Saturn in the 2008/2009 apparition: Part I

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This report describes the observations of Saturn made by Saturn Section members during the 2008/2009 apparition. During this apparition, the rings were edge-on to the Sun and Earth on 2009 Aug 11 and Sep 4 respectively. The former event was difficult and the latter impossible to observe from the Earth as both occurred close to solar conjunction on Sep 17. During the apparition both major belts were visible and observations showed that the North Equatorial Belt (NEB) had a noticeable blue colour compared to the warm colour of the South Equatorial Belt. A number of storms were observed during this apparition and four of these were reliably followed. Evidence is also presented that shows that one SEBZ storm had lasted over at least three apparitions. Observations of a number of satellite and shadow transits and Titan eclipses will be presented in Part II of the paper.

Introduction

After solar conjunction on 2008 Sep 4 at 02h UT,[1] Saturn reached its first stationary point on 2009 Jan 1 at 20h UT. Opposition occurred on 2009 Mar 8 at 20h UT[2,3] in the constellation of Leo, just to the north of the star Sigma Leonis. At opposition, Saturn's apparent magnitude was +0.5, its apparent equatorial diameter was 19".8 and the apparent major axis of the rings was 44".9.

The planet reached its second stationary point on 2009 May 17 at 19h UT and was in conjunction with the Sun again on 2009 Sept 17 at 18h UT.[2,3] 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.

The ring inclination with respect to the Earth reached a minimum of just less than –0.8° at the end of Dec. This gave the best opportunity for observers to see the rings when very narrow. At opposition the ring inclination with respect to the Earth was –2.6°.

The inclination reached a maximum of approximately –4.15° in mid-May before decreasing again to the edge-on phase. The rings were edge-on to the Sun on Aug 11 and edge-on to the Earth on Sep 4.

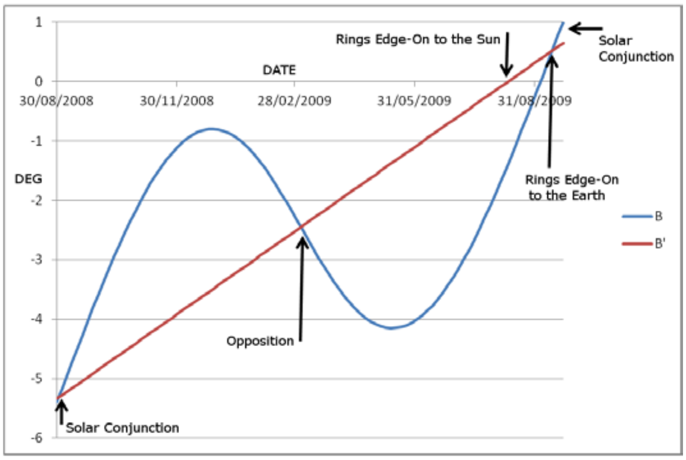

Figure 1. The variations in Saturn's polar and ring inclination as seen from the Earth (parameter B or D_E as used in recent BAA *Handbooks*) and from the Sun (parameter B') during the 2008/2009 apparition. Negative values indicate that the South Pole and rings were inclined towards the Earth and the Sun. Key dates, such as opposition, are indicated by vertical arrows.

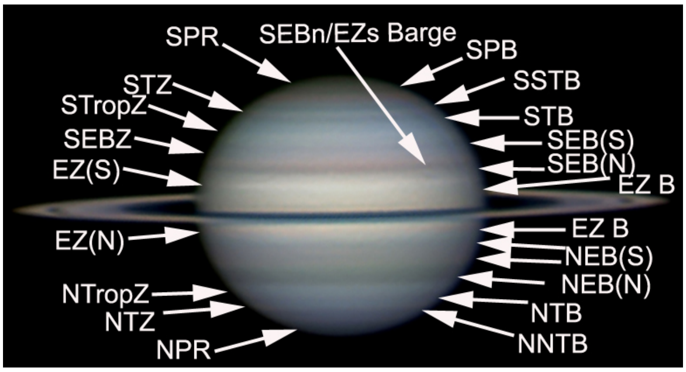

Figure 2. Belt and zone nomenclature used in this report. This figure is based on an image taken by Lawrence on 2009 Mar 16, 23h 47m, CM1= 318.6, CM2= 309.3, CM3=148.0. This image also shows the reddish coloured SEBn/EZs barge as indicated.

Observations

Those who contributed visual observations and those who contributed digital observations are listed in Tables 1 and 2 respectively.

The first observation of the apparition was made on 2008 Oct 18 (Maxson) and the final observation was made on 2009 Aug 14 (Akutsu). As in previous apparitions, a wide range of apertures and telescope types was used. Many instruments were in excess of 300mm. Schmidt–Cassegrain telescopes were again popular amongst those who took images. Although medium to large apertures were mainly used for imaging, Meadows was able to image the major features using a 105mm aperture Maksutov. Hill was also able to image the major features plus Titan's shadow in transit (see Part II). The author was also able to use the Faulkes remote telescope on Hawaii (Figure 20).

Most images were taken using webcams or high speed USB 2.0 cameras by Lumenera or DMK. However Bailey experimented with imaging the planet using a DXLeica8 fixed lens camera with eyepiece projection. The major features were recorded both with single frames and stacked frames.

The *WinJUPOS* software[4] was again used to derive spot longitudes, average spot drifts and belt latitudes. These positions plus visual central meridian transits are stored in a *WinJUPOS* database which has been created for Saturn Section observations.

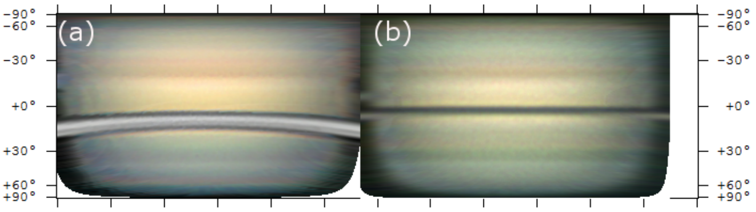

Figure 3. A comparison of the latitudes of the northern hemisphere belts during the 2007/2008 and 2008/2009 apparitions, as described in the text. Two typical images from these apparitions have been made into a cylindrical projection map using the *WinJUPOS* software. Positive values indicate northern latitudes and negative values show southern latitudes.
(a). 2008 Feb 12, 14h 10m UT. CM1= 199.9, CM2= 98.9, CM3= 58.1. *(Wesley)*
(b). 2009 Mar 27, 12h 49m UT. CM1= 220.6, CM2= 230.8, CM3= 56.7. *(Buda)*

Nomenclature and terminology

The belt/zone nomenclature used in this report is shown in Figure 2. This report also uses the abbreviations and terminology used in recent apparition reports. All drawings and images shown in this report are oriented with south upwards and with the preceding (*p.*) edge to the left except for Figure 28 in Part II. This is the orientation seen in an inverting telescope from the northern hemisphere. Planetographic latitudes are used unless otherwise stated.

Latitudes

A number of the best colour images were measured using the *WinJUPOS* software to derive the average latitudes of the edges of the belts during the apparition. The results are shown in Table 3, which gives the average planetographic and the average planetocentric latitudes plus the standard deviations of the measurements.

The edges of some belts were indistinct even in the best images. In these cases, the measurement process was more difficult to undertake and this factor probably contributed to the scatter of the measurements. Further, the results shown in Table 3 do not account for any measurer bias. It is therefore possible that the variation in latitude measurements may be greater than the quoted standard deviations.

No obvious variations in the latitude of any belt were detected during the period covered by this report but the scatter in the measurements could hide small variations.

The structure and derived latitudes of the southern hemisphere major belts were similar to that recorded during the 2007/2008 apparition[5] although the SEB(N) did not exhibit a noticeable double structure. For example, the latitudes of the northern and southern edges of the SEB over the two apparitions are compared in Table 4.

At higher latitudes, the scatter in the measurements was expected to be greater but even the latitudes derived for the higher latitude southern hemisphere belts showed good agreement over these two apparitions. In contrast, the derived latitudes for the northern hemisphere belts show some differences as illustrated in Figure 3 and shown graphically in Figure 4.

Table 1. Visual observers, 2008/2009

Observer	*Location*	*Telescope**
Abel, Paul G.	Leicester	150mm Newt & 203mm Newt
Adamoli, Gianluigi	Verona, Italy	235mm SCT & 125mm Mak
Brook, Clive	Plymouth, Devon	127mm OG
Colombo, Emilio	Cambio, Italy	150mm Newt
Foulkes, Mike	(See Table 2)	(See Table 2)
Graham, David	Richmond, N. Yorks.	150mm OG & 230mm Mak
Gray, David	Kirk Merrington, Co. Durham	415mm DK
Heath, Alan	Long Eaton, Notts.	203mm SCT & 250mm Newt
Leatherbarrow, Bill	Sheffield	235mm SCT
Line, Ray	Wellingborough, Northants.	212mm Newt
McKim, Richard	Upper Benefield, Northants.	410mm DK
Orr, Adrian	Pickering, N. Yorks.	250mm SCT
Phelps, Ian	Warrington, Cheshire	215mm Newt
Robertson, Andrew	Broome, S. Norfolk	305mm Mewlon

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

Table 2. Photographic & digital imaging observers, 2008/2009

Observer	*Location*	*Telescope**	*Camera*	*Filters (IR Blocking +)*
Arditti, David	Edgeware, Middlesex	356mm SCT	Luminera Skynyx 2.0	RGB, Baader UV (320–390nm)
Akutsu, Tomio	Cebu, Philippines	356mm SCT	DMK21AU04	RGB, UV (Shuler), IR (800nm), Methane (893nm)
Bailey, Kevin	Swindon	254mm Newt	DXLeica8	–
Barry, Trevor	Broken Hill, Australia	406mm Newt	DMK21AU04	RGB
Buda, Stefan	Melbourne, Australia	405mm DK	DMK21AU04	RGB
Casquinha, Paolo	Palmela, Portugal	356mm SCT	Skynyx 2.0M	RGB
Castellà, Jaume	Badalona, Spain	280mm SCT	DMK21F04AS	RE, G, B, IR
Edwards, Peter	Horsham, West Sussex	279mm SCT	Modified ToUcam Pro	RGB
Foulkes, Mike	Henlow, Beds. Haleakala, Hawaii, USA (Faulkes Telescope N.)	203mm SCT 2000mm R–C	DMK21AU04	RGB, IR(>685nm)
Friedman, Alan	Buffalo, NY, USA	250mm Mak	DMK218F04	–
Go, Chris	Cebu City, Philippines	280mm SCT	DMK218F04	–
Hill, Rik	Tucson, Arizona, USA	90mm Mak	SPC900NC	–
Kidd, Simon	Welwyn, Herts.	356mm SCT	Skynyx 2.0	RGB
Lawrence, Peter	Selsey, West Sussex	356mm SCT	Skynyx 2.0M	RGB
Leatherbarrow, Bill	Sheffield	235mm SCT	DMK21AU04	–
Lewis, Martin	St. Albans, Herts.	222mm Newt	DMK21AF04.AS	–
Maxson, Paul	Surprise, Arizona, USA	25mm Mak	DMK21AU04	–
Meadows, Peter	Chelmsford, Essex,	105mm Mak	DMK21AU04	–
Meredith, Cliff	Prestwich, Manchester	203mm SCT	ToUcam Pro	–
Mobberley, Martin	Cockfield, Suffolk	300mm SCT	LU075M	RGB
Peach, Damian	Loudwater, Bucks.	235mm & 356mm SCT	Skynyx 2.0M	RGB, IR (889nm)
Phillips, Jim	Charleston, SC, USA	254mm OG	DMK21AU04	RGB
Pratt, Alex	Leeds	200mm Mak	ToUcam Pro	–
Sampson, Ed	Goring by Sea, West Sussex	300mm Newt	DMK21	RGB
Salway, Mike	Central Coast, NSW, Aust.	300mm Newt	DMK21AU04	RGB
Sharp, Ian	Ham, West Sussex	280mm SCT	Skynyx 2-0M	RGB
Sussenbach, John	Houten, The Netherlands	280mm SCT	ATK 2HS, Vesta, DMK21AU04	RGB
Tyler, David	High Wycombe, Bucks.	356mm SCT	Skynyx 2.0M	RGB
Wesley, Anthony	Murrumbateman, Australia	333mm Newt	Skynyx 2.0M	RGB

*Cass= Cassegrain; DK= Dall–Kirkham Cassegrain; Mak= Maksutov; Newt= Newtonian; OG= Refractor; R–C= Ritchey–Chrétien; SCT= Schmidt–Cassegrain

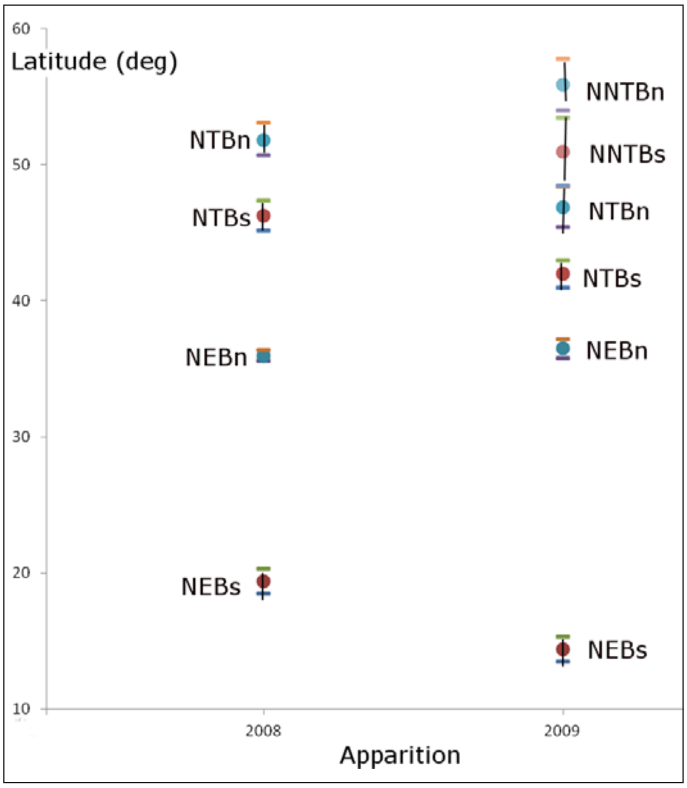

Figure 4. A comparison of the planetographic latitudes of the major belt edges in the northern hemisphere for the 2007/2008 and 2008/2009 apparitions. The error bars of the latitude measurements are shown. The results are discussed in the text.

Table 4. Comparison of the planetographic latitudes of the SEBs and SEBn for the 2007/2008 and 2008/2009 apparitions

	2007/2008	*2008/2009*
SEBs	35.4°S ± 1.0° (1σ)	35.5°S ± 1.2° (1σ)
SEBn	19.0°S ± 0.8° (1σ)	18.8°S ± 0.7° (1σ)

During both of these apparitions, the major belt observed in the northern hemisphere was designated as the NEB and this showed a double structure. As can be seen in Figures 3 and 4, the latitudes of the northern edge of this belt (the NEBn) were consistent between the two apparitions allowing for measurement errors.

During the 2007/2008 apparition (Figure 3(a)), a bright zone (assumed to be part of the EZ) was visible to the south of what was designated as the NEBs. The southern edge of this zone was limited either by the northern edge of the SH R on G or the northern edge of the projection of the rings onto the planet. Around the time of opposition, this limiting edge corresponded to a planetographic latitude of approximately 14°N.

However the latitudes covered by this bright zone were darker in the 2008/2009 apparition as shown in Figure 3(b) and formed part of what has been assumed to be the NEB(S). The southern edge of this was now at a latitude of 14.4°N ± 0.9°. Consequently there have been some changes in this region over the two apparitions with an expansion of the darker NEB material further south.

These changes were not limited to the NEB. During the 2007/2008 apparition a closely double NTB was observed. This spanned the latitudes of the belts designated as the NTB and NNTB during the 2008/2009 apparition as shown in Figure 4.

Table 3. Latitudes of the belts, 2008/2009

Belt	*Measured planetographic latitudes (°)* *Average planetographic latitude*	*No. of measurements*	*Std dev. (°)*	*Derived average planetocentric latitudes (°)*
SPRn	68.7S	12	4.1	63.9S
SPBs	67.3S	6	0.8	62.3S
SPBn	61.3S	19	1.7	55.5S
SSTBs	56.7S	25	1.4	50.5S
SSTBn	52.6S	25	0,9	46.2S
STB(S)s	48.0S	25	0.9	41.5S
STB(S)n	45.2S	18	0.8	38.8S
STB(N)s	42.9S	11	1.1	36.5S
STB(N)n	40.8S	17	0.7	34.5S
SEB(S) southern component s. edge	35.5S	25	1.2	29.6S
SEB(S) southern component n. edge	34.4S	5	1.9	28.6S
SEB(S) northern component s. edge	31.5S	6	1.8	26.0S
SEB(S) northern component n. edge	29.9S	23	1.3	24.6S
SEB(N) southern component s. edge	23.6S	25	1.3	19.2S
SEB(N) northern component n. edge	18.8S	25	0.7	15.2S
C. of narrow belt in the southern EZ	15.9S	18	0.6	12.8S
EBs	10.1S	22	1.0	8.1S
EB northern component s. edge	5.6S	6	1.6	4.5S
EB northern component n. edge	2.9S	10	0.6	2.3S
C. of N EZ belt	9.8N	18	1.0	7.8N
NEB(S) s. component s. edge	14.4N	25	0.9	11.6N
NEB(S) s. component n. edge	18.2N	16	0.9	14.7N
NEB(S) n. component s. edge	21.3N	7	0.8	17.3N
NEB(S) n. component n. edge	22.5N	17	1.5	18.3N
NEB(N) northern component s. edge	28.4N	25	1.0	23.3N
NEB(N) northern component n. edge	36.5N	25	0.7	30.5N
NTBs	42.0N	20	1.0	35.7N
NTBn	46.9N	13	1.5	40.4N
NNNTBs	51.0N	18	2.5	44.6N
NNNTBn	55.9N	16	1.9	49.7N
NPRs	61.8N	12	1.5	56.1N

Latitude measurements were made from images taken by Akutsu, Arditti, Buda, Casquinha, Go, Lawrence, Peach and Wesley over the period from 2008 Dec 7 until 2009 May 21. Standard deviations are given to one decimal place.

Visual intensity and colour observations

Table 5 shows the average visual intensity estimates for the belts and zones made during the apparition. No colour filters were used for these observations. Gray made an extensive set of visual observations.

For each belt or zone, this table gives the average value derived by each observer plus the overall average based on all observations. There is some scatter in the observations but these qualitative estimates indicate that the SEB(N) was a darker belt than the NEB(N). The EZ(S) was the brightest zone. Adamoli, Gray, Line and McKim never observed Cassini's Division to be black (intensity 10).

Many observers provided images taken with red, green and blue filters and several were able to image the planet using infrared filters. Akutsu and Peach imaged the planet with methane filters (893nm and 889nm respectively). Akutsu also provided images taken using ultraviolet filters. The typical appearance of the planet with this range of filters is shown in Figure 5.

Visual colour estimates of the belts and zones are shown in Table 6. This table also gives a visual as-

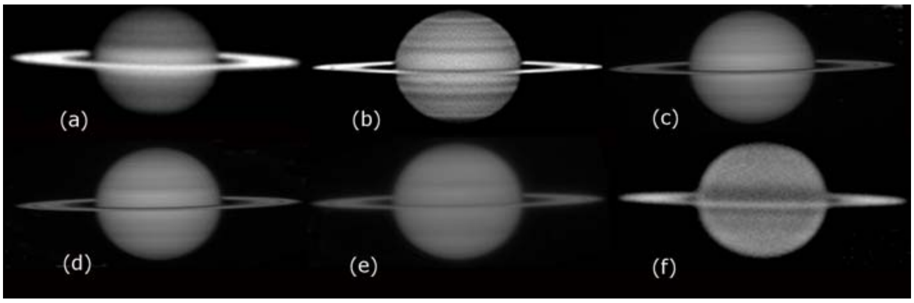

Figure 5. Typical images of Saturn during 2008/2009 taken in different wavelengths.
(a). 2009 Apr 1, 21h 20m UT. CM1= 65.02, CM2= 171.7, CM3= 71.4. *(889nm, Peach)*
(b). 2009 Mar 7,14h 46m UT. CM1= 325.9, CM2= 168.9, CM3= 99.1. *(800nm, Akutsu)*
(c). 2009 Mar 17, 00h 08m UT. CM1= 334.5, CM2= 234.2, CM3= 153.1. *(Red, Lawrence)*
(d). 2009 Mar 17, 00h 08m UT. CM1= 334.5, CM2= 234.2, CM3= 153.1. *(Green, Lawrence)*
(e). 2009 Mar 17, 00h 08m UT. CM1= 334.5, CM2= 234.2, CM3= 153.1. *(Blue, Lawrence)*
(f). 2009 Mar 7, 15h 12m UT. CM1= 341.1, CM2= 183.5, CM3= 113.7. *(UV, Akutsu)*

sessment by the author of the colours shown in the colour images.

The SEB had a warm colour with the SEB(S) appearing as warm grey or light brown and the SEB(N) having a distinct warm or orangey brown colour. The SEB(N) appeared pale in red light images compared with blue light (Figures 5(c) and 5(e) respectively) thus confirming the warm colour.

This contrasted with the cold tone of the major components of the NEB and related NEBZ. A greenish or bluish colour was often recorded for the NEB(N) in the colour images. The NEB (especially the NEB(N)) appeared darker in red light images compared with blue light images (Figures 5(c) and 5(e) respectively) confirming this bluish colour.

Table 6 shows that there was disparity between some observers in the colour estimates of some features although the colour contrast between the SEB and NEB was sometimes noted. In a number of high resolution images, the SSTZ appeared reddish (e.g. as shown in Figures 2, 3, 6 and 13).

In 889nm filter images, the planet appeared dark although the EZ (both northern and southern halves) appeared bright and both the NEB and SEB were visible. In addition, the rings appeared bright and were visible where projected against the planet's disk.

At 800nm, the major belts and zones were visible with the NEB(N) being the most prominent belt. The NEB(S), SEB(N) and the SSTB were also prominent. Both polar regions were dark. The rings were

Table 5. Average visual intensity estimates, 2008/2009

Observer	*Abel*	*Adamoli*	*Colombo*	*Gray*	*Heath*	*Line*	*McKim*	*Apparition average (all obs.)*	*Total no. of obs.*
Dates	2008 Dec 7 to 2009 Jun 3	2008 Dec 9 to 2009 Aug 5	2009 May 1 to 2009 Jul 19	2008 Oct 8 to 2009 Jun 1	2009 Feb 11 to 2009 Jun 3	2008 Nov 25 to 2009 May 9	2009 Feb 13 to 2009 May 18		
The planet									
SPR Cap				5.4 (41)			5.0 (2)	5.4	43
SPR	4.5 (18)	4.5(16)	3.4 (4)	4.3 (42)	2.8 (10)	2.9 (7)	4.3 (10)	4.1	107
SPB	4.4 (3)			5.3 (42)			4.8 (9)	5.2	54
SSTZ	3.5 (13)			3.5 (42)				3.5	55
SSTB	3.9 (15)			4.9 (42)			4.5 (1)	4.6	58
STZ	2.9 (18)	2.2 (14)	3.1 (4)	2.8 (42)			3.2 (7)	2.8	45
STB	4 (18)	4.2(3)					4.5 (5)	4.1	23
STropZ	2.1 (18)	2.3 (10)	3.1 (4)	2.8 (42)		2.9 (4)	3.2 (11)	2.6	95
SEB(S)	5.2 (18)	4.6 (16)		5.0 (42)		3.8 (5)	4.8 (12)	4.9	93
SEBZ	1.7 (6)	4.6 (15)		4.2 (42)		3.0 (2)	3.4 (11)	3.9	76
SEB(N)	5.9 (18)	4.6 (16)	3.2 (4)	5.7 (42)	4.9 (10)	3.7 (7)	5.5 (12)	5.3	109
EZ(S)	0.5 (18)	1.1 (16)	2.3 (3)	1.6 (42)	1.6 (10)	2.1 (7)	1.6 (12)	1.4	108
EB	1.7 (5)			3.0 (42)			3.4 (9)	2.9	56
EZ(N)	1.2 (18)	2.2 (16)		1.7 (42)	2.0 (10)	2.0 (2)	2.1 (11)	1.8	99
NEB(S)	4.7 (18)	3.9 (8)		4.4 (41)		2.9 (4)	4.5 (11)	4.4	82
NEBZ	1.9 (18)	3.7(5)		3.4 (42)			3.5 (10)	3.1	75
NEB(N)	5.5 (18)	4.5 (16)	2.2 (4)	6.0 (42)	4.0 (10)	3.7 (5)	5.1 (12)	5.2	107
NTropZ	2.8 (18)	2.3 (16)	3 (4)	2.9 (42)		3.0 (1)	3.6 (11)	2.9	92
NTB	3.9 (14)			4.5 (42)				4.4	56
NTZ	3.1 (13)	2.3 (14)		3.5 (42)			3.6 (10)	3.2	79
NNTB				6.5 (42)			4.5 (1)	6.5	43
NPR	4.3 (18)	4.5 (14)	3.1 (4)	5.8 (42)	3.4 (10)	3.1 (6)	4.2 (4.2	4.7	105
The rings and shadows									
Ring A1							3.6 (2)	3.6	2
Ring A2							3.1 (2)	3.1	2
Ring A		5.9 (13)	5.8 (4)	4.9 (32)	3.0 (3)	1.0 (1)	3.0 (10)	4.7	63
Cassini's Divn		8.8 (9)		6.4 (30)	10.0 (2)	8.3 (7)	6.3 (12)	7.1	60
Ring B1		4.4 (13)	5.6 (4)	3.5 (33)	4.0 (3)	1.1 (7)	1.8 (12)	3.3	72
Ring B2				4.2 (33)			2.9 (12)	3.9	45
Ring B3							3.0 (1)	3.0	1
Ring C		6.7 (5)	5 (1)	6.8 (26)	3.0 (2)		4.2 (10)	6.0	44
Ring C(M)				5.9 (15)			8.0 (6)	6.5	21
SH G on R		9.8 (5)	10 (3)		10.0 (2)		10.0 (4)	9.90	14
SH R on G		7.7 (16)	9 (2)	8.6 (39)	7.9 (8)		9.8 (5)	8.4	70

Intensities are made on the scale: 0= bright white, 10= black. The number of observations made by each observer is shown in ( ).
Gray recorded different apparition averages for the *p*. and *f*. side of ring A (4.7 and 5.1 respectively). The overall average is shown in the above table.
McKim gave intensity estimates for ring A1 and A2. These are shown separately from the overall Ring A averages in the above table.
Colombo and Heath gave intensities only for the SEB as a whole and NEB as a whole. These have been allocated to the SEB(N) and NEB(N) respectively.

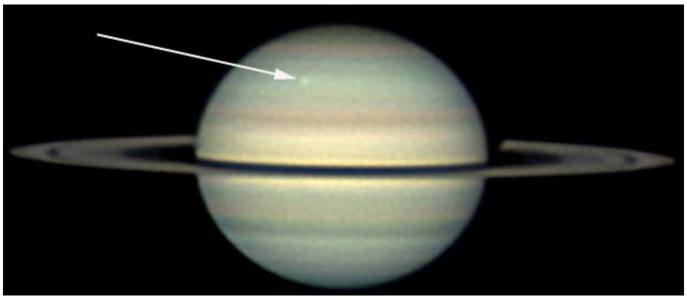

Figure 6. 2009 Apr 12, 11h 02m UT. CM1= 347.0, CM2= 202.8., CM3= 9.5 *(Image by Buda)*. Shows the STB(N) white spot no 1, *p.* the CM (arrowed).

bright with Ring A and B having equal brightness.

In red light images, the STB(S) was dark as was the SSTB. The EZ(S) appeared slightly brighter than the EZ(N).

In green light images, the major belts were also visible with the darkest being the SEB(N) followed by the NEB(N). As in red light images, the EZ(S) was brighter than the EZ(N) and the NTropZ was also prominent. The belt structure was less prominent in blue light images with the SEB(N) being the most prominent followed by the NEB(N).

In UV images, the disk appeared almost featureless. The EZ(N) and EZ(S) appeared dark with a shading at the position of the NEB(N). The rings appeared prominent.

The planet

South Polar Region (SPR)

This region was seen obliquely throughout the apparition.

The maximum inclination of the South Pole with respect to the Earth only reached just over 4.1° during mid-May but this was after opposition. Consequently the detection of detail close to this pole was more difficult than in recent apparitions.

The typical appearance of the high southern latitude regions is shown in various figures of this report.

Low-resolution observations showed a large dark grey region around the pole with its northern boundary marked by a dark belt. This has been designated as the SPR Band (SPB). High-resolution observations showed this to be separated from the true SPR by a lighter zone.

South South Temperate Regions

The SPB and the South South Temperate Belt (SSTB) were separated by a light zone (SSTZ) which, as noted earlier, often showed

Table 6. Colour estimates, 2008/2009

Observer	*Abel*	*Adamoli*	*Colombo*	*McKim*	*Colour from digital images assessed by the author*
Dates	2008 Dec 7 to 2009 Jun 3	2008 Dec 9 to 2009 Aug 5	2009 May 1 to 2009 Jul 19	2009 Feb 13 to 2009 May 18	
The planet					
SPR Cap					
SPR	Grey	Grey or grey brown			Dark grey
SPB					
SSTZ	Grey-yellow				Warm or reddish colour in high resolution colour images
SSTB	Grey-brown				Grey or grey brown
STZ	Light greyish yellow	Yellow or yellow grey		Slightly yellowish	Light grey or pale yellow
STB	Light brown				Grey
STropZ	Greenish yellow	Yellow or yellow white		Slightly yellowish	Greenish tinge
SEB(S)	Light brown	Brown, greyish brown or orange brown*	Orange grey or grey	Orange brown	Warm grey or light brown
SEBZ	Greyish yellow		Orange grey or grey		Light grey or warm grey
SEB(N)	Dark brown		Orange grey or grey	Orange brown	Warm brown
EZ(S)	Pale yellow	Yellow or yellowish white	Orange grey or grey	Yellow	Cream or yellow
EB	Grey				Grey
EZ(N)	Yellow	Yellow or yellowish white		Pale yellow or grey	Light grey or pale yellow
NEB(S)	Light blue	Grey or grey brown	Orange grey or grey	Pale orange brown	Grey or warm grey
NEBZ	Greenish yellow	Grey or grey brown	Orange grey or grey		Greenish tinge or grey
NEB(N)	Blue /purple	Grey or grey brown	Orange grey or grey	Orange brown	Green
NTropZ	Greenish yellow	Yellow or white	Greyish yellow	Yellowish or bluish/ greenish grey	Grey or bluish grey
NTB	Greyish brown				Grey
NTZ	Greyish yellow	Yellow or yellow white	Greyish yellow	Yellowish or bluish/ greenish grey	Grey or bluish grey
NPR	Grey	Grey or blue grey			Grey
The rings and shadows					
Ring A		Grey or yellow	Dark grey		
Cassini's Divn.		Black	Black		
Ring B		White or greyish yellow			
Ring C		Grey			
SH G on R		Black	Black		
SH R on G		Black or grey	Black		

* *The SEB(S), SEB(Z) & SEB(N) were seen as one single belt.*

a reddish colouration in high resolution colour observations. It also appeared bright in red light images.

The SSTB often appeared as slightly darker than the southern component of the STB although both belts had a similar colour. The SSTB generally appeared single but some higher resolution images indicated a double structure with the south component slightly fainter.

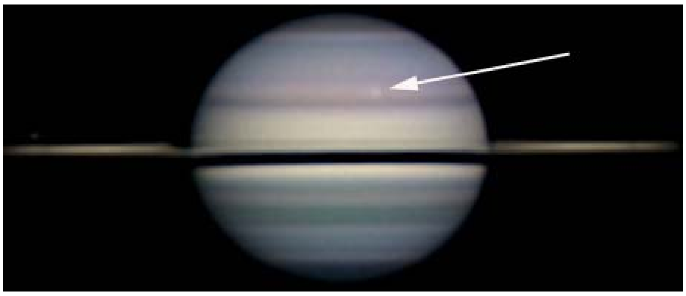

Figure 8. 2008 Dec 22, 05h 09m UT. CM1= 14.9, CM2= 224.0., CM3= 164.9. *(Image by Casquinha)*. Shows the SEBZ white spot no.1 (arrowed) approaching the CM.

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

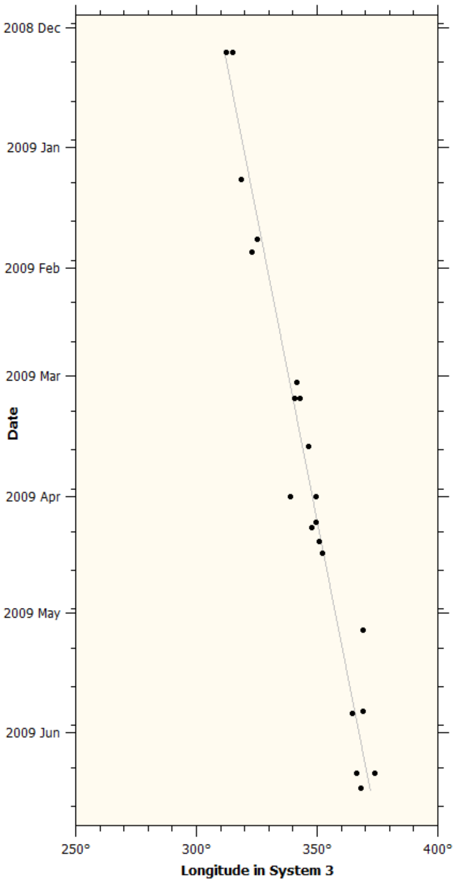

Figure 7. Drift chart for the centre of bright spot STB(N) no.1 in System 3 for 2008/2009. The positions (shown as dots) have been derived from images taken by Akutsu, Arditti, Barry, Buda, Foulkes, Go, Maxson, & Peach, plus measurement of a drawing by Gray. The solid line represents the average drift derived from these observations.

A light STZ separated the STB and SSTB. Peach recorded a single light spot in this zone on Mar 1 (Figure 17(e)).

The STB was double with the southern component appearing darker with a warm grey colour. The northern component was fainter and generally appeared grey.

The most significant feature of this region was a bright storm designated as STB(N) no.1. This appeared as a bright spot in amateur instruments. Typical observations of this spot are shown in Figures 6 and 16(a). This spot stretched from the northern edge of the STB(S), across the STB(N) and into the STropZ.

The drift chart (longitude vs time) is shown in Figure 7. Table 7 gives its derived average drift, latitude, size and dates when observed. It was visible in many colour images and also those taken only in red light. It was slightly less prominent in green light images but was not detected in any blue light images. It was only seen visually by Gray.

Some variation in intensity was suspected during this apparition but this variation could also have been due to seeing effects.

This spot generally appeared circular in most observations. However images taken by Maxson on Apr 19, Peach on May 26 and Wesley during June show that the storm had expanded to over 10° in longitude. This increase in size probably explains the uncertainty in the average longitudinal extent shown in Table 7.

On Mar 6, a high resolution red light image taken by Wesley showed a smaller bright spot immediately *f.* of this spot on the STB(S). Observations over the last few apparitions have shown that the latitude of this spot is prone to such bright storms. For example during the 2007/2008 apparition,[5] two such spots were detected but there is no evidence that they survived into this apparition. The rotation periods of these two spots were slightly longer than that of the spot observed during this apparition.

Bright spots observed at this latitude during previous apparitions have also been associated with Saturn Electrostatic Disturbances (SEDs). Ref 6 shows that this spot was also associated with a long duration SED.

South Tropical Zone (STropZ)

This was a bright zone and the main feature of this region was STB(N) spot no. 1, described above.

South Equatorial Belt (SEB)

Table 7. Longitudes and drifts for the STB(N) & SEBZ

	STB(N)	*SEBZ*
Spot no.	1	1
Description	White Spot STB(N)	White Spot SEBZ
Planetographic latitude (°)	40.8S±1.3(1σ)	28.1S±1.12(1σ)
L3 (0)	340.5±1.0(1σ)	7.4±0.8(1σ)
DL3 per day	+0.32±0.02(1σ)	−7.0097±0.17(1σ)
DL3 per 30 days	+9.6±0.6(1σ)	−210.03±0.52(1σ)
Rotation period	10h 39m 38.0s±1.0(1σ)	0h 33m 53.583±0.81(1σ)
Dates	2008 Dec 7 to 2009 Jun 15	2008 Dec 7 to 2009 May 5
No of obs. for drift	21	20
Avge extent in longitude (°)	6.9±2.0(1σ)	5.0±1.2(1σ)
No of obs. for avge extent	14	13

L3(0) is the System 3 longitude at opposition on 2008 March 8.
() indicate the estimated opposition longitude for any spot not observed at opposition.
DL3 per day is the drift relative to System 3 in degrees of longitude per day.
DL3 per 30 days is the drift relative to System 3 in degrees of longitude per 30 days.

This belt was noticeably double, separated by a bright zone (the SEBZ). Both components were visible in relatively small telescopes.

The northern component was darker than the southern component and was one of the darkest belts visible. The colours of this belt have been described earlier in this report.

Higher resolution observations particularly by Go and Peach also showed the SEB(S) to be double.

Gray sometimes recorded some darker segments on the SEB(S). Two dark segments were also recorded on the SEB(S) in images by Go. However these observations were scattered, so it was impossible to establish if any of these segments lasted for any extended period of time.

The most interesting feature in this region was a bright storm which appeared as a small bright spot in the SEBZ (designated

SEBZ spot no. 1). This was only recorded in images and was not detected visually. Typical observations are shown in Figures 8, 11, 13 and 16(a). Table 7 also gives the latitude, drift rate and size of this spot.

This spot showed a rapid negative drift with respect to System 3 and Figure 9 shows the drift chart for this spot in a modified longitude system based on its average drift of −7.0097 °/day with respect to System 3.

This spot was observed up to May 5. However it is possible that it may have been visible as late as July 8, as a light spot was suspected in this region on an image taken by Wesley, several degrees from the predicted track shown in Figure 9. As this was only suspected this longitude has not been used in the main analysis or shown in Figure 9.

Similar single bright spots were observed at a similar latitude during each of the two previous apparitions.[5,7] In the 2007/2008 report,[5] it was suggested that as the extrapolated track of the 2006/2007 spot lay close to the track of the 2007/2008 spot, it was possible that these spots may have been a single object.

This is explored further in Figure 10, which is an extension of Figure 9 to also include the longitude positions of the 2006/2007 and 2007/2008 spots. The extrapolated track of the 2006/2007 spot extends close to the beginning of the track of 2007/2008 spot (9°.6). Further, the extrapolated track of the 2007/2008 spot extends close to the beginning of the track of the 2008/2009 spot (7°.6 higher). This may be explained by some uncertainty in the derived average drift rates coupled with slight changes in the average drift rate between the three apparitions. Further, the average negative drift rate with respect to System 3 of the 2008/2009 spot had reduced slightly compared to the earlier apparitions. The latitudes of all three spots are also in good agreement allowing for measurement errors.

These results show that there was a single spot in this region that lasted over the three apparitions.

Unfortunately there are extensive gaps in the observations for several months around the time of solar conjunction which prevent absolute certainty in this result.

Interestingly some spots were also observed in the SEBZ during the 2005/2006 apparition coupled with a single spot during the 2009/2010 apparition. It will be interesting to see if any of these features lie on or close to the track shown in Figure 10 when the related apparition reports have been completed.

Abel, Gray and McKim sometimes recorded darker segments or mottling on the SEB(N) but none of these objects could be tracked.

Table 8. Longitudes and drifts for the SEBn/EZs & EZ(N)

	SEBn/EZs	*EZ(N)*
Spot no.	1	1
Description	Dark barge SEBn/EZs	EZ(N) bright spot
Planetocentric latitude (°)	16.2S±0.7(1σ)	9.5N±1.3(1σ)
L1(0)	264.9±0.7(1σ)	147.9±0.5(1σ)
DL1 per day	+11.4±0.26(1σ)	+0.9953±0.013(1σ)
DL1 per 30 days	+342.0±0.7.83(1σ)	+29.86±0.388(1σ)
Rotation period	10h 22m 25.2s±1.17(1σ)	10h 14m 3.466s±0.55(1σ)
Dates	2009 Jan 10 to 2009 Apr 4 (May 13)	(2008 Dec 7) 2009 Jan 3 to 2009 Apr 22 (May 19)
No of obs. for drift	23	33
Avge extent in longitude (°)	6.7±1.6 (1ό)	5.0±1.3(1σ)
No of obs. for avge extent	23	23

L1(0) is the System 1 longitude at opposition on 2008 March 8.
() indicate the estimated opposition longitude for any spot not observed at opposition.
DL1 per day is the drift relative to System 1 in degrees of longitude per day.
DL1 per 30 days is the drift relative to System 1 in degrees of longitude per 30 days.

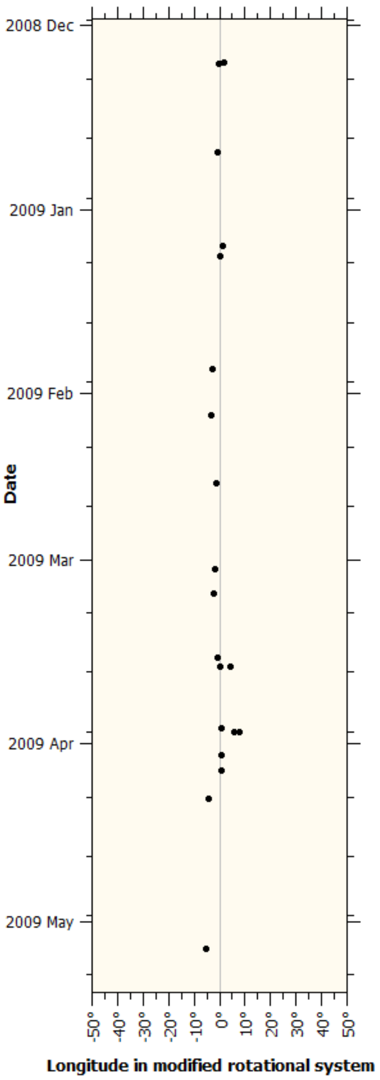

Figure 9. Drift chart for the centre of bright spot SEBZ Spot no.1 during 2008/2009 in a longitude system drifting at −7.0097°/day with respect to System 3. The reference date is opposition. The positions (shown as dots) are derived from images taken by Akutsu, Arditti, Barry, Buda, Casquinha, Go, Peach & Tyler. The solid line represents the average drift derived from these observations.

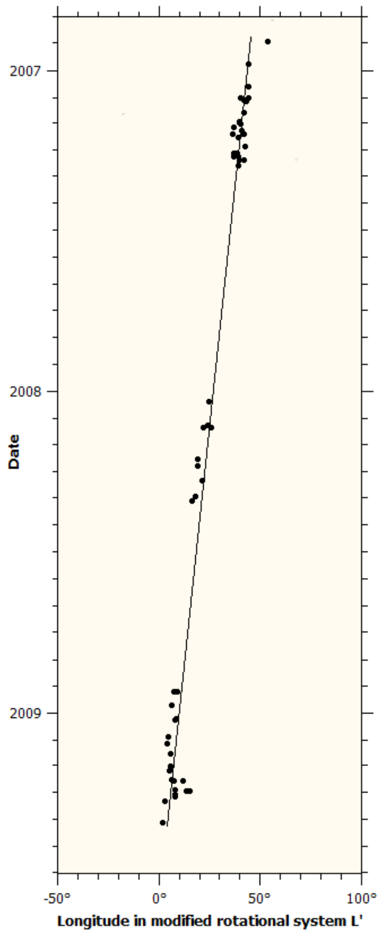

Figure 10. Drift chart of the prominent SEBZ spots observed in the 2006/2007, 2007/2008 and 2008/2009 apparitions in the same modified longitude system used in Figure 9.

Equatorial Zone (EZ)

The EZ was divided into two by the Equatorial Band (EB). The EZ(S) was generally brighter than the EZ(N) and was the brightest zone visible.

A narrow belt was observed in the southern half of this zone

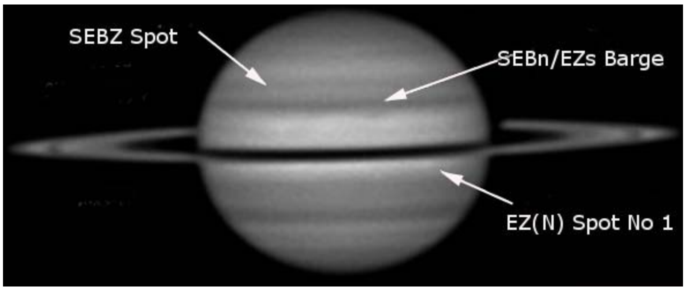

Figure 11. 2009 Mar 29, 23h 58m UT. CM1= 141.5, CM2= 72.1., CM3= 255.1. *(Image by Tyler, green filter)*. SEBn/EZs barge no 1 *p.* the CM, plus the EZ(N) spot no.1 near the *f.* limb and SEBZ spot no.1 approaching the *p.* limb.

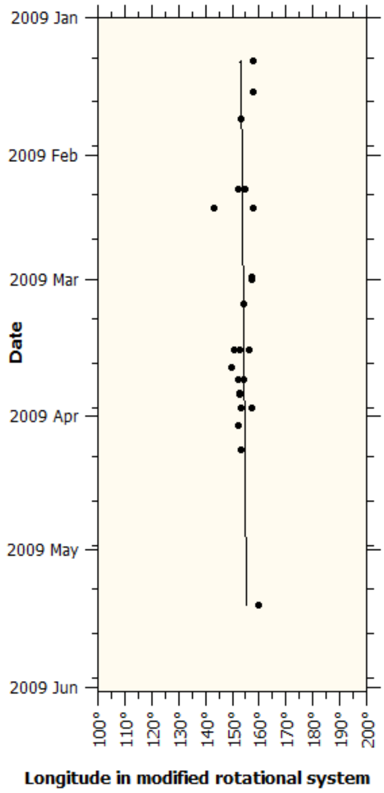

Figure 12. Drift chart of the centre of the SEBn/EZs barge in a modified longitude system drifting at 11.4°/day with respect to System 1. The reference date is opposition. The positions (shown as dots) are derived from images taken by Akutsu, Arditti, Buda, Casquinha, Go, Lawrence, Peach, Tyler & Wesley. The solid line represents the average drift derived from these observations.

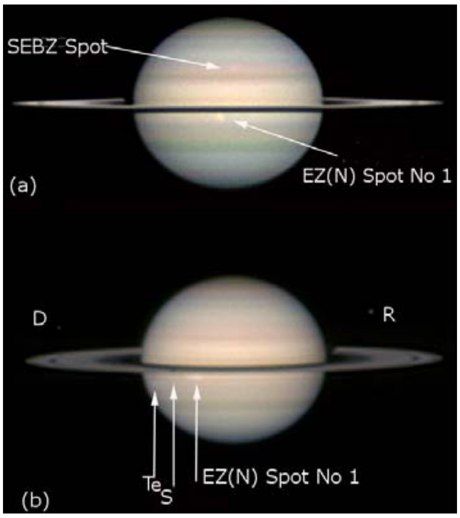

Figure 13. Typical observations of the bright spot in the EZ(N) designated spot no.1 (arrowed). **13(a).** 2009 Feb 4, 16h 24m. CM1= 123.6, CM2= 336.2, CM3= 223.5 *(Image by Buda)*. Also shows the bright spot no.1 in the SEBZ. **13(b).** 2009 Apr 16, 03h 13m. CM1= 209.2, CM2= 306.6, CM3= 108.6 *(Image by Friedman)*. Also shows Tethys (labelled Te) and its shadow (labelled S) in transit. Dione and Rhea (labelled D and R respectively) are also faintly visible.

just to the north of the SEB(N) (see Table 3). Although recorded in higher resolution images, it was only observed visually by Gray on Feb 8. This belt has been observed during recent apparitions. In refs 5 & 7 and this report, it is designated as a belt in the southern EZ whereas in some earlier reports, McKim designated it as an EZ(S)B (see for example ref. 8).

The most interesting feature on this narrow belt was a dark very elongated spot or barge as shown in Figures 1, 11 & 27(a) (Part II). Its drift chart in a modified longitude system is shown in Figure 12. This is designated as SEBn/EZs barge in Table 8. This spot often showed a reddish colour. In some observations, additional elongated darker patches were sometimes suspected on this southern EZ belt but none of these could be tracked.

Abel, Akutsu, Go, Graham, McKim, and Wesley sometimes recorded some lighter areas in the EZ(S) including one adjacent to the dark SEBn/EZs barge (Go). However none of these could be tracked due to the limited number of observations.

The EB was broad and higher resolution observations showed it to have darker northern and southern edges. It was recorded as double by Gray on Feb 8.

Early during this apparition, the southern edge of the EZ(N) was partially hidden by the SH R on G. Later, its southern edge was marked by the projection of the rings onto the globe. The EZ(N) was generally less bright than the EZ(S). However it appeared brighter than the EZ(S) in an image taken on Jun 22 by Wesley.

The most interesting feature in this region was a bright storm which appeared as a bright spot (designated as EZ(N) spot no.1). It is shown in Figures 11, 13, & 17(e) and its drift chart is shown in Figure 14. Its average drift, latitude and longitudinal extent are shown in Table 8.

Despite its relatively small size (5°), its brightness ensured that it was often recorded. It was imaged in apertures as little as 203mm (Foulkes) although it was only seen visually by Gray.

It was well observed from 2009 Jan 3 until Apr 22. However a similar object was seen on 2008 Dec 7 and 2009 May 19. Although there are a few weeks' gap between these two observations and the main observations, these two observations lie on the same track shown in Figure 14. Consequently this spot seems to have been visible for much of this apparition. This spot overlaid a faint belt that was sometimes observed at this latitude. This belt was only detected visually by Gray and McKim.

This was not the only spot detected at this latitude and a number of others were shown in images and reported visually. The positions of these additional spots are also shown in Figure 14. The spots particularly showed up in red light images and two such spots flanking EZ spot no. 1 are shown in Figure 17(e). These two spots were also recorded on additional dates, and drifts similar to EZ spot No. 1 are indicated. In particular three observations of the spot *f.* no 1 show a drift of +1°.16/day; close to the derived drift of spot no. 1. However in this and the other cases there are too few observations to derive accurate drifts. It is also possible that some of these additional spots may have been short-lived.

North Equatorial Belt (NEB)

The NEB was a dark double belt separated by a broad NEBZ. The northern component appeared darker and single although often appeared to fade in intensity from north to south. Gray recorded the northern component as double on Mar 2.

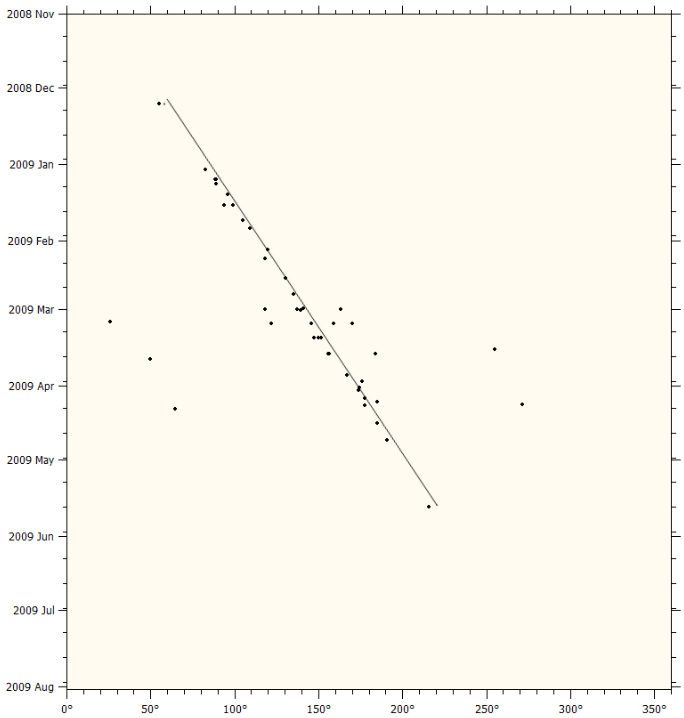

Figure 14. Drift chart of the centres of bright spots in the EZ(N) in System 1, based on observations by Abel, Akutsu, Arditti, Barry, Buda, Casquinha, Foulkes, Friedman, Go, Gray, Maxson, McKim, Peach, Sharp, Tyler & Wesley. The positions are shown as dots. The solid line gives the track of EZ(N) spot no.1.

Abel and Gray sometimes recorded darker segments and condensations on this belt but none could be tracked. McKim recorded this belt as mottled on Mar 20. The southern component was sometimes recorded as double in some high-resolution images by Buda, Go, Lawrence, Peach and Tyler.

On some images, the NEB(S) appeared fainter and more diffuse than in others. However no obvious correlation of the fading with longitude could be found.

McKim considered the NEB(S) was fading; becoming more difficult to detect during May. Further on Jul 18, an image by Wesley showed this component to be faint and diffuse. A striking feature of the following apparition (2009/2010) was the diffuse nature of the NEB as a whole. These observations indicate that the fading may have started during the 2008/'09 apparition.

North Temperate Belt (NTB), North North Temperate Belt (NNTB) and the North Polar Region (NPR).

The NTB and NNTB generally required higher-resolution observations to be detected. This allowed the NTropZ and NTZ to be distinguished as well. Often when visible, the NNTB appeared darker than the NTB. Both belts were sometimes more obvious in red light images.

The NPR appeared dark, and a narrow NNTZ was sometimes detected. The North Pole was tilted away from the Earth. In subsequent apparitions when the north pole was tilted at a high angle to the Earth, amateurs were able to detect the North Polar Hexagon.[9] However this was not seen in this apparition even in polar projections made from the best images.

The rings and shadows

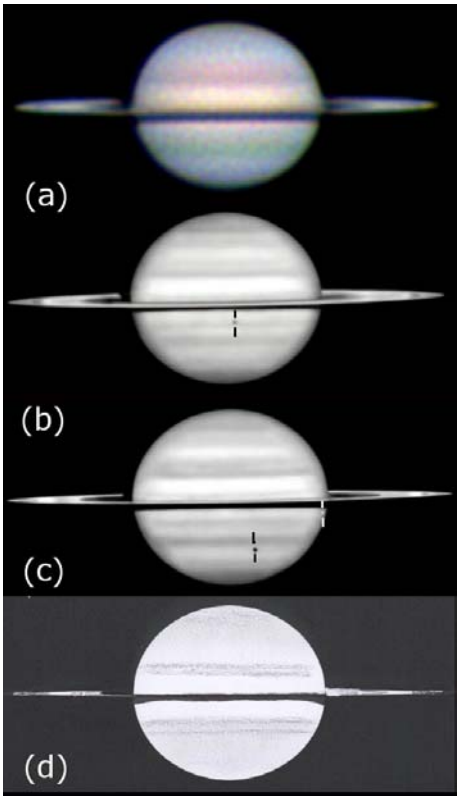

Figure 15. Appearance of the rings during 2008 October to November.

15(a). 2008 Oct 27, 13h 03m UT. CM1= 171.2, CM2= 18.6, CM3= 26.7 *(Image by Maxson)*.

15(b). 2008 Nov 12, 06h 50m UT. CM1= 140.9, CM2= 199.9, CM3= 189.0. *(Drawing by Gray)*. The shadow of Tethys is approaching the CM. (dark tick marks)

15(c). 2008 Nov 20, 04h 00m UT. CM1= 315.7, CM2= 170.0., CM3= 99.6. *(Drawing by Gray)*. The shadow of Rhea (dark tick marks) is approaching the CM with Rhea itself (light tick marks) on the *f.* limb, north of the SH R on G.

15(d). 2008 Nov 25, 06h 20m UT. CM1= 299.3, CM2= 299.0, CM3= 272.4. *(Drawing by Leatherbarrow)*. Shows brighter regions at the position of Ring B.

The figures included in this report illustrate the appearance of the rings due to the varying inclinations to the Sun and Earth shown in Figure 1. In particular, this is illustrated in the sequences of images given in Figures 15 to 19.

Observations during 2008 Oct to Nov

The appearance of the rings during this period is shown in Figure 15.

At the time of the first observation of this apparition, the inclination of the rings was approximately –4.6° with respect to the Sun. However the inclination with respect to the Earth was only –2.7° and so the rings appeared narrow.

With this geometry, the shadow of the rings onto the globe (SH R on G) was projected onto the northern hemisphere, north of the ring projection onto the globe. The curvature of the northern edge of the SH R on G near each limb was seen in higher-resolution observations.

Ring detail, including Cassini's Division and the gaps between the rings and the planet, became progressively more difficult to detect over this period as the inclination with respect to the Earth decreased (Figure 1). The shadow of the globe onto the rings (SH G on R) was visible *p.* the planet but this too became more difficult to detect. Rings A and B were visible and the narrow ring appeared brighter at the position of Ring B.

Observations during 2008 Dec

The inclination with respect to the Sun at the end of December was approximately −3°.5, but the ring inclination with respect to the Earth reached a minimum of approximately −0°.8 on Dec 24. For a few weeks either side of this date, the rings appeared bright but very narrow, as shown in Figure 16. On Dec 9, Adamoli reported the rings to be bright but not as bright as the planet. He recorded the rings to be at their brightest at the position of ring A.

The SH R on G was still visible and projected onto the EZ(N).

Some images taken over this period show the outer edge of the rings to be slightly fainter at the position of ring A. The gap between the rings and planet was not recorded. The SH G on R was suspected *p.* the planet in some observations.

Peach's image taken on Dec 7 (Figure 16(a)) hinted at the appearance of Cassini's Division and this is also indicated in a drawing by Abel on the same date. Casquinha's image (Figure 16(d)) taken at the minimum inclination also hints at Cassini's Division being visible.

2009 Jan to Opposition

Over this period, the ring inclination with respect to the Earth began to increase again; reaching −2°.6 at opposition. The inclination with respect to the Sun continued to decrease reaching −2°.4 at opposition. The appearance of the rings over this period is shown in Figure 17.

The rings still appeared bright and as the inclination to the Earth increased some ring detail became visible again. By early Feb, the gap between the planet and the rings started to become visible in higher-resolution observations. In addition, Ring A and B could be differentiated, with Ring B reported to be brighter than Ring A. Although Ring A became visible the division into A1/A2 was only detected with certainty in Peach's image on Mar 1 (Figure 17(e)).

Ring C became visible in each ansa in high-res observations. Later, a few observations suggest the projection of Ring C (C(M)) over the planet; particularly at the *p.* and *f.* limb. However this was never certain. The Cassini's Division and the SH G on R also became easier to see although this became narrower towards opposition.

The width of the SH R on G began to decrease over this period but was still visible north of where the rings projected onto the planet until early March. During early March the ring inclination to the Earth and Sun became equal. Higher-resolution observations by several observers showed this shadow to be bisected by the rings where they crossed the planet, such as shown in Figures 17(d) and 17(e). Within a few days, this shadow then appeared south of where the rings projected onto the planet (Figure 17(f)).

Around the time of opposition, Go's images on Mar 6 & 7 (Figure 17(f) plus Wesley's image on Mar 6) showed the rings to be brighter (*i.e.* the opposition or Seeliger effect). McKim was able to observe on Mar 8 at 22h 40m (close to the time of opposition at 22h 00m[2]) but didn't consider the rings to be brighter than when he observed on Mar 4. No shadow of the globe on the rings (SH G on R) was visible. The SH G on R was hinted at in Go's images of Mar 6 and 7.

Opposition to 2009 July

Following opposition, the most striking feature in the appearance of the rings was their decrease in brightness (Figure 18) as their inclination to the Sun decreased further (Figure 1).

This was reported by several visual observers. [McKim: rings not as bright (Mar 15); Heath: rings dull (Mar 18); Adamoli: rings duller (Apr 5); McKim: rings dull (Apr 18); Graham: rings dull (Apr 19 and May 12); McKim: rings very dull (May 8); Graham: Rings dull (May 12); McKim: rings very dull (May 18); Adamoli: rings darker (May 31); Graham: rings dull (Jun 1) and Adamoli: rings faint (Jun 13)].

This was also shown in the images taken over this period. Images taken with exposures to correctly record the planet (and the rings prior to opposition) now resulted in underexposed rings due to the decrease in ring brightness. The underexposure became more noticeable as the brightness decreased towards July (Figure 18).

The inclination of the rings to the Earth however increased to approximately –4°.15 in mid-May, allowing features such as Cassini's Division to become easier to detect.

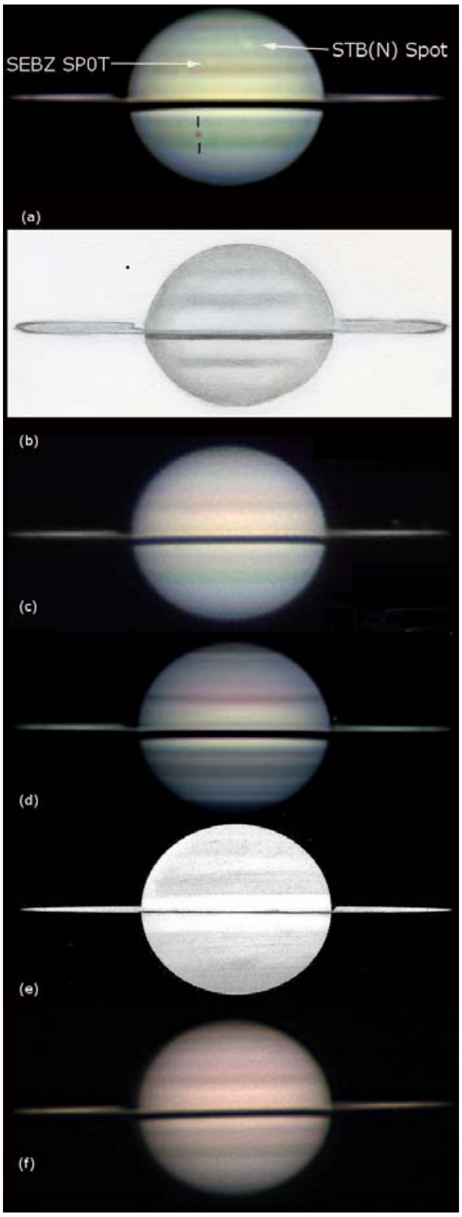

Figure 16. Appearance of the rings during 2008 December.

16(a). 2008 Dec 07, 06h 47m UT. CM1= 7.1, CM2= 338.5, CM3= 297.5. *(Image by Peach)*. Shows STB(N) spot no.1 and SEBZ spot no.1 (arrowed). The shadow of Dione was in transit (dark tick marks).

16(b). 2008 Dec 07, 07h 07m UT. CM1= 18.8, CM2= 349.8, CM3= 308.7. *(Drawing by Graham)*

16(c). 2008 Dec 19, 18h 20m UT. CM1 =105.6 , CM2= 33.9, CM3= 337.8. *(Image by Buda)*. Rhea (designated R) is faintly visible south of the rings, *f.* the planet.

16(d). 2008 Dec 24, 05h 26m UT. CM1= 273.6, CM2= 57.7, CM3= 356.2. *(Image by Casquinha)*

16(e). 2008 Dec 27, 06h 55m UT. CM1= 338.9, CM2= 24.1, CM3= 318.9. *(Drawing by Orr)*

16(f). 2008 Dec 30, 05h 20m UT. CM1= 296.3, CM2= 246.7, CM3= 178.0. *(Image by Kidd)*

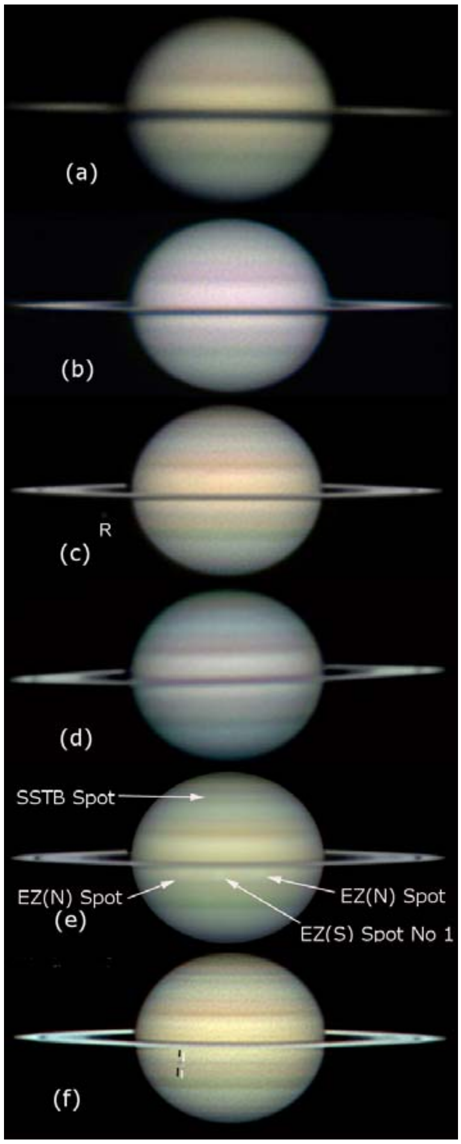

Figure 17. Appearance of the rings from 2009 January to opposition.

17(a). 2009 Jan 03, 03h 20m UT. CM1= 3.4, CM2= 187.3, CM3= 113.9. *(Image by Sussenbach)*

17(b). 2009 Feb 05, 15h 09m UT. CM1= 204.0, CM2= 26.0, CM3= 272.2. *(Image by Salway)*

17(c). 2009 Feb 18, 16h 34m UT. CM1= 71.0, CM2 =191.2, CM3= 61.6. *(Image by Buda)*. Rhea (designated R) is faintly visible north of the rings, *p.* the planet.

17(d). 2009 Feb 28, 22h 46m UT. CM1= 92.9, CM2= 241.8, CM3= 99.8. *(Image by Tyler)*.

17(e). 2009 Mar 1, 00h 10m. CM1= 142.2, CM2= 289.2, CM3= 147.1. *(Image by Peach)*. Shows STB(N) spot no.1 and three light spots in the EZ(N) including EZ(N) no.1.

17(f). 2009 Mar 7, 15h 06m UT. CM1= 333.9, CM2= 266.9, CM3= 116.9. *(Image by Go)*. Dione (light tick marks) and its shadow (dark tick marks) in transit.

Abel recorded the darker ring A1 and brighter ring A2 several times over this period but McKim found he could rarely differentiate these except on Apr 22. A number of high-res images resolved A1 and A2 (*e.g.* Figures 13(b), 18(a), 18(b) and 18 (e)). In some of Peach's images (taken on Mar 18 and Mar 20), a narrow dark line was recorded at the position of the Encke gap.

Rings B1, B2 and B3 were sometimes distinguished.

The SH R on G became broader appearing through C(M).

After mid-May, the inclination of the rings began to decrease again making the ring detail more difficult to see. In Wesley's image taken on Jul 27 the rings appear very dark indeed.

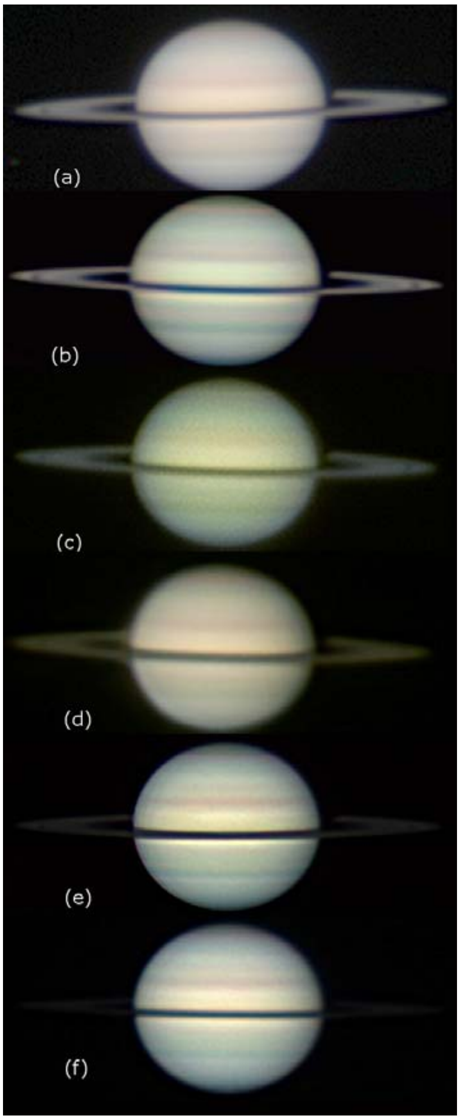

Figure 18. Appearance of the rings from 2009 Opposition to July.

18(a). 2009 Mar 13, 22h 41m UT. CM1= 266.8, CM2= 355.9, CM3= 198.2. *(Image by Lewis)*

18(b). 2009 Apr 3, 21h 40m UT. CM1= 322.3, CM2= 94.4, CM3= 271.5. *(Image by Tyler)*

18(c). 2009 Apr 20, 20h 22m UT. CM1= 229.6, CM2= 174.5, CM3= 331.1. *(Image by Mobberley)*

18(d). 2009 May 21, 21h 33m UT. CM1= 162.9, CM2= 185.0, CM3= 304.1. *(Image by Sussenbach)*

18(e). 2009 Jun 22, 08h 02m UT. CM1= 61.6, CM2= 148.3, CM3= 229.6. *(Image by Wesley)*

18(f). 2009 Jul 18, 07h 54m UT. CM1= 45.1, CM2= 12.3, CM3= 62.2. *(Image by Wesley)*

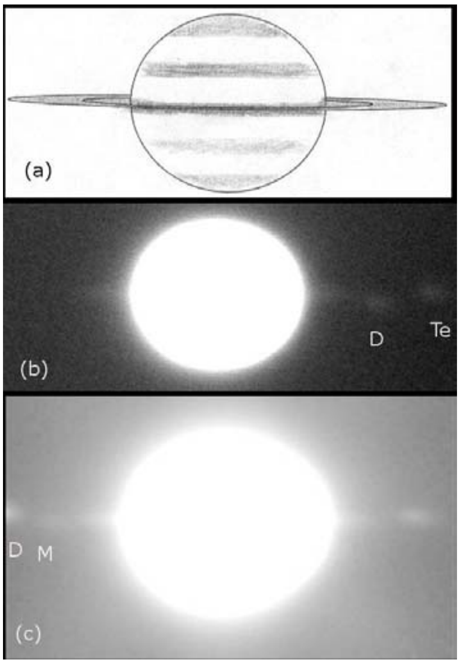

Figure 19. Observations around the time of the ring plane crossing with respect to the Sun. The detected satellites are labelled M: Mimas, E: Enceladus, Te: Tethys and D: Dione

19(a). 2009 Aug 5, 19h 00m UT. CM1= 150.3, CM2= 241.2, CM3= 268.88. *(Drawing by Adamoli)*

19(b). 2009 Aug 10, 10h 34m UT. CM1= 114.5, CM2= 55.2, CM3= 77.3. *(Negative image by Akutsu)*

19(c). 2009 Aug 14, 10h 56m UT. CM1= 264.0, CM2= 75.1, CM3= 92.3. *(Negative image by Akutsu)*

Ring plane crossing with respect to the Sun

Adamoli was able to observe on Aug 1 and Aug 5 shortly before the ring plane crossing with respect to the Sun, which occurred on Aug 11. Despite the low altitude, the poor seeing and using only a 127mm aperture Maksutov telescope, he recorded the rings as a ‘faint ethereal line of light’ on Aug 1. On Aug 5 they appeared thin at the limit of perception (Figure 19(a)).

Akutsu was able to image the planet around the time of the Sun ring plane crossing. His observations were made under difficult conditions (in twilight and with the planet only a few degrees above the horizon). As well as exposing to record detail on the planet, longer exposures were also used in order to detect the satellites and the rings – if present. Negatives of the longer exposure images are shown in Figures 19(b) and 19(c).

The image taken on Aug 10 shows a faint but distorted narrow line at the position of the rings, both *p.* and *f.* the planet.

His image taken on Aug 14 a few days after the ring plane crossing shows a similar feature at the position of the rings. However on this date, the side of the rings not illuminated by the Sun was presented to the Earth. It would therefore be expected that the rings would not be visible.

However when observed under favourable conditions, the dark side of the rings can be detected but appearing faint. This appearance may be due to sunlight filtering through the rings or sunlight reflected off the planet onto the dark side of the rings.

Although observing conditions were poor, the long exposure may have allowed the rings to be detected after the ring plane crossing.

Ring plane crossing with respect to the Earth

The rings were edge-on to the Earth on Sep 4. This occurred shortly before solar conjunction so this event was not observed.

Faulkes Telescope observations

The rings outside of ring A (the F, E and G rings) are very faint and their detection requires very large telescopes or spacecraft.

As the rings appeared narrow during this apparition, the glare around the planet was reduced compared to when the rings are inclined at a greater angle. This reduced glare allowed the fainter inner satellites to be observed. Consequently the author thought it would interesting to see if fainter rings could be observed with one of the larger robotic telescopes that are available to schools and amateurs. Thanks to the efforts of Richard Miles, the author was granted two 30 minute slots on the Faulkes Telescope North on Hawaii, which can be controlled via the internet.

The plan was to try to image the sky either side of the planet with both the rings and planet outside the field of view of the camera. Indeed one of the restrictions placed on this activity by the telescope operators was not to undertake exposures with Saturn in the field of view of the camera. Miles also assisted the author to derive the coordinates to which the telescope would slew to achieve this objective.

The first 30 minute slot on the telescope was awarded on the afternoon of 2008 Dec 24. This was convenient as the ring inclination to Earth was at minimum. Unfortunately local weather conditions prevented the telescope being used and the slot was lost. The second 30 minute slot was booked for 2009 Jan 8 and again Miles assisted with the derivation of the slew co-ordinates. This time local conditions were favourable and some imaging was undertaken.

The initial images were planned to be of the sky *p.* the planet. Interestingly the first few test images were slightly blurred which may have been due to the telescope having not fully damped following the initial slew. Although the slew co-ordinates were derived not to have the rings within the field of view, the outer edge of the *p.* edge of the rings did appear at the *f.* edge of the camera field. As a result, some further short slews had to be undertaken to achieve the objective, thus losing some time. ▶

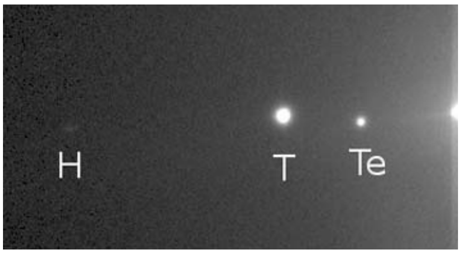

Figure 20. Image of the sky *p.* Saturn taken on 2009 Jan 8 at 13:27 UT using the Faulkes Telescope North with a red filter. 5×2 sec exposures. The satellites Titan (T) Tethys (Te) and Hyperion (H) are labelled. The *p.* tip of the main rings is at the right hand side of the image. A faint linear streak extends from this towards Tethys. *(Image by Foulkes.)*

It was then decided to concentrate on the region *p.* the planet. A number of relatively short exposures was taken and a typical red light result is shown in Figure 20.

In Figure 20, the brighter *p.* edge of the ring is visible at the *f.* edge of the image with the planet and main body of the rings outside the field of view. The satellites Hyperion and Tethys are also visible. However nothing else was recorded, apart from *p.* the edge of the rings. Here was a faint linear light streak extending from the *p.* tip of the main rings towards Tethys.

It is not clear what this may be and it could be just be noise or an after-image on the chip after slewing the telescope to move the rings just out of the field of view.

Unfortunately the results were negative and in hindsight, much longer exposures should have been attempted.

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I would like to thank Richard Miles for arranging the time slots on the Faulkes Telescope North and providing useful advice both in planning the observations and the use of this telescope.

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