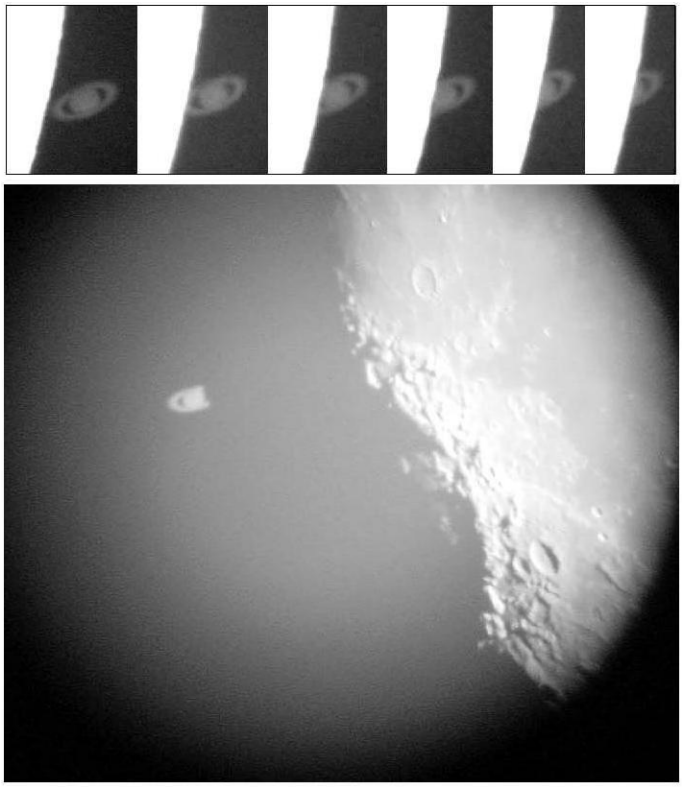

Figure 11. Occultation of Saturn by the Moon, 2001 Nov 3. *Top:* part of an image sequence taken through high altitude cloud showing the disappearance at the sunlit limb, 21:03:14 to 21:04:06 UT; *bottom*, the reappearance at the dark limb, 22:01:38 UT. 305mm SCT and small consumer-level digital camera, *H. W. McGee*.

Shadows and the Terby White Spot

During 2001–'02 the illusion of the Terby White Spot (TWS) adjacent to the ShGR was quite noticeable. Thus on Nov 26 the writer could hardly miss seeing the TWS, while on Dec 1, a few days prior to opposition, he had the illusion of a TWS on both sides of the ball. Heath received an identical impression on both Dec 1 and 8, opposition having occurred on Dec 3. Further from opposition Heath often saw the TWS, on one side only. The illusion arises from the strong contrast between ring B1 and the darkened limb of the planet or ShGR. H. M. Johnson's classic paper[11] is still of much interest.

The shadow of the rings on the globe (ShRG) was often hidden by the rings. During Sep 15–20 Grafton's images resolved a portion of it through ring C crossing the globe (C_m) on the *f.* side only.

Bicoloured aspect of the rings

Positive sightings of the so-called bicoloured aspect of the rings – a phenomenon reported since the 1940s – were reported by three visual ALPO observers.[5] The bicoloured effect has been discussed by Dobbins *et al.*[12–14] These authors have described how it was apparent upon an image by Di Sciullo taken at this opposition (Jan 20) after colour enhancement (note that Figure 8 illustrates that image without enhancement). Venable[15] considered that optical effects could adequately account for the colour anomaly on this date. It is an established fact that some visual observers have shown a particular susceptibility to detecting the bicoloured aspect, whereas most have never suspected it. Venable[16] has set out his case that the classic bicoloured aspect is a purely visual phenomenon which the Stiles–Crawford Effect (an off-axis effect within the human eye which is more pronounced at short wavelengths) and/or vignetting could account for.

Of the BAA observers, Heath, who had made positive sightings in the past, did not notice the bicoloured effect this apparition: he looked for it specifically on five dates only, between Dec 1–Jan 20. No positive sightings were made by others.

The azimuthal (or 'quadripole') brightness variation within the rings (which does not involve colour differences) was well-established many years ago by photography.

The satellites

Observations of occultations of Titan and the other satellites by the Moon could be made, as noted in the following section.

Occultations by the Moon

During the apparition there were several occultations by the Moon (Figures 11–14). Graham illustrated some of these in the *Journal*.[17]

2001 Sep 10

A superb image of the 2001 Sep 10 event taken with the Mount Wilson 60-inch reflector was published in *Sky & Telescope*.[18] We did not receive any observations of this event, which was not observable from the UK.

2001 Nov 3

Niechoy saw the approach of the planet to the Moon. An image of the occultation by W. D. Leslie appeared in the *Journal*.[19] Beaumont, Graham, James, Joye, McGee (Figure 11), Phelps (with timings) and Mobberley also witnessed the occultation, whose predicted Greenwich timings were from 21:04.6 to 22:02.1 UT.

2001 Dec 1

Foulkes attempted to observe the event (predicted for 02:25.1 to 03:34.9 UT from Greenwich), but was clouded out.

2002 Feb 20

Parker (Figure 12) obtained a fine sequence of images of this event.

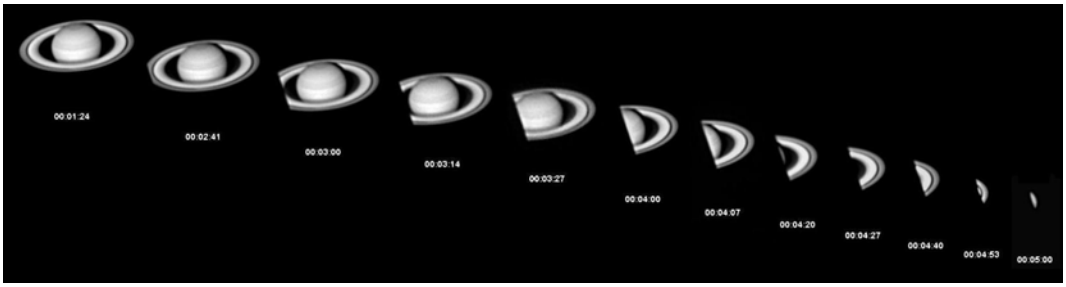

Figure 12. Occultation of Saturn by the Moon, 2002 Feb 20. Image sequence 00:01:24 to 00:05:00 UT, 410mm refl., red 630nm filter, ST9E camera at f/46, *D. C. Parker*.

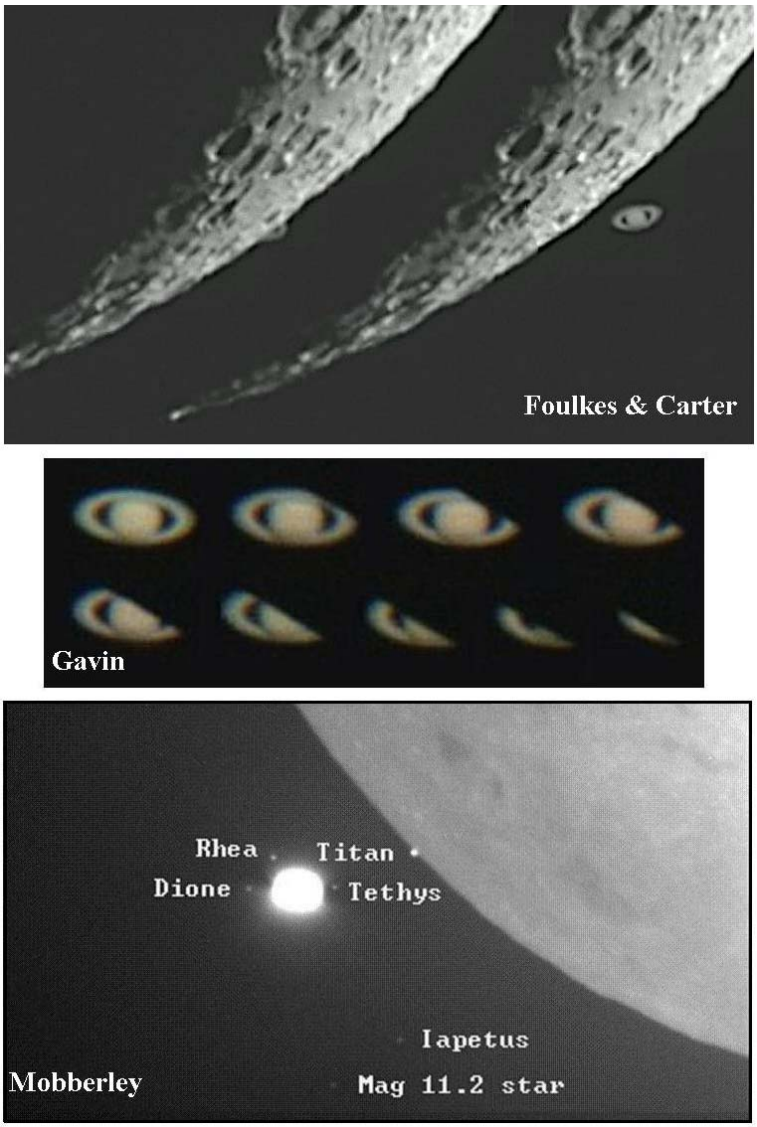

Figure 13. Occultation of Saturn by the Moon, 2002 April 16, observed by *M. Foulkes & P. Carter* (203mm SCT, HX 516 CCD at f/10), *M. V. Gavin* (300mm SCT, Minolta D7 camera) and *M. P. Mobberley* (20:52:00 UT, with the occultation of Titan imminent, 490mm refl., f/4.5, MX916 CCD). North is uppermost.

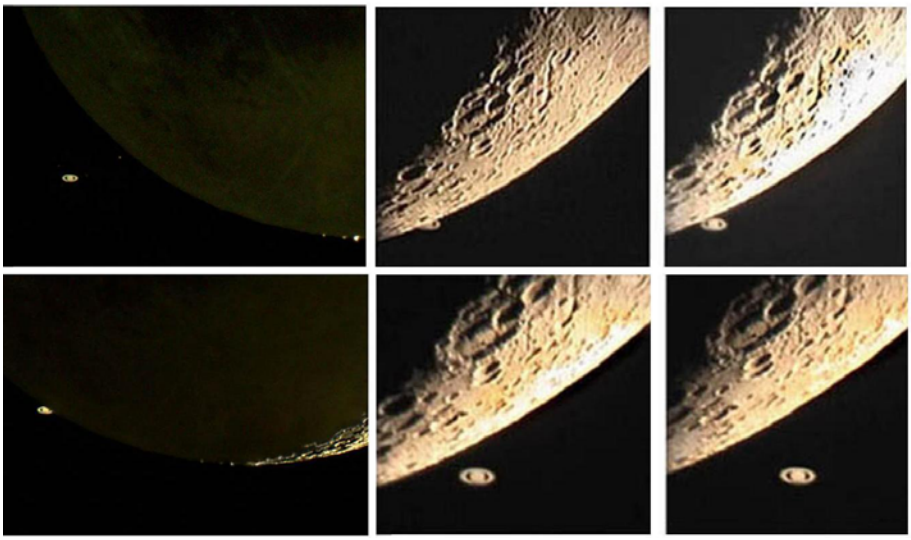

Figure 14. Occultation of Saturn by the Moon, 2002 April 16. *Left:* two images of the disappearance at the dark limb, with Titan about to be occulted in the upper frame; *right:* four images of the reappearance at the sunlit limb, 21:26–21:30UT, 203mm SCT with Nikon 995 digital camera (disappearance) and digital video camera (reappearance), *G. W. Austin*. North is uppermost.

2002 Apr 16

Some images of the 2002 April 16 event (Figure 13) previously appeared in monochrome in the Journal.[17,20] The event was beautifully imaged by Austin (Figure 14) and Hatch, both of whom captured much detail within the lunar Earthshine.[17] Beaumont, Boots & Wooldridge (who submitted precise timings), Foulkes & Carter (Figure 13), Gavin (Figure 13), Graham, Heath, Mobberley (Figure 13), Rogers and Taylor (who submitted precise timings) also saw this event well. The predicted timings for Greenwich were from 21:00.2 to 21:26.0 UT. These observers were also able to watch the occultation of Titan at the dark lunar limb: Mobberley's image illustrates the moment well.

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