Venus 2004: east and west elongations and solar transit

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A report of the Mercury & Venus Section (Director: R. J. McKim)

The year 2004 was exceptional in producing the first solar transit of Venus since the late Victorian era. The bright aureole and atmospheric ring were re-observed, and the entire phenomenon was witnessed for the first time ever in hydrogen alpha light. Although routine observations throughout 2004 were unexceptional, patterns of visibility of bright and dark markings, cusp extensions and cusp caps were recorded. No correlation was found between the latitude of the sub-Earth point and the visibility of either cusp cap, with the S. cap predominating for most of the year. It was possible to accurately follow individual ultraviolet dark markings over many consecutive rotations, extending from the E. to W. elongations, and thereby to make a current measurement of the synodic atmospheric rotation period for the near-equatorial features: 3.996 ± 0.001 days. The true Ashen Light was reported visually on only a few occasions, but these correspond closely to times when infrared emission from the surface of the dark side was recorded in 1-micron waveband images. Some of the stable dark side albedo features were also visible on the 1-micron images, and have been tentatively identified with known surface features. Infrared imaging at the same waveband showed little detail on the sunlit disk, but a few bright spots were sufficiently well observed to suggest a synodic rotation period close to 5.0 days, not atypical for the lower cloud decks.

Introduction

Observers and observational circumstances

During 2004 Venus was in transit across the Sun for the first time since the late Victorian era. Extensive descriptive accounts of the transit have already appeared on a BAA CD-ROM[1] and in the *Journal*,[2,3] along with three brief interim reports of the E. and W. elongations of 2004.[4–6] There were a good number of visual reports for the eastern (evening) elongation, but only a small number for the western (morning) one. Large numbers of visual observations were made by Adamoli, Haas, Heath, McKim and Niechoy. Many ultraviolet images were submitted, more than for any previous year: Cooper, Peach & Tyler obtained excellent data from the UK, and numerous other observers from overseas provided high quality work. Pellier obtained exceptional images in the infrared 1-micron band that seem to show actual surface details.[4] Of the many transit reports to hand, a report by the Orwell Astronomical Society was especially detailed and interesting. Table 1 is a list of observers.

Given the eight-year 'cycle' of elongations of Venus, observational circumstances were similar to favourable previous elongations such as those of 1956, 1964, 1972, 1980, 1988 and 1996. Some physical data follow:

Superior conjunction:	2003 Aug 18
Greatest elongation east:	2004 Mar 29 (46°)
Declination at greatest elongation east:	+22°
Inferior conjunction (transit):	2004 Jun 8
Declination at inferior conjunction:	+23°
Greatest elongation west:	2004 Aug 17 (46°)
Declination at greatest elongation west:	+20°
Superior conjunction:	2005 Mar 31

During the year 2004, the latitude of the sub-Earth point (hereinafter denoted 'De') varied over the extreme range from –5.4° (late April) to +3.8° (mid-July).[7]

For the present paper, Blaxall established the date of apparent dichotomy at the E. elongation by computer analysis of a large number of visual phase observations, and Heath carried out preliminary analysis of the visual observations for the same elongation. The Director performed the other analyses, and has been responsible for writing the report.

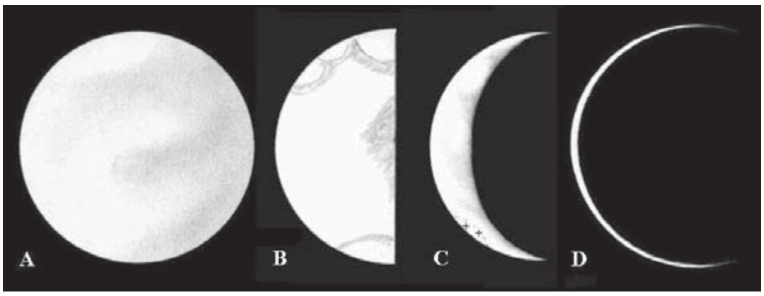

Figure 1. Drawings at the E. elongation.
A. 2003 Sept 17d 11h 30m, 215mm refl., ×230, ×345, W80A blue filter, *D.Fisher*: early view of nearly full disk with bright S. cuspidal area. **B.** 2004 Mar 25d 19h 00m, 90mm OG, ×130, W44A blue and W58 green filters, *E. L. Ellis*: straight terminator and various bright limb areas. **C.** 2004 May 13d 17h 45m, 203mm Schmidt–Cass., ×250, W80A blue filter, *M.Frassati*: showing bright area (indicated by + +) at NE limb. **D.** 2004 Jun 3d 18h 30m, 203mm Schmidt–Cass., ×133, W80A blue filter, *M. Frassati*: horns extended beyond semicircle.

Ultraviolet and infrared filters

The visibility of albedo detail upon Venus in the near-ultraviolet improves with diminishing wavelength down to *ca*. 340nm; nothing is gained by further decrease. It is satisfying to record that UV imaging has been taken up seriously by a large number of observers. The appropriate filters (used in conjunction with an IR-blocking filter such as the Schott BG38 or the True Technology IR block (750nm cutoff)) are given in Table 2. There also exists the Baader U filter (300–400nm waveband). Those using the W47+IR blocking combination were actually imaging in a waveband encompassing both the violet and ultraviolet.

In addition, a few observers used various IR filters in the waveband range 780–1000nm (1000nm = 1 micron), which will be discussed later.

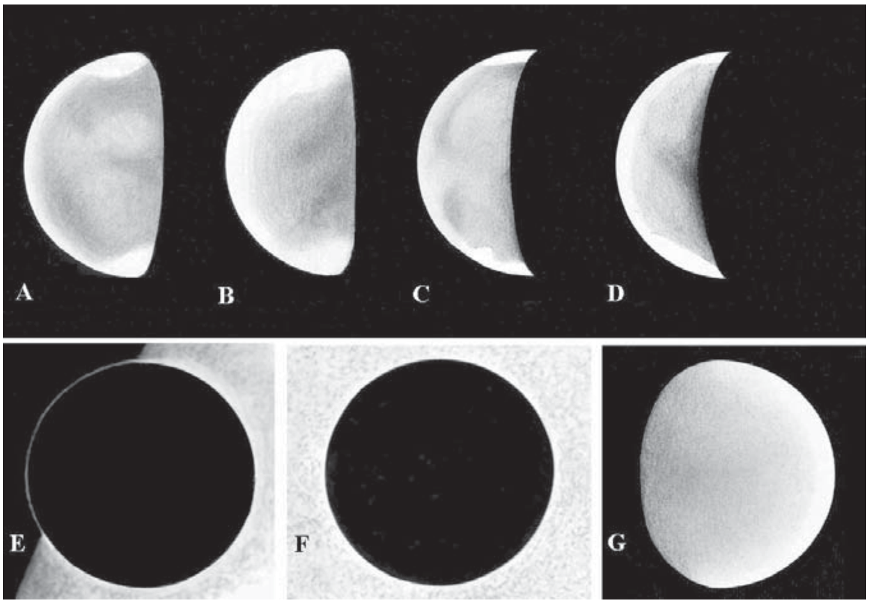

Figure 2. Drawings by the Director at E. elongation, transit and W. elongation. A–D with 410mm Dall–Kirkham Cass., E–F with 76mm OG, G with 70mm OG.
A. 2004 March 7d 18h 00m, white light (W21 orange similar), ×256, showing typical shadings and cusp caps. **B.** 2004 Mar 7d 18h 121m, W47 blue-violet filter, ×256, showing wider limb band, smaller phase, different atmospheric belts to white light (A). **C.** 2004 Apr 19d 19h 25m, W21 orange filter, ×256, showing bright patch at NNE limb. **D.** 2004 Apr 19d 19h 28m, W38A blue filter, ×256, showing N cusp larger and engulfing the bright limb patch seen in (C). **E.** 2004 Jun 8h 05h16m (approx.), showing the atmospheric arc around the dark limb at ingress. **F.** 2004 Jun 8: general mid-transit view against the solar photosphere. **G.** 2004 Dec 9d 07h 50m, ×100: typical view of gibbous disk. *R. J. McKim.*

The east and west elongations

During the E. elongation, drawings were obtained from 2003 September 13 to 2004 June 8, and CCD/webcam images from December 28 to June 8. At the W. elongation, visual records cover the period 2004 June 8 to 2005 March 20, with images from June 8 to January 8. Examples of drawings feature in Figures 1–2, and CCD images in Figures 3–8.

Dichotomy

General

Past Section Director J. Hedley Robinson[8] recommended the use of the W15 yellow filter in standardising (and reducing scatter in) visual phase estimates. Recent observers have used a wider variety of filters, and unfortunately neglected the adopted standard. We continue to analyse visual phase estimates for the sake of historical continuity. The CCD images submitted were mostly highly processed IR or UV ones, and therefore unsuitable for this programme. Contrast enhancement darkens the terminator, reducing the apparent phase. Ideally, phase measurement work would require unprocessed images taken with the W15 or similar filter. Dichotomy was estimated graphically from visual estimates between 40% and 60% phase.

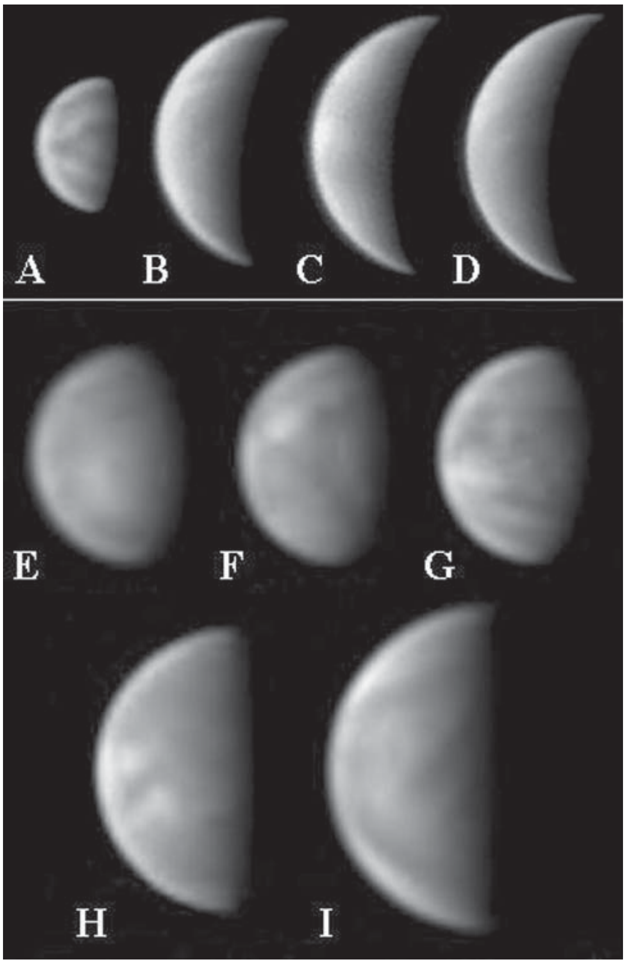

Figure 3 *(right).* Ultraviolet CCD images at the E. elongation 2004, by observers in Europe: J. Cooper (UK) with 178mm Mak–Newt., ATK-1HS and Schuler UV 365nm filter (top row, **A–D**); C. Pellier (France) with 355mm Schmidt–Cass., ATK-1HS and Schuler UV 365nm filter (bottom two rows, **E–I**).
A. Feb 28d 18h 08m; **B.** Apr 19d 19h 23m; **C.** Apr 22d 20h 14m; **D.** Apr 24d 20h 08m; **E.** Feb 7d 16h 29m; **F.** Feb 8d 16h 12m; **G.** Feb 9d 16h 14m; **H.** Mar 16d 15h 42m; **I.** Mar 29d 17h 36m.

E. elongation

Meeus[9] calculated apparent dichotomy as falling on 2004 March 31.6. The Director confirmed this by extrapolation from the 2004 *Astronomical Almanac*.[7] The observed phase in red, orange, yellow and green filters is always very similar to that in white (integrated) light. A progressively greater difference appears in blue and violet light; the fall-off of illumination at the terminator is more abrupt at shorter wavelengths. Though these aspects were often recorded in 2004, the number of drawings available was adequate to reliably establish only two dates of apparent dichotomy, for no filter and green filter; the Director estimates a probable error of about half a day, and so the two results perhaps do not differ significantly from one another:

	Observed dichotomy	*Anomaly (days early)*
White light (no filter)	2004 Mar 28.9 (±0.5)	2.7 (±0.5)
W58 (green) filter	2004 Mar 29.8 (±0.5)	1.8 (±0.5)

Adamoli saw the terminator straight on March 29, as did Ellis on March 25 (Figure 1B) and Haas on March 25 and 29.

W. elongation

There were few visual observations at the critical time, but the work of Adamoli and Middleton leads to a graphical date

Table 1. Observers of Venus, 2004

Name	*Location(s)*	*Instrument(s)*	*Observed* **
G–L. Adamoli	Verona, Italy	108mm OG & 125mm Mak–Cass.	E T W
T. Akutsu*	Tochigi, Japan	320mm refl.	W
A. Ayiomamitis	Athens, Greece	355mm Schm.–Cass.	E T
J. A. Clark	Gravesend, Kent	203mm Schm.–Cass.	E W
E. Colombo	Gambarana, Italy	150mm Mak–Cass.	E
J. A. Cooper*	Northampton & Selsey	178mm Mak–Newt.	E T
E. Y. Crandall	Winston-Salem, N. Carolina, USA	254mm refl.	W
E. L. Ellis	St Albans	90mm OG	E
D. Fisher	Sittingbourne, Kent	215mm refl.	E T W
M. Frassati	Crescentino, Italy	203mm Schm.–Cass.	E T
M. H. Gaiger	Kingston on Thames, Surrey	220mm refl.	E T
W. H. Haas	Las Cruces, New Mexico, USA	152, 203 & 320mm refls.	E
J. P. Hatton*	Mill Valley, California, USA	235mm Schm.–Cass.	E W
A. W. Heath	Long Eaton, Notts.	254mm refl. & 203mm Mak–Cass.	E T W
M. J. Hendrie	Colchester, Essex	152mm OG	E T
T. Ikemura*	Nagoya City, Japan	310mm refl.	E W
P. Lawrence	Selsey, West Sussex	102mm OG	E T
P. R. Lazzarotti* (with P.Guidoni)	Massa & Rocchetta, Italy	252mm refl.	E T W
G. MacLeod	Reay, Caithness, Scotland	152mm OG	W
R. J. McKim	Upper Benefield, Northants.	70mm & 76mm OGs & 410mm Dall–Kirkham Cass.	E T W
F. J. Melillo*	Holtsville, New York, USA	203mm Schm.–Cass.	E W
C. Meredith	Prestwich, Manchester	203mm Schm.–Cass.	E T
R. W. Middleton	Brightlingsea, Essex	127mm OG & 254mm refl.	E W
D. Niechoy	Göttingen, Germany	203mm Schm.–Cass.	E T W
T. Olivetti*	Bangkok, Thailand	180mm Mak–Cass.	W
R. W. Panther	Walgrave, Northants.	60mm & 90mm OGs	E W
D. A. Peach* (with D. B. V. Tyler)	Loudwater, Bucks. & Selsey, W. Sussex	279mm Schm.–Cass.	E T W
C. Pellier* (with G. Farroni)	Bruz & Paris, France	180mm & 400mm refls. & 210mm Dall–Kirkham Cass.	E W
B. Shaw	Oakley, Hants.	127mm OG	W
M. M. Taylor	Glenfield, Leicester	203mm refl. & 355mm Schm.–Cass.	E T W
D. del Valle	Aquadillo, Puerto Rico	203mm Schm.–Cass.	T W
J. C. Vetterlein	Rousay, Orkney, Scotland	175mm Mak–Cass.	E
K. Yunoki*	Sakai City, Japan	200mm refl. & 600mm Cass.	E

The ten observers indicated thus* contributed UV images.
** E= Eastern elongation, T= Transit, W= Western elongation.

Table 1. (continued)

The following (UK-based unless otherwise stated), not already mentioned above, sent observations of the transit only:
D. R. Airey, J. Aucken, G. Austin, N. Bailey, R. M. Baum (with Mrs A. Baum & J. Baum), P. Bishop, D. Blackburn, P. Blakemore, K. W. Blaxall, R. Bosman (Enschede, Holland), A. Brown, D. Brown, N. D. Bryant, F. C. Butler, T. Byatt, P. Carson, R. Cockman (Sharm el Sheikh, Egypt), A. Cole, A. C. Cook, J. Cook, L. Crook, J. Cuckney, R. Dodd (Kefalonia, Greece), J. Dragesco (St Clément-de-Rivière, France), S. Elliott, A. Emberson, R. Emery (Sharm el Sheikh), S. England, G. Ensor, D. Fagg, D. Ford, G. Foster, M. Frost, P. J. Garbett, M. V. Gavin, M. Giuntoli (Montecatini Terme, Italy), V. & L. Gonano (Udine, Italy), D. L. Graham, D. Gray, R. Gray, B. Griffin, O. Gwynne, R. Henderson, A. J. Hollis, N. D. James (reporting on behalf of a large party based at Sharm-el-Sheikh, including N. S. Evans, M. Foulkes, D. Hatch, N. D. Hewitt, Mrs H. McGee, J. W. Mason and others already listed), K. Jeffrey, R. Johnson, J. Jones, J. Keery, J. Kemp, R. Knisely–Marpole, T. Lombry (Brussels, Belgium), C. J. R. Lord (with R. Rutter & R. Smith, CDEPA, Portugal), P. Macdonald, L. T. Macdonald (Saintes, France), R. A. Marriott (with M. Finney & P. Goulstone), G. Marsh (Tulbingerkogel, Vienna, Austria), P. J. Meadows, A. J. Miklavcic (with K. Sabina, Ljubljana, Slovenia), D. S. C. Midwinter, B. Mitchell, M. P. Mobberley (on behalf of a large group at Selsey at the residence of Sir P. A. Moore, including N. Boyle, R. Flegg, J. R. Fletcher, C. Lintott, B. May, G. Rogers and others already listed), F. Montanucci (Rome, Italy), S. L. Moore, R. Murrell (Malta), C. Newsome, S. Nissenbaum, G. North, R. Northcott, D. Perkin, J. P. Petit (Paris, France), J. Platten, M. J. Porter, C. Potter, G. Poyner, A. Pratt (Paphos, Cyprus), D. E. Purchase, N. Puttick, J. H. Rogers, A. W. Rumble, B. Shaw, D. Shepherd, N. Shomali, A. Sieroslawski, M. Sinton, G. R. Smith, I. S. Smith, K. Smith (Sharm el Sheikh), L. Smith, E. H. Strach, D. Strange, A. Symon, Wei-Leong Tan (Singapore), A. Tatler, A. Taylor, M. Taylor, E. T. H. Teague, J. Thorpe (Mosman Park, W. Australia), E. T. Thurgur (Sharm el Sheikh), G. Thurston, A. C. Tough, A. J. Vincent, J. Weightman, G. White, A. White and Mrs V. White (Sharm el Sheikh), J. Youdale. The Director observed the transit in company of Mrs M. McKim and Miss M. A. McKim (aged 14 mths), and showed the mid-stages of the event to several hundred pupils at Oundle School, Northants.

There were also transit reports from Cleveland & Darlington AS & Wynyard Planetarium/Observatory, Stockton-on-Tees (*per* J. McCue); Hampstead Scientific Society, London (*per* D. G. Daniels); Hanwell Community Observatory, Oxford (*per* D. Randell); Leeds Astronomical Society (*per* R. Emery); Mid-Kent AS (*per* P. W. Parish); Open University Astronomy Club (from P. Chambers, A. Cooper, A. Norton, A. Rix, M. Stewart & J. D. Tanner; see the *Journal*, **115**(3), 144–149 (2005)); Orwell Astronomical Society, Ipswich (*per* J. Appleton) and South Lincs. Astronomy & Geophysics Society.

of apparent dichotomy (W15) for comparison with the predicted time[9] of August 17.5:

	Observed dichotomy	Anomaly (days late)
W15 (yellow) filter	2004 Aug 23.0 (±1.0)	5.5 (±1.0)

Adamoli saw the terminator straight and the phase exactly 50% on August 22; del Valle's CCD image of the same date confirms this.

As the terminator appears straight for some four days, the decimal days in the quoted anomalies seem redundant. The 2004 results agree with the range of smaller anomalies recorded in the past.[8,10]

Dark markings

General

It was confirmed during 2004 that the W47 blue-violet filter gives an accurate but lower contrast view of the ultraviolet markings; for imaging purposes the W47 filter must be allied with an IR-blocking filter (such as the Schott BG38: the W47 has a significant 'red leak'). See Figure 5. Used visually the W47 is rather dense, and requires a modest aperture (254mm or more). Because the cone cell response of the human eye in violet light is less sensitive than at longer visible wavelengths, such observations are best done by photography or imaging. However, we do encourage suitably equipped observers to continue to make drawings with this filter so that their work can be analysed with UV images, whilst those without UV filters no longer need be prevented from obtaining images of the UV markings.[11]

If we consider the UV images in Figures 3 and 4, it is clear that a fixed observer can sample only restricted longitude ranges of the planet's atmosphere during a single elongation. If an observer records a dark marking, it will be observable every four days thereafter at the same hour. A second observer at a different terrestrial longitude may never be able to see the same feature at the same elongation, but instead is able to record different (perhaps less conspicuous) patterns inaccessible to the first. Because the synodic period of the equatorial atmospheric rotation is actually 3.99525 Earth days, if we view Venus at four-day intervals at the same hour, there is a slow drift of the markings from the *p.* to the *f.* limb of the planet (in the direction of the retrograde rotation) over a period of months, so that at the next elongation a different range of longitudes and features will be accessible. Is this a partial explanation of why a fixed observer sees the markings better at some elongations than at others?

We may also note in passing that the morphologically similar Y and Ψ markings are on average 90° (equivalent to 24 hours) apart in longitude. This may be the reason why so many previous observers estimated the atmospheric rotation period as being close to one terrestrial day.

E. elongation

The character of the half-tone albedo markings observed in white light was entirely typical. Between 2003 September 13 and 2004 May 19, visual observers reported at least some details on the disk. Both diagonal and horizontal bands were seen, which were darkest and easiest to see near the terminator, representing imperfect views of parts of the characteristic Y- and Ψ (psi)- shaped ultraviolet markings. (These markings run E–W along their long axes.) The collars at the cusps were not frequently seen during this elongation, but the southern collar (never very dark) was somewhat more often reported than the northern. This was also apparent from the UV images.

As in the past, the visual appearances of the shadings through other filters or in white light often seemed to differ from one another (see the pairs of filter drawings in Figure 2).

Drawings from Europe show a different part of the planet than UV images from Japan or the USA west coast (Hatton) because of the time difference, but the USA east coast (Melillo) ob-

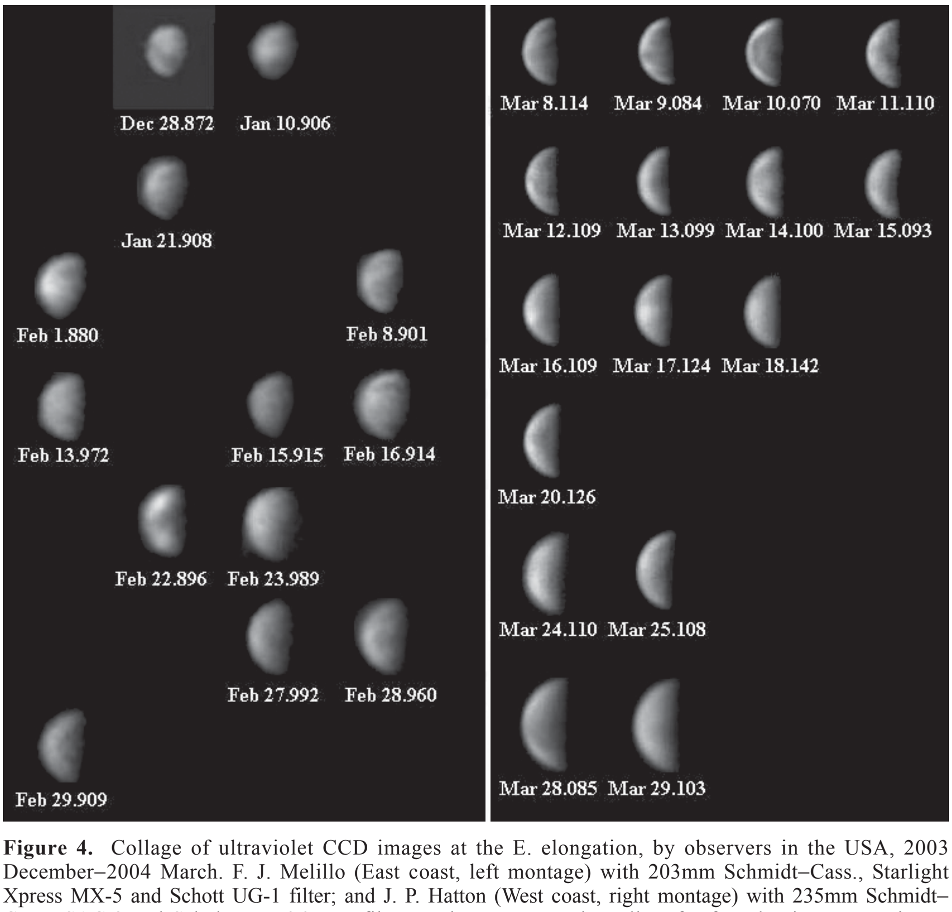

Figure 4. Collage of ultraviolet CCD images at the E. elongation, by observers in the USA, 2003 December–2004 March. F. J. Melillo (East coast, left montage) with 203mm Schmidt–Cass., Starlight Xpress MX-5 and Schott UG-1 filter; and J. P. Hatton (West coast, right montage) with 235mm Schmidt–Cass., SAC-8 and Schuler UV 365 nm filter. Both sets arranged to allow for four-day intercomparisons.

servations are only a few hours later and can be directly compared. On Feb 22 McKim sketched diagonal bands and bright cusps in accord with Melillo's CCD image. On Feb 28 Cooper (Figure 3A), Melillo (Figure 4) and McKim (white light) all found a long diagonal belt running N*p* to S*f* from the S. polar collar towards the equator. On Apr 19 Cooper (Figure 3B) and McKim (blue light, Figure 2D) both showed bright cusps and a diagonal marking near the equator, though the accord is not perfect. On Mar 1 Heath and Meredith sketched the same diffuse markings in the N. and S. hemispheres which were recorded in more detail in Pellier's UV image.

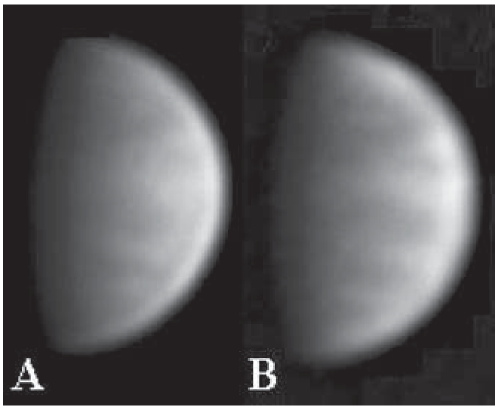

Figure 5. UV *vs* W47 imaging, 2004 September 19. **A**. P. R. Lazzarotti, 252mm refl., Lumenera LU075, W47+IR blocking filter, 05h 43m; **B**. D. A. Peach, 279mm Schmidt–Cass., ATK-1HS, Schuler UV 365nm filter, 06h 07m.

The UV images (such as Pellier's of Jan 29, Feb 7 (Figure 3) or Mar 29 (Figure 3) and Hatton's of Mar 10 (Figure 4)) clarify why a C-shaped albedo feature is often drawn by visual observers adjacent to the bright limb during evening (but not morning) elongations. Sometimes dismissed as an effect of contrast, it is a real feature corresponding to the diverging forks of a Y-shaped UV feature emerging onto the visible disk, distorted by perspective.

W. elongation

The visibility of dark shadings (reported between 2004 July 7 and 2005 March 20) appeared much as at the E. elongation, but there were too few good drawings to specifically comment upon the behaviour of the polar collars.

The southern polar collar was better seen than the north in the UV/violet images. From Sept 19 to Nov 6, numerous images showed a short horizontal band within a large bright S. cap. As this band was present in all the best images over this period, with some on adjacent days, it must have been circumpolar.

Terminator

E. elongation

Except near dichotomy, the terminator was a perfect semi-ellipse without irregularity. Terminator shading was seen from 2003 mid-September onwards. A few days prior to apparent dichotomy, the S. cusp was visually slightly blunted whilst the N. one was straight. After dichotomy, the N. horn appeared sharper or more prolonged than the south for a few days. This behaviour is typical. On April 1 (theoretical phase 0.5) the Venus ephemeris gives De= –4.4° and Ds= –2.6°; thus the Sun was at a marginally lower altitude than the Earth above the Cytherean S. pole (and higher above the N.), and this difference may relate to the foregoing anomalies.

W. elongation

No confirmed terminator irregularities were seen. Few observations were made near the critical dichotomy period. Terminator shading was reported visually between 2004 late June and 2005 February.

Bright areas

E. elongation

The bright 'limb band' was constantly apparent (being specifically noted from 2003 mid-September onwards), clearly differentiated from the general disk shading except at very small phase. The limb brightness extended to the cusps, which often showed discrete cusp caps. The limb band appeared wider in blue or violet light.

Apart from the limb band, one of the most strikingly bright areas was imaged in the UV by Pellier (Figure 3) and Melillo (Figure 4)[12] on Feb 8; their images 5 hours apart beautifully show it rotating inward from the limb. It was not certainly imaged on Feb 4. The location of this cloud is seen on Cooper's Feb 28 image (Figure 3) but it was then no longer bright. Pellier's UV images of Feb 9 and 13, and Feb 10 and 14 also show changing bright areas extending inward from the *p.* limb; Peach's Feb 19 image (of a different longitude) is of a similar nature; Pellier's Mar 16 image (Figure 3) shows two near-equatorial bright areas near the *p.* limb; mere traces of them remain on his Mar 28 image.

Of the visual work, McKim on Feb 28 recorded a lighter halftone near the central terminator, and on Apr 19 in orange and white light he recorded a bright patch at the NNE limb close to the N. cusp cap (Figure 2C) which in blue light (Figure 2D) seemed engulfed by the cap. Ellis saw bright patches at the limb, on Mar 25 (SE limb, Figure 1B), Mar 29 (SE, one atmospheric rotation later and partly confirmed by

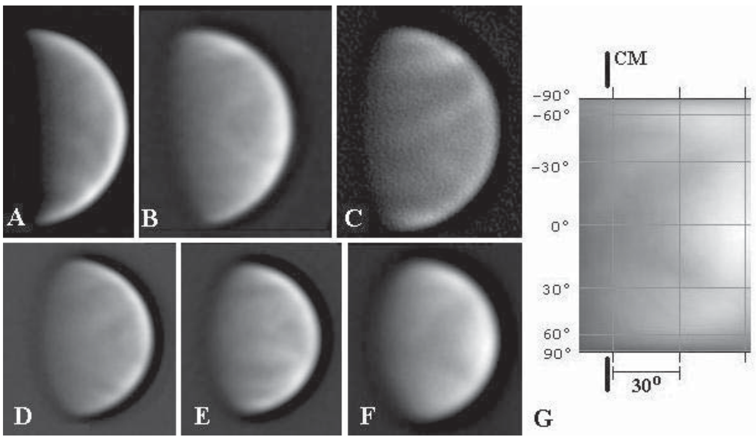

Figure 6. Collage of ultraviolet CCD images, showing the variation in appearance of the Y-shaped feature denoted 'UB' during the W. elongation 2004. (See also Figure 3F.)
A. C. Pellier, Aug 15d 04h 56m, 180mm refl., UV 365nm filter. **B.** D. A. Peach & D. B. V. Tyler, Sept 16d 05h 10m, 279mm Schmidt–Cass., UV 365nm filter. **C.** T. Akutsu, Sept 27d 21h 13m, 320mm refl., U-340 filter. **D.** T. Olivetti, Oct 13d 23h 55m, 180mm Mak–Cass., W47+IR blocking filter. **E.** T. Olivetti, Oct 21d 23h 39m, as D. **F.** T .Olivetti, Oct 29d 23h 17m, as D. **G.** Map projection of F, with the central meridian (CM) indicated.

Table 2. Ultraviolet filters

Type	Bandwidth or peak transmission wavelength	BWHM* (nm)	Observer(s)
IDAS U	270–380		Yunoki
Schott BG12	405	150	Lazzarotti
Schott UG-1	355	65	Melillo
Schuler U 340	?		Akutsu
Schuler U /UV 365	300–400		Cooper Hatton Peach & Tyler Pellier
U-360	330–360		Ikemura
W47+Schott BG38	310–480		Lazzarotti Olivetti
(for W47 alone	440	70)	

**BWHM = bandwidth at half maximum*

a Pellier image); these may represent later sightings of a bright incursion of the limb brightening into the SE disk seen by Colombo, Mar 9. Other bright patches were seen by Ellis on Apr 2 (ENE), and Apr 16, 23 (SE, SSE; the former also imaged by Melillo), May 6 (SSE), whilst on May 13 (six atmospheric rotations after the Director's Apr 19 observation) Frassati distinctly saw a light spot near the NE limb (Figure 1C). Heath on Mar 30 drew a vaguely lighter patch adjacent to the terminator just S. of the disk centre: it was better seen in blue light.

W. elongation

No special light areas were noted at limb or mid-disk in the scant visual data. The limb brightening was constantly present, being definitely recorded between 2004 late June and 2005 early January. In the UV images a specific bright area at the NW limb was captured by Akutsu on Aug 31, and then by Melillo in the same location on Sept 12, three rotations later. It had disappeared by Sept 20. Lighter patches on mid-disk are shown on Olivetti's images of Nov 19.

General

In summary, the light areas are much more changeable than the dark UV markings, and at most seem to persist for perhaps six rotations, but the majority did not survive for more than two. The variable bright markings are mostly the cause of variations in the classic UV dark markings.

Cusp caps

E. elongation

Bright cusps were definitely recorded visually from 2003 Sept 17 (Fisher, Figure 1A) to 2004 May 23 (after which the crescent was too narrow to tell). The caps were never large nor strikingly bright visually. Taking the work of Ellis, Fisher, Haas, McKim, Meredith and Middleton together there is very good agreement that the S. cusp was almost always larger and more prominent from 2003 September till 2004 May. From the ephemeris, the sub-Earth point was south of the equator between Feb 1 and inferior conjunction. However, there were some exceptions, and from the work of the above observers alone these were as follows: Jan 26 (Middleton): N. cusp brighter than S.; Feb 22 (McKim): N. cusp larger than S.; Mar 1 (Meredith): N. cusp brighter than S.; Apr 16 (Middleton): N. cusp brighter than S.; and Apr 16 (Ellis): N. cap elongated, S. cap prominent.

In the UV images in Figures 3 and 4 there is not much difference between the cusp caps, when visible. However, the S. limb is often shown as brighter than the north.

W. elongation

Comments upon there being visually definite cuspidal light areas were made between Aug 7 and Nov 19. In August the S. was almost always larger and brighter (or was the only cap visible), and only on two dates were both caps reported equal; De was then positive, so there was no correlation. From September–November, too few visual records exist for generalisations.

In the ultraviolet images for late August and September, the S. cusp cap was often the larger, though sometimes the smaller N. one was brighter. The S. cap seemed to grow during September, reaching enormous proportions on some images in the second half of the month. This situation prevailed throughout October (though with some exceptions) and at least until late November. During this period a horizontal dark belt cut across the large cusp cap: see earlier. Then, Olivetti's images of Nov 26–28 showed each cuspidal area about equally large and bright. (In November De was slightly negative, so again there is no correlation with cap visibility.) The December and 2005 January images showed the N. cap as the larger of the two.

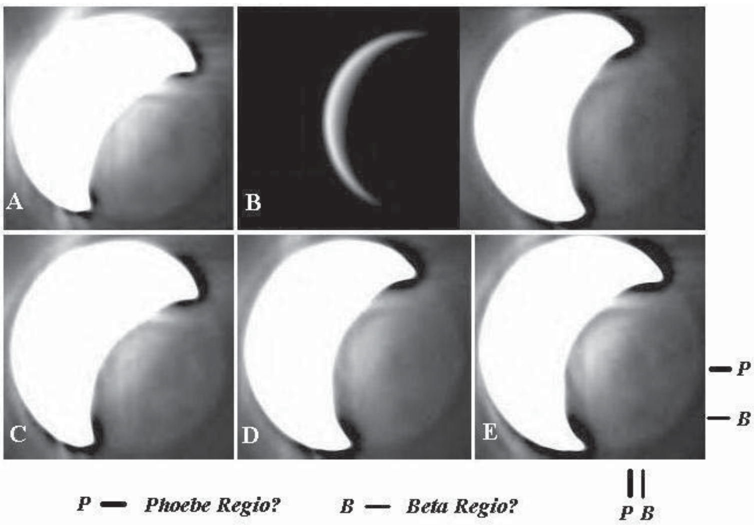

Figure 7. Infrared (λ= 1 micron) images of the thin crescent, at the E. elongation 2004, by C. Pellier with 355mm Schmidt–Cass., ATK-1HS, showing infrared emission from the night side.
A. May 16d 20h 21m; **B.** May 17d; left: short exposure image, 20h 13m; right, 8s exposure, 20h 22m; **C.** May 18d 20h 30m; **D.** May 19d 20h 36m; **E.** May 21d 20h 31m. Note the darker patches on the night side, relatively static from night to night. The ephemeris CML varied from 310° (May 16) to 318° (May 21), and De = –4°.[7] The indicated dark patches have been tentatively identified with surface features.

Cusp extensions

E. elongation

Using a 203mm aperture under transparent New Mexico skies, Haas made the most systematic records. Allowing for varying conditions these nicely showed the increase in length of the cusps (or horns) as Venus approached the Sun: the greatest extension of the crescent to about 270° (*i.e.*, 45° extension per cusp), was seen on June 2. Other observers also reported extensions (Figure 1D). The observations on June 6 were made two days before the transit with Venus only 3° east of the Sun.

Observer	*Date(s)*	*estimated angular length of crescent (°)*
Haas	Apr 15–May 1	182–185
Haas	May 2–14	185–195
Haas	May 17–28	205–220
Fisher	May 19	185
Fisher	May 22	225
Fisher	May 23	215
Frassati	May 24–25	205
Haas	May 30–Jun 4	225–270
Frassati	Jun 3	230
Ikemura (CCD)	Jun 5	240
Pellier (CCD)	Jun 5	250
Lawrence (CCD)	Jun 6	250
Lazzarotti (CCD)	Jun 6	255

Having seen modest cusp extensions on June 3 and 4, Hendrie observed on June 5 at 08:00 UT with a long dewcap on his 152mm OG, ×80. Venus was 4.8° from the Sun's centre. 'Crescent very thin but now appears well over 180° long, and at moments of best seeing is a complete ring.' And many observers would see a fringe of light around Venus' dark limb – visible even upon the projected image in some cases – as she neared (or ended) her transit across the Sun's disk on June 8.

W. elongation

A number of significant cusp extensions feature on Niechoy's drawings, June 12–26. The crescent was *ca*. 210° long on Pellier's June 12 image.

Ashen Light

Between May 17 and June 4, Adamoli, Haas and Meredith sometimes reported the well-known impression where the invisible body of the planet appears darker than the sky. The Ashen Light proper appears lighter than the sky when seen after dark. Although it is not impossible that the Light's intrinsic reddish tint causes it to appear darker than the sky before dark by subjective colour contrast, the absence of confirmation suggests that these impressions were of the illusory type. Using a small refractor in full daylight, Adamoli reported a very faint and difficult fringe of light surrounding the unseen dark limb between 2004 Apr 27 (phase *ca*. 0.3) and May 24. Rightly sceptical of its reality, he nevertheless had the same impression at the W. elongation, Jun 28 to Aug 13. To the Director, the long-enduring nature also suggests illusion as the cause.

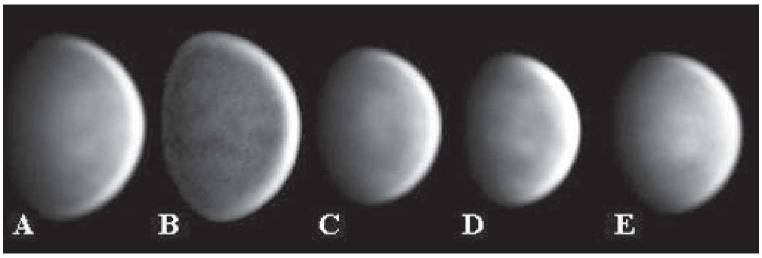

Figure 8. Infrared (λ= 1 micron) images, at the W. elongation 2004, by T. Olivetti (180mm Mak–Cass., A, C–E) and T. Akutsu (320mm refl., B). Contrast has been somewhat enhanced to highlight the brighter patches.
A. Nov 6d 23h 43m; **B.** Nov 9d 21h 21m; **C.** Nov 19d 23h 50m; **D.** Nov 20d 23h 58m; **E.** Nov 26d 23h 40m.

On May 19 upon the twilight sky Haas (203mm aperture) reported having seen a faint outline of the dark limb. On May 18 upon the evening sky Niechoy was sure he could see the Ashen Light as being slightly *lighter* than the sky, with a grey colour over the whole of the dark side. (Adamoli also recorded the 'fringe of light' on that date.) This coincidence in date suggests the May 18 and 19 sightings may have been real. Other possible reports of the Ashen Light, in 2004 April, do not seem objective. Hendrie on Jun 5 felt that the unilluminated disk (completely encircled by a ring of light: see above) was of a different colour to the sky, and (as he was observing in full daylight) regarded it as an illusion. After inferior conjunction, Adamoli reported what was probably the true Ashen Light on Jun 28, and Niechoy also reported it on Jul 23. Niechoy often had the impression of the unilluminated side appearing darker than the sky.

We conclude the Ashen Light was at most weakly visible on May 18–19 at the E. elongation and Jun 28 and Jul 23 at the W. elongation. Remarkably, the dates for the E. elongation closely coincide with Pellier's successful attempts (May 12–21) at recording infrared emission from the planet's nightside: see below.

The present Director has fully reviewed many of the historical BAA Ashen Light observations elsewhere.[13]

Re-measurement of the atmospheric rotation period

In order to identify stable atmospheric configurations over more than one rotation, the Director arranged all the observations for each elongation into horizontal strips four days long, so that markings at the same longitude fell into vertical columns. Although their forms varied a good deal from one rotation to the next, the equatorial atmospheric markings clearly followed a four-day period. The large number of UV/violet images obtained during the W. elongation (by observers nicely distributed around the globe) made it possible to identify several individual cloud markings over longer intervals than at the E. elongation. Overlay grids (for the appropriate value of the sub-Earth latitude) or appropriate software could be used to create partial maps, but this would not be easy, for the resolution, image size and degree of image processing varied a good deal between observers.

It is not the purpose of this paper to give an exhaustive analysis of the rotation of the UV markings. The Director simply used some of the better defined near-equatorial dark markings to re-determine the atmospheric rotation period. Since Boyer defined the *synodic* period as standard,[14] we need not allow for the change in angular positions of Earth and Venus as defined by the phase angle. Light-time differences exert a marginal effect, and need not be considered here. (During 2004 light-time varied from 2 to13 minutes: at worst this corresponds to a rotational shift of less than 1°, several times smaller than the error in measuring any soft-edged shading.)

Data from the E. and W. elongations were combined to give a longer timebase. Marking UA is the C-shaped marking near the *p*. limb in Figure 3I. Marking UB is the C-(or Y-shaped) feature near the central meridian in Figures 3A and F, and could be reliably identified on images as far as 42 rotations apart: 2004 Feb 8 (Pellier) and 2004 Oct 29 (Olivetti). Figure 6 is a collage of its various appearances during the W. elongation, illustrating its variability: its form is best seen in Figures 6F and G. All displacements with respect to the central meridian were converted to synodic rotation periods. The results are tabled below, showing the better precision obtained over longer intervals:

Mark	*Limiting dates and times (UT)* *dd:hh:mm dd:hh:mm*	*Interval (d)*	*Synodic period (d)*
UA	Jan 29:16:44–Mar 29:17:36	60.0361	4.00
UB	Feb 08:16:12–Feb 28:18:08	20.0806	4.04
UB	Feb 08:16:12–Oct 29:23:12	168.2917	3.996

For the most reliable result, 3.996 days, assuming a cumulative measurement error of 5° yields an uncertainty in the period of ± 0.001 days. Compare the accepted *average* period of 3.99525 ± 0.00001 days which Boyer obtained over the much longer interval of 1893 to 1978.[14] Given the known diurnal fluctuations in rotation rates, the slight differences in period between the so-called regular and irregular markings, and that our observations extended for less than half a year, the agreement is excellent.

Observations in the infrared

Night side thermal emission

By deliberately overexposing and stacking multiple images of the bright crescent near inferior conjunction – as already reported in a Section Note[4] – Pellier was able to record infrared emission from the dark hemisphere at a wavelength of 1 micron (1000nm). He obtained successful images at all six attempts: May 12, 16, 17, 18, 19 and 21 (Figure 7). At wavelengths other than 1000nm the dark side emission is absorbed by the Venusian lower clouds; imaging of the surface in infrared was also done by the *Galileo* spacecraft at λ= 1.05 micron.[15]

Upon Pellier's images, the dark side showed slight albedo features, stable over several days, and therefore apparently corresponding to actual topography. In infrared, darker areas would be higher and cooler: see Figure 7. The dark patches W. of centre may correspond with elevated terrain about *Phoebe Regio* and *Beta Regio*. The reader can find further details elsewhere.[15]

Observations of the sunlit disk

Observations with infrared filters revealed a dusky terminator and a bright limb that sometimes extended to the cusps. The latter were no brighter than the limb, and tended to appear dark in IR. Any albedo markings imaged rarely corresponded with the UV features; most characteristic were extremely diffuse dusky shadings near the cusps and faint horizontal bands. No bright areas upon mid-disk were recorded in any of the IR images, except Akutsu's of 2004 Nov 9 and Olivetti's of Nov 6, 19, 20 and 26: see Figure 8.

The patterns of bright areas on Nov 9 and 19, and Nov 6 and 26 are very similar. The first of these markings (denoted IA in the following table) was a bright cloud centred near 14°N. The second (IB) was the centre of a complex of bright markings centred upon the equator. Crisp *et al*.[15] deduced a period of 5.15±0.1 days for a bright spot at 16°N, imaged during 1990 January–February at λ= 2.2 microns. If we reasonably assume the image pairs to be at similar longitudes, and the period to be about five days, we can deduce a current synodic rotation period for the atmosphere. Unfortunately there were no images for the intermediate five-day intervals in either case, but neither did the bright areas show up on any other images taken within the period.

Mark	*Limiting dates and times (UT)*	*Interval (d)*	*Synodic period (d)*
IA	2004 Nov 6.9882–Nov 26.9861	19.9979	5.00
IB	2004 Nov 9.8896–Nov 19.9930	10.1034	4.98

The average period is 4.99±0.01 days. At wavelengths of one to a few microns the markings correspond to lower, more slowly-moving clouds than those comprising the UV-absorbing strata.[15]

Concerning the dark markings, Akutsu imaged with IR-800 and IR-980 filters, recording faint markings, more certainly with the 980nm filter. Hatton[19] made images centred on 850nm using Schuler photometric filters. These occasionally showed slight structure. Olivetti obtained similar results; his 2004 Dec 16 images are interesting in showing a light diagonal area in UV which became a darker band in IR. (Such inverse relationships between images are, however, unusual.) Peach & Tyler made images with a Schuler 850nm filter. On 2004 Oct 1 they detected horizontal banding, quite different from the simultaneous UV image. Pellier made images at both 780nm and 1000nm. The 780nm images showed faint but real markings whose character differed from his simultaneous UV images. The darker of the vague shadings corresponded roughly in position to the cusp collars. The 1000nm images were more bland, but sometimes revealed the 780nm features if they were sufficiently prominent.

We hope for further systematic results during the programme of ground-based support for ESA's *Venus Express* mission, commencing 2006 May.[19]

Occultation by the Moon

During the E. elongation there was a daylight occultation of Venus by the Moon on May 21, which Heath and McKim

Table 3. Timings (UT) of the 2004 June 8 solar transit

Observer	*Location*		*T1*	*T2*	*T3*	*T4*
G. Adamoli	San Bonifacio, nr Verona, Italy		05.24.30	(05.38)*	–	–
	Cerro Veronese, nr Verona, Italy		–	–	11.04.00	11.22.45
P. J. Garbett	Bedford	white light	05.19.58	–	–	–
		H-alpha**	05.18.40	05.37.10	–	–
R. Gray	Calverton, Nottingham		–	–	11.03.45	11.22.25
M. J. Hendrie	Colchester, Essex	white light	05.20.30	05.39.43	11.04.02	–
		H-alpha**	–	–	–	11.23.45
P. Lawrence	Selsey, W.Sussex		05.20.02	05.39.47	11.04.11	11.23.41
C .J. R. Lord	CDEPA, Portugal		05.21.00	05.40.00	11.06.00	11.24.30
R. J. McKim	Upper Benefield, Northants.		(05.20)*	05.39.30	11.04.00	11.23.17
G. Marsh	Tulbingerkogel, Austria		(05.20)*	(05.39)	–	11.23.08
B. Mitchell	Norwich, Norfolk		–	05.39.05	11.03.31	11.23.17
S. L. Moore	Thorpe Le Soken, Essex		05.20.15	05.39.35	11.04.23	11.23.49
D. E. Purchase	Laycock Abbey, Wilts.		–	05.39.23	11.04.16	–
D. Shepherd	Ventnor, IOW		–	05.39.39	11.03.33	11.23.05
G. Thurston	Hartley Wintney, Hants.		05.20.20	05.40.00	11.04.09	11.23.03

*Rough timings are given in brackets. This applies especially to T1, where some observers were taken by surprise and others (like the Director) troubled by early cloud. Some observers timed to the nearest 30 seconds. T3 is expected to be the most precise timing. The timings contributed from Sharm el Sheikh, Egypt, are not in good internal accord due to the black drop effect, and have not been included here. A large number of timings were also made by members of the Orwell AS, mostly using the 254mm OG at Orwell Park Observatory.
**All the above timings were made in white light, except for those indicated (H-alpha). Garbett's T1 and T2 specifically refer to contact of the leading edge of Venus with the top of the spicules in the chromosphere.

attempted to watch from the Midlands. Heath was frustrated by cloud and rain. Dodging between cumulus clouds, McKim followed the planet to within a minute of the occultation, when it was hidden from view. In a clearing a few minutes later, only the Moon remained. It was not possible to wait for the reappearance. From the south coast, Lawrence had better luck, capturing both disappearance and reappearance by CCD,[1] whilst from Scotland Vetterlein took a series of images to show the reappearance around 12:11UT.

Ayiomamitis was able to image the disappearance from Athens, and his collage (partly reproduced in Figure 9) formed a BAA website 'picture of the day'.

The solar transit

In the following, we shall abbreviate first contact as T1, second contact T2; at the end of the event, third contact is T3 and last contact T4. Images and drawings feature in Figures 10–13.

General and optical

Conditions in the UK were often excellent with good steady seeing, although there was more trouble with cloud in the northwest. The long duration of the event even allowed some UK observers to get pleasantly sunburnt. Completely cloudless skies were experienced by the large BAA party that travelled to Sharm el Sheikh, Egypt (latitude 27.9°N), but unsteady seeing and excessive heat caused other problems.[1–3]

The bulk of the transit material is pictorial rather than scientifically useful. Overwhelmed by the spectacle, few observers made proper measurements of any sort. One historically useful and widely noted point: there was an almost complete lack of observations of the notorious black drop effect.[16] The only reports of it came from those observing in bad seeing, and especially from those using small apertures in bad seeing. (Many observers on the 18th and 19th century transit expeditions used small refractors on tropical islands.) Thus the phenomenon has nothing to do with the Venus atmosphere but is merely a resolution effect exacerbated by unsteady terrestrial air. A similar optical effect (in both visual and imaging work) can be seen where Saturn's shadow upon its rings just touches tangentially either the Cassini Division or the outer edge of ring A.[17]

In integrated light the sharp black disk of Venus was always crisply defined, with none of the interior points of light, moving or otherwise, that had sometimes been reported at past Mercury or Venus transits: these latter were simple optical phenomena.

Timings

Few observers made accurate timings of T1, T2, T3 and T4, and we intend no calculation of the solar parallax here, but for the historical record we list the more reliable data in Table 3. The transit lasted a little longer in H-alpha due to the added thickness of the chromosphere.

It was possible to use one's value of T3, in conjunction with a similar determination made from South Africa, to calculate the distance of the Earth to the Sun via the Open University's website, and several members took advantage of this with satisfactory results. More precise was the ESO website which offered a calculation of parallax based upon all of one's timings T1–T4. Historically the length of the transit (and thus the parallax angle) was defined as the difference between T2 and T3. Measurement of this interval to an accuracy of 1 second yielded an Earth–Sun distance correct to 0.17%.[16]

Solar activity

The view in white light, though unique, gradually became monotonous, partly due to the low level of sunspot activity. McKim measured the positions of two very small active areas, lat. –2 to –8°, long. 219–208° (Rotation 2017). At the longer wavelength of the red hydrogen alpha emission line, the view was more interesting (Figures 10–11), and the seeing often better. There were a few moderate plages, and some bright flocculi, some of which were associated with the active areas. Unfortunately, the only large limb prominence of the morning was at its best just before the transit had fully begun.

Figure 9. Occultation of Venus by the Moon, 2004 May 31, by A. Ayiomamitis (Athens), using 355mm Schmidt–Cass., f/18, Baader IR-cut filter, digital camera at prime focus. Observer's location: lat. +38.2997°, long. 23.7430°.

The Venus atmosphere

A bright fringe around Venus when viewed against the Sun – its illuminated atmosphere – was reported by most observers (Figures 2E, F, 10, 13A). This same fringe was also apparent in H-alpha light. The solar granulation could not be seen through the fringe. The very highest resolution images were obtained in the near-infrared by Lazzarotti & Guidoni (Figure 12), upon which the fringe is not so bright. Here it is revealed as a partially transparent region, with an ill-defined outer edge, beyond which the granulation gradually becomes fully visible. (On these processed images an inner, completely opaque white fringe does not exceed 2 pixels in width, compared with 140 pixels for the diameter of Venus, and seems to be merely a processing artefact.) Most drawings and small-scale images show the bright aureole as relatively wider than in reality: the Director noticed that its width was not proportionately increased by higher magnification, so that contrast played a part in exaggerating its width in small images.

The atmospheric arc around the unilluminated limb just before T2 (Figure 2E) and just after T3 (Figure 13B–C) was reported by a number of observers. This was mostly viewed in white light (by both direct vision and projection), but there were also reports of its visibility in H-alpha.

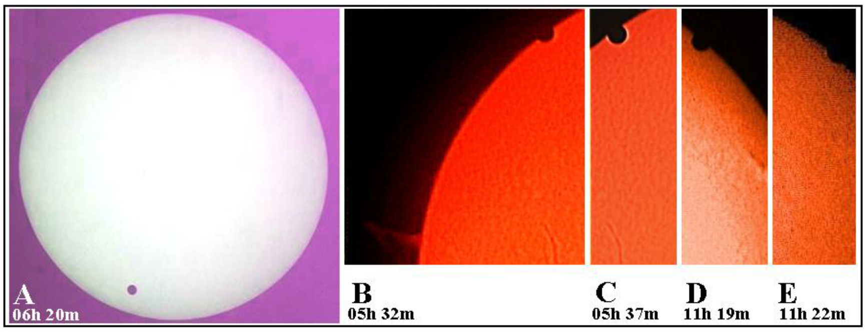

Figure 10. Images of the transit of 2004 June 8 by R. J. McKim. (A has N up, W to left.) **A**. Photograph of white-light projected image with 76mm OG at 06h 20m. **B–E.** Images through 40mm OG with Coronado H-alpha filter, Philips ToUcam, showing ingress and egress. **B.** 05h 32m; **C.** 05h 37m; **D.** 11h 19m ; **E.** 11h 22m.

Individual comments

– **G.Adamoli** (110mm OG): At T3: 'The slow movement of the planet and its oblique direction to the limb rendered timings uncertain by some tens of seconds.'

– **R. M. Baum, Mrs A. Baum & J. Baum** (115mm OG): Noted '...a fringe of light or brightness encircling the silhouette of the planet. Subdued and fragile this persisted throughout the observation... However, we were more certain of a narrow dusky penumbral feature that surrounded the disk.' (Figure 13A)

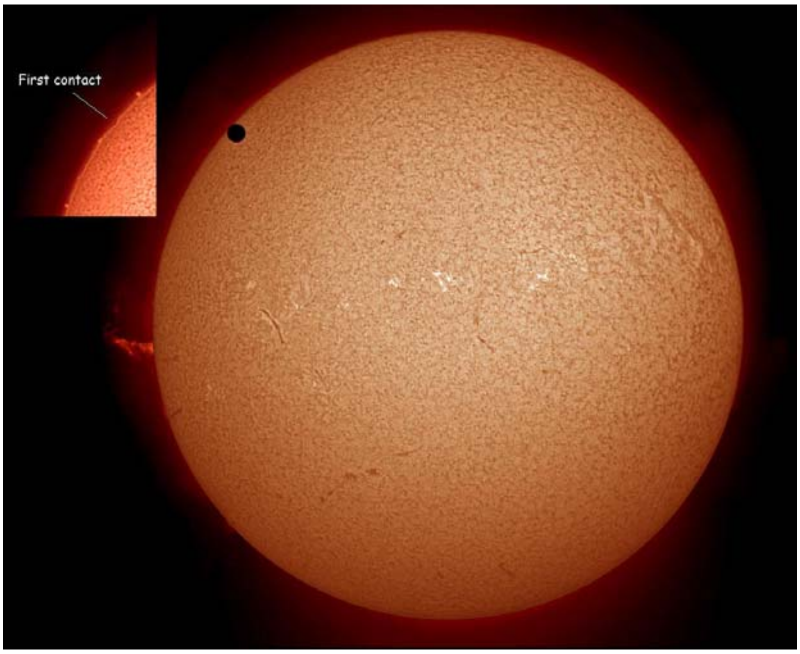

Figure 11. Images of the transit on 2004 June 8 by P. J. Garbett with 90mm OG plus SolarMax 40 H-alpha filter. Main image at 05h 37m10s; the inset shows the moment of first contact.

– **G. Ensor** (76mm OG): Succeeded in photographing the atmospheric ring just prior to T2.

– **M. Foulkes & D. Hatch** (200mm Mak–Cass.): Despite unsteady seeing at Sharm el Sheikh, they secured enhanced webcam images showing the thread of light around Venus' limb at 05:37 UT.

– **M. Frassati** (203mm Schmidt–Cass.): Frassati was able to see the complete atmospheric ring at both ingress (T2) and egress (T3). Sequences of his sketches have already been published,[1–3] and we choose just one drawing for this Report (Figure 13, B & C). The ring was asymmetric at egress, being brighter and wider in the southern part. This aspect was confirmed in CCD images by L. Comolli, published elsewhere.[18]

– **P. J. Garbett** (90mm OG with SolarMax 40 H-alpha filter): Garbett secured the best H-alpha transit images of those submitted to the BAA. An example from moments after T1 (Figure 11) beautifully shows the large rocket-shaped limb prominence (that would soon collapse) situated to the north of the egress position. T1 occurred early in H-alpha (Table 3).

– **S. Goldsmith,** Mid-Kent AS (120mm OG with DayStar H-alpha filter): Viewed the illuminated limb in H-alpha just after T3.

– **R. Gray** (127mm Mak–Cass.): Noticed a faint and narrow white ring in the place of the planet against the sky about 30s *after* T4. In fact Gray's T4 (Table 3) is a little early, so that Venus was not yet separated from the Sun's limb.

– **B. Griffin** (254mm refl.): 'For a few moments before ingress (second contact) I was confident in seeing the limb of Venus protruding outside the solar limb, and in moments of good seeing there appeared to be a whitish arc defining the protruding Venus limb.'

– **A. W. Heath** (40mm Coronado H-alpha telescope): With Venus against the Sun, 'The aureole was best seen with the red filter [W25] but was also seen with the others... [W15, W58, W80a]' 'The aureole ... may have varied very slightly in intensity from time to time though this may have been due to local thin cloud.' '11:25 UT. Careful look for the planet off solar disk in H-alpha but nothing seen.' 'I started observational astronomy in 1952 and at this time there were three future events which many looked forward to. The first was Halley's Comet in 1985–'86, the second was the 1999 total eclipse of the Sun and finally the transit of Venus. Alas all have now passed!'

– **P. Lawrence** (102mm OG): Imaged the faint atmospheric ring just after T3.

– **C. J. R. Lord** (102mm OG; SolarScope 60 for H-alpha observation): Chose a site on the Portuguese Algarve (CDEPA) where T1 commenced immediately after sunrise, and where the probability of a very clear morning sky would be greater than 80%. At egress, the black drop 'was observed and photographed in white light but not in H-alpha. T3 & T4 were timed (±30s) and occurred 2 minutes later in H-alpha, corresponding to a chromospheric depth of 6 arcsec. After T4 part of Venus could be seen silhouetted against the chromosphere.' (See also Table 3 and the note by V. White below.)

– **R. J. McKim** (76mm OG, and 40mm Coronado H-alpha telescope; Figures 2E–F,10): Was not able to observe ingress in H-alpha, but with a 76mm OG in white light by direct vision saw the whole disk of the planet briefly outlined by a thread of light just before T2 (Figure 2E). Watched the egress by projection and in H-alpha by direct vision but did not re-observe the phenomenon, due to dimming by the slight cirrostratus then present. After T4 he looked visually (and by CCD) in H-alpha for Venus silhouetted against the inner corona but predictably could not see it. The black drop was only seen in a few instants of poorer seeing, and this did not affect timings; otherwise the only approach to the phenomenon was a slight dimming (at ingress and egress) of the Sun's limb between Venus and the sky. 'Near the limb, Venus' aureole seemed marginally brighter than on mid-disk...'

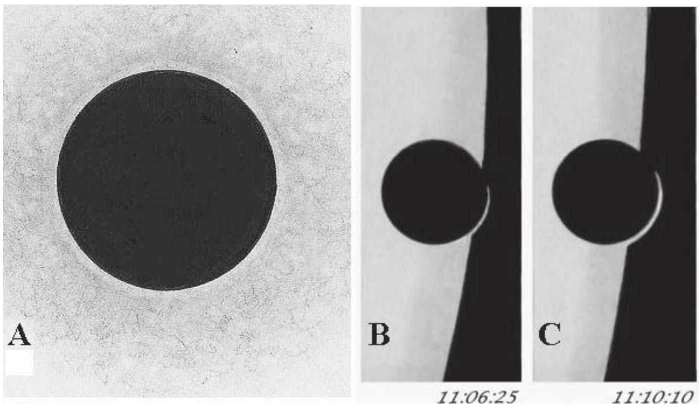

Figure 13. Other visual observations at the transit, 2004 June 8.
A. General view showing the planet against the Sun by R. M. Baum with 115mm OG, ×286, by projection.
B & C. The illuminated arc at transit egress, showing asymmetry, by M. Frassati with 203mm Schmidt–Cass., ×133, direct vision.

– **B. Mitchell** (203mm Schmidt–Cass.): As Venus was leaving the Sun's disk (11:08 UT) he drew a faint line of light around the dark limb.[1,3]

– **M. P. Mobberley**: Commenting upon the Selsey observations of the black drop: '...many observing visually with small, filtered apertures saw it; but when those with the highest quality instruments and webcams examined their digital video files it appeared to be nothing more than seeing-related. In the rarest sharp moments... there was no black drop at all...'

– **Orwell AS** (254mm OG): From 11:05–11:17 UT its members could see (on a large and well-shaded projected image) the thread of light surrounding the dark limb of Venus between T3 and T4.

– **G. North** (216mm refl.): At T3: 'No black drop seen but the bright fringe surrounding Venus lifts beyond the limb of the Sun, forming an arc of light, for a few moments before it fades away.'

– **E. T. H. Teague** (63mm OG): At 11:19 UT, just before T4, also drew the light fringe around the limb of the planet.

– **Mrs V. White** (40mm Coronado H-alpha telescope): Just before T2 was able to observe the faint ring of light around the limb in H-alpha. In fair seeing conditions, T2 was followed by an obvious black drop in white light but the effect was not discerned at all in H-alpha. (See earlier remarks.) Noticed that T1 occurred earlier in H-alpha than in white light, with the reverse happening at T4, the difference amounting to some 45 seconds.

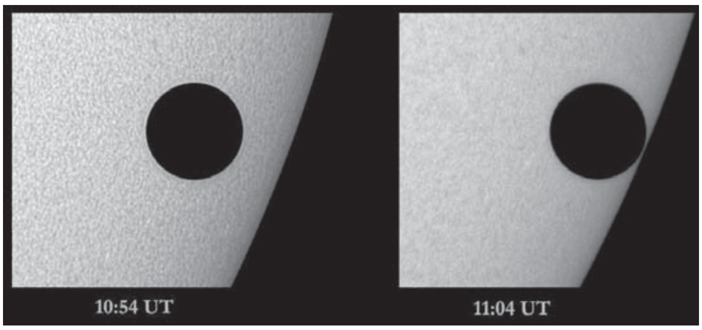

Figure 12. The 2004 June 8 transit imaged in very good seeing in the red and near-infrared (550–1000nm) waveband by P. Lazzarotti & N. Guidoni (Rochetta, Italy) with 130mm OG. Note the lack of solar granulation near Venus, and the complete absence of any black drop in the approach to T3. (N up, E to left, in contrast to most other figures which have S up and W to left.)

The next transit

The next Venus transit will occur on 2012 November 5–6, when only part of the event will be observable from the UK.

Acknowledgments

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10 Many dates of observed dichotomy are summarised and discussed in A. W. Heath & E. L. Ellis, *ibid*., **115**(2), 79–83 (2005)
11 During J.Hedley Robinson's Directorship of the Mercury & Venus Section, copies of the Section's W47 drawings were sent to Boyer at Meudon Observatory at his request, for analysis as part of a long-term research programme.
12 F. J. Melillo's website provides an animated .gif file for comparison with Pellier's image: **http://hometown.aol.com/frankj12/venusindex.html**
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