

The eastern & western elongations of Venus, 2007–'17

II. The nocturnal hemisphere

Richard McKim

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

Results for the planet's dayside were described in Part I. Here we discuss the nocturnal hemisphere, with details of infrared thermal emission (IRTE) imaging and the Ashen Light (AL). Images of the IRTE revealed up to nine topographic features upon the surface of the planet and enabled the slow rotation rate of the surface to be measured for the first time from amateur images. D. Gasparri recorded subtle, IR-absorbing low-altitude clouds of large scale, which were more prominent in 2009 than in 2017. The 2017 inferior conjunction saw remarkable high resolution reached by P. Miles and A. Wesley: the small bright spots they resolved upon the planet's surface might provide evidence for active volcanism. The AL was recorded in a small number of visual observations, with only a few sightings confirmed by a second observer. However, on 2009 Mar 12 the AL was imaged in the visible waveband by Gasparri and – at the same hour – independently observed at the eyepiece by G. Adamoli. The few positive AL sightings seem to be linked to solar Coronal Mass Ejection events. We review possible mechanisms to account for the AL.

Introduction

This paper, which is a continuation and sequel to Part I,¹ deals with nightside phenomena. We covered seven inferior conjunctions (IC), with the observers and elongations listed in Part I. Our observations of the nightside infrared thermal emission (IRTE) were all made within the near-infrared ($\lambda \sim 780\text{--}2500\text{nm}$), typically with a 1-micron (μm) filter; at this wavelength the atmosphere of Venus is translucent. Some observers experimented with filters having a different passband.

The nightside infrared thermal emission

Important ground-breaking studies have previously been published by Section member Daniele Gasparri.² Mapping the surface features through the 1 μm atmospheric window sometimes revealed very subtle albedo changes apparently caused by variable, large-scale lower clouds. Ongoing volcanic activity would also locally change albedo:³ could it explain the rather subtle, large-scale variations over the course of a few days revealed by Gasparri?

A highlight of the previous eight-year cycle had been the first amateur imaging of the IRTE, in 2004, with some indication of coarse surface topography.^{2,3} To avoid excessive irradiation, such data can only be obtained at a narrow crescent phase, yet not too close to IC. The dark patches most easily captured during the evening elongations correspond with elevated (and cooler) terrain about *Beta Regio* and *Phoebe Regio*. That the same features are observed at every inferior conjunction is plain from Figures 1–4. Gasparri was able to identify as many as seven surface features,² and for the present report recognised nine. Willem Kivits drew attention to the IRTE being visible even in daylight, with phase as high as 50%. However, most observers found it more convenient to wait till after sunset.

At IC in 2017 through use of special equipment, and in particular a narrowband IR filter, Phil Miles and Anthony Wesley were able to achieve remarkably high resolution in the IRTE, revealing

several compact bright spots that rotated with the ground.⁴ These bright spots might be interpreted in terms of active volcanism, as discussed later.

IC in 2007: inferior conjunction Aug 18

No suitable images were submitted prior to IC. During 2007W, 2007 Sep 13–16, A. van Kranenburg captured surface details with a filter passing wavelengths longer than 990nm.⁵ The IRTE was also imaged by D. L. Arditti at 807nm, Sep 25, by ‘... severely over-exposing the planet in the IR. I have tried this at 807nm before, and got negative results on the nightside, but this is the first time I have used so large an aperture as the C14. Subjecting this image to a substantial and careful levels stretch in *Photoshop*, it seems to me that the nightside glow may just about be detected. This has been demonstrated before with 1000 & 990nm filters, where the effect seems to be much more visible.’ The visible spectrum stretches from about 390–780nm.⁶

IC 2009 Mar 27

Before IC, G. & J. Ackermann imaged surface details in the IR on 2009 Mar 14–21 (Figure 1), as did R. Bosman on Mar 11–17, while Gasparri (Mar 12–18) and K. Yunoki (Mar 10–18) mapped the details they imaged. The dark side was also successfully imaged by T. Akutsu on Mar 5, Kivits on Jan 30–Mar 3 (even in broad daylight), S. Kowolik on Feb 28–Mar 7, F. J. Melillo on Mar 3–4 and D. A. Peach on Mar 6.

Measuring the daily change in position of the surface features, Gasparri (235mm SCT) was able to confirm the synodic rotation period of Venus as $240 \pm 6\text{d}$.⁷ With a resolution of 2.4arcsec, the features *Asteria Regio*, *Beta Regio*, *Devana Chasma*, *Hyndla Regio*, *Navka Planitia* and *Phoebe Regio* were definitely identified from *Magellan* altimetry: see Figure 2. Gasparri was able to take the processing much further, and to entirely eliminate the albedo arising from surface topography by dividing images upon alternate days.

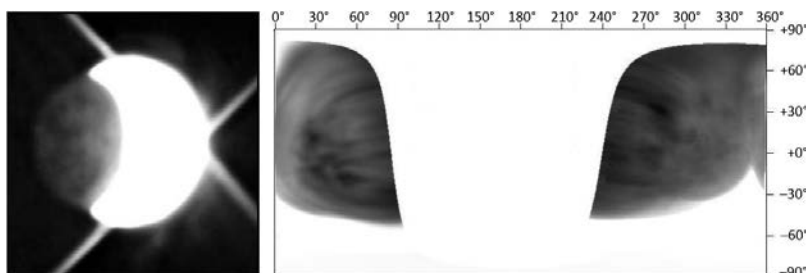


Figure 1. *Left:* The IR thermal emission (IRTE) and surface detail captured by G. & J. Ackermann with 317mm DK Cass., Schott 1000nm filter and AVT F033B camera, 2009 Mar 14d, 18:29 UT. *Right:* Surface map from all the 2009 IR thermal emission data by G. & J. Ackermann. North is uppermost.

After this some weak large-scale features – believed to be low latitude IR-absorbing clouds – remain (see Figure 3).

After IC, G. & J. Ackermann imaged surface details on Apr 11: see Figure 1 for the chart constructed from all their 2009 images. Kivits caught the dark side emission on Apr 18–May 18 (again, with the Sun well above the horizon), as did S. W. Massey on Apr 16–18.

IC 2010 Oct 29

No relevant images were submitted.

IC 2012 Jun 6

Before IC, success was achieved by Arditti (2012 May 22), J. Boudreau (May 20–24, with surface details), Gasparri (May 12, with surface details), T. Ikemura (May 18), Kivits (Apr 22–May 26), Melillo (May 12–20, with surface details; Figure 4) and Yunoki (May 18–22).

Following IC, the IRTE was captured by Kivits on Jun 30 & Jul 7.

Kivits reported the Asahi 990nm filter to be superior to the Schott 1000nm, and succeeded in imaging the IRTE in full daylight. He also got a positive result with an 807nm filter on May 14.

IC 2014 Jan 11

Prior to IC, successful work was done by Boudreau (Jan 1, with surface details), Ikemura (2013 Dec 1–2014 Jan 5), Massey (Dec 22–26), Melillo (Dec 18–28) and Wesley (Dec 12–25, with the rotation of surface details demonstrated; Dec 18–25, Figure 5).

No relevant images were submitted following IC.

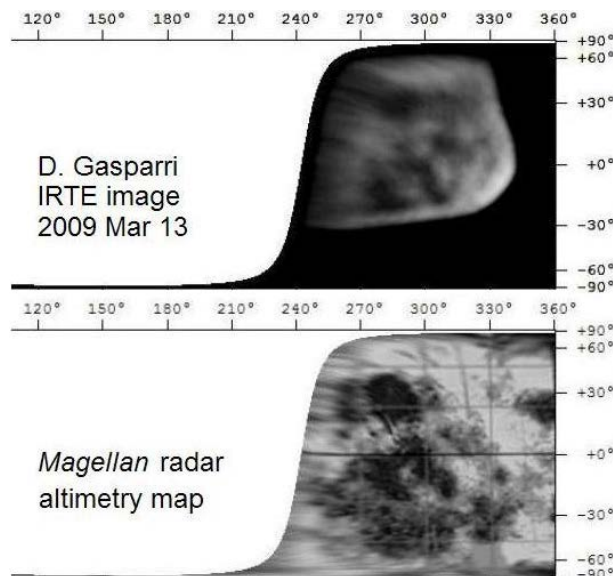


Figure 2. The IRTE and surface detail mapped by D. Gasparri, 2009 March (235mm SCT, ST-7XME camera, Schott 1000µm filter), with Magellan altimetry map. North is uppermost.

IC 2015 Aug 15

No relevant images were submitted.

IC 2017 Mar 25

Prior to IC, successful images were taken by Akutsu (Feb 16–Mar 16, with surface details; Figure 6), Arditti (Mar 2, with surface details), Boudreau (Mar 12, with surface details), Gasparri (Feb 18–19, with surface details; Figure 7), Melillo (Mar 5–12, with surface details) and Miles (Jan 25–Feb 8). Miles captured the IRTE two full months prior to IC. Gasparri combined his 2009, 2012 & 2017 IC work to identify and map nine surface features (Figure 7).

Gasparri again divided one night’s image by another to search for diffuse low clouds. Compared with IC in 2009, only a trace of such features could be detected: see Figure 3.

Following IC, and as already reported in detail elsewhere,⁴ the most remarkable work in this field for the Section to date was achieved by Miles and Wesley. They used a specially designed narrowband filter (BWHM 20nm) system in conjunction with a fully baffled, large-diameter instrument. Using this equipment, and obtaining greatly enhanced IRTE images, Miles and Wesley drew attention to a particularly bright spot near the equator and close to the boundary with the planet’s dayside. The spot is shown in a sequence of images in Figure 8, and

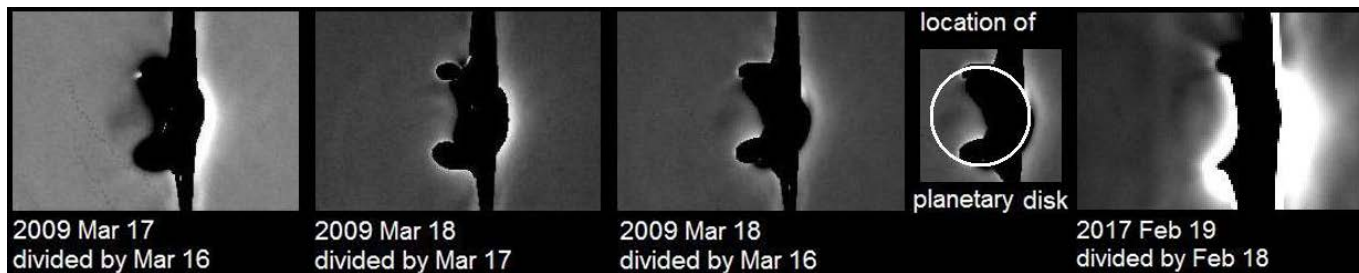


Figure 3. Large-scale clouds in the lower atmosphere of Venus revealed by D. Gasparri, 2009 March & 2017 February with 235mm SCT, ST-7XME camera, Schott 1000µm filter. In these reversed albedo images, the large vertical black structure is the vastly overexposed sunlit crescent of Venus. Faintly visible to the left is the IRTE from the dark hemisphere of Venus, from which the topography has been eliminated by dividing one image by another. North is uppermost.

compared with surface topography in Figure 9.

Measurement shows the bright spot was no larger than 700km in diameter: not being fully resolved, it could be much smaller. As already noted,⁴ the most exciting possibility would be an actual volcanic eruption, though interpretation of strongly processed images must always be done with care. *VEX* data show that cloud variability (perhaps of the type recorded by Gasparri) can cause significant variations in surface brightness, which observations at a fixed wavelength could not record; it is possible that this factor could account for the brighter feature.

The location of the bright spot illustrated in Figure 9 was in a lowland area just south of E. *Eistla Regiones* (centred upon 16°N, 40°E). A second, brighter spot a little way following the first one appeared to further brighten as it approached the Central Meridian (CM) on May 6 & 8. It has been remarked that the spots might be intrinsically warmer places on the planet's surface, and appear brighter when they are close to the centre of the disk because of the reduced path length through the clouds there.⁴

Discussion of IRTE results

The 2007–'17 data have revealed much more topographic detail than previously. The impressive image-processing skills of Gasparri revealed the presence of weakly absorbing low-altitude clouds. These were less evident in 2017 compared with 2009. This is interesting because Melillo, in reviewing his IRTE data for 2005–'17, quite independently concluded that its intensity was variable; he found it weakest at IC in 2009 compared with the later years, and perhaps strongest in 2012.

The infrared-bright spots captured by Miles and Wesley *might* provide evidence of active volcanism, in which case they would constitute a remarkable ground-based discovery.⁴ However, we must recall that these observations are of a delicate nature, requiring strong processing and hence great care in interpretation. On the other hand, in Part I we suggested that there was other evidence for some recent change in the planet's atmosphere, based upon bright cloud distribution and cusp extension data.¹ The long-running trend for a considerably higher percentage of bright clouds in the S. hemisphere was apparently reversed during 2017, while the degree of atmospheric scattering at IC in 2015 & 2017 was considerably less than in comparable earlier elongations. Of course, these types of observations may be unrelated.

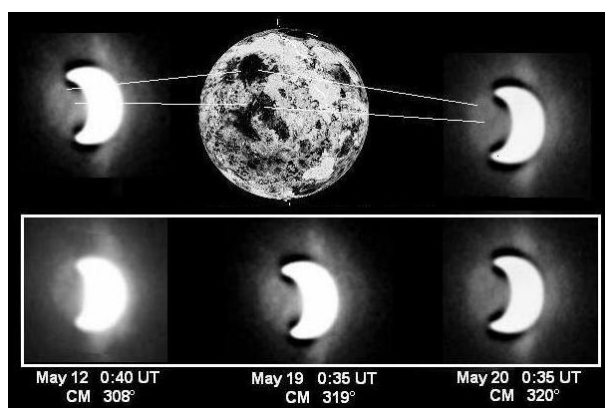


Figure 4. The IRTE and surface detail captured by F. J. Melillo, 2012 May 12–20 with 254mm SCT, StarlightXpress MX-5 camera, Schott 1 μ m filter, 14–15 images of 3s exposure at $f/10$. South is uppermost.

The Ashen Light

Too few visual observers followed Venus upon a dark sky: the Ashen Light (AL) is fainter than the twilight sky, so negative imaging records made during twilight can be of no possible value in disproving visual sightings taken against a dark background. Cusp extensions assist the eye to suggest an illusion of the nightside's presence, but nearly all positive AL sightings were made outside the period when there were significant extensions. In any case, close to IC the planet can never be

seen upon a dark enough background.

Elongations differ in favourability for making searches, as explained elsewhere.⁸ Many general reviews of the AL exist; we cite only Sheehan *et al.* (2014) here,⁹ while Gingrich (2014) suggests how lunar occultations might help resolve the problem.¹⁰

The AL is a visual waveband phenomenon. There are many different opinions upon the wavelength range of the human eye; we shall adopt $\lambda = 390\text{--}780\text{nm}$ as the extreme limits.⁶ The violet limit rises significantly in wavelength with age.

The most significant new development was again due to Gasparri, who imaged the AL in the visible waveband on 2012 Mar 12. For the most part, attempts to witness the phenomenon were visual ones. Adamoli, Baum, Gray, McKim, Macsymowicz and Niechoy often searched visually, while Gasparri and Kivits carried out valuable long exposure tests (see Part I, Table 1, for observer location and equipment). Niechoy's full results are preserved in the Section records: only a summary is given here.

Maksymowicz (joining us from 2009E) very frequently experienced the illusory form of the AL in daylight, but found that it exhibited a different focus to the crescent. He also recorded a degree of patchiness. W. H. Haas has observed such patchiness both inside the crescent as well as upon the surrounding sky, demonstrating that it is illusory.¹¹ As Macsymowicz recorded something other than the classic Ashen Light, we do not cite his daylight work, which may be seen at the ALPO Japan website.¹²

For those who insist upon a dark (or nearly dark) sky and a moderate to large aperture, we have positive AL sightings during 2007W, 2009E & 2012E. Niechoy was most impressed with it on 2012 Apr 24 where there was high contrast with the background. It was at 2012E also that Gasparri imaged the AL, on an evening when Adamoli made a positive visual record. To Niechoy, the AL appeared to show colour on a few evenings: *e.g.*, partly brownish or reddish on 2007 Jul 2, 2009 Jan 20 & 21, and 2012 Apr 22 & 24, *etc.* Adamoli saw the coppery tint several times (see below), and Longshaw also had one such impression.

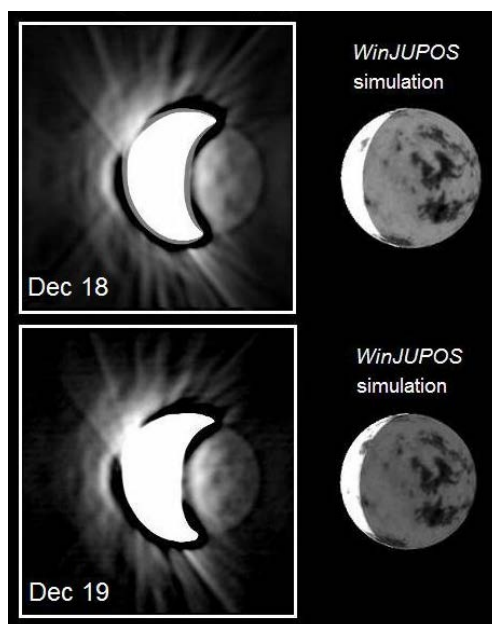


Figure 5. The IRTE and surface detail captured by A. Wesley on 2013 Dec 18d, 10:48 UT & Dec 19d, 09:50 UT. 406mm refl., ASI120MM camera with Thorlabs FELH 1000nm longpass filter; 60min at 7.5fps and 30min at 5fps respectively. South is uppermost.

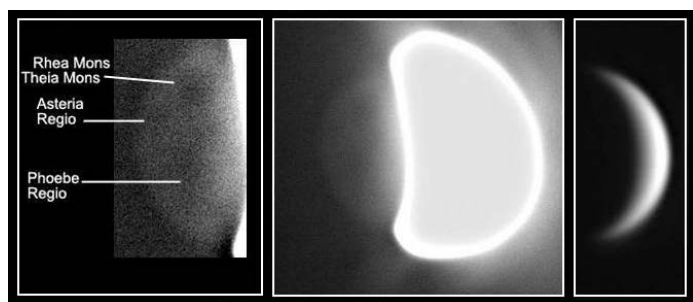


Figure 6. The IRTE and surface detail imaged by T. Akutsu on 2017 Feb 25d, 09:23 UT. 355mm SCT, ASI17MM camera and 970nm IR filter. The normally exposed crescent is shown on the far right. North is uppermost.

It was considered necessary to recount the observations in more detail than usual, in attempting to find a solution to the AL problem. Observations were made in integrated light (INT) unless stated. We list only sightings during twilight (T) or at night (N) – when the nightside appeared lighter than the background sky – and for which the observer seemed convinced. In the following text we have quoted the observers’ own designations of T and N, but the precise angle of the Sun below the horizon could be obtained from *WinJUPOS*. Times are quoted for the end of an observing session at an E. elongation and upon commencement at a western one. ‘OB’ signifies the use of an occulting bar, ‘a.v.’, denotes averted vision and ‘n.v.’ means ‘not visible’. Wrritten numbers of filters used are denoted by ‘W’.

IC 2007 Aug 18

2007E

With Venus some 8° south of the Sun at IC, conditions were not favourable. Some positive sightings came to hand only after the summary published at the time.⁵

Adamoli (125mm Maksutov-Cassegrain (MKT)) reported the AL on Jun 22 (19:30 UT (T)), ‘faint but definite’ with W25 and a.v. with the dark limb seen; Jun 25 (18:55 UT (T)), ‘rather easy’ with W25 and a.v. (on that date Niechoy did not observe in T or N); Jul 1 (19:20 UT (T)), faint with W25/15 and a.v. (not confirmed by Hancock 30min earlier; Niechoy did not observe in T or N) & Jul 9 (18:25 UT): faint, seen only with W25. However, Adamoli did not use an OB.

Niechoy (203mm SCT) had a few positive sightings: 2007 Jul 2 (INT, W25, 47, 20:38 UT (T)), 7 (W25, 20:14 UT (T)) & 13 (19:48 UT (T)), but these, like the others, were all in twilight only so there are no definite sightings at 2007E.

2007W

Gray saw the AL on Sep 23 (05:10 UT (T); certain) & 26 (05:00 UT (T);

glimpsed). The author immediately issued an alert to Section members on Sep 23. Gray secured further positive views on Sep 30 (05:20 UT, near the N. cusp only) & Oct 7 (05:20 UT, with patchiness noted). Gray found that only with the W22 filter could he see the AL; with the W23A stacked with it, contrast was better and the sky darker. A Baader Neodymium filter helped to darken the sky. An OB did not remove the positive impressions. Gray saw the AL complete except on Sep 30, and with some brighter areas. On the above dates Niechoy did not observe. Gray’s drawings feature in Figure 10.

Niechoy’s positive sightings were: Sep 17 (INT, W25, 47, 04:01 UT (T)), 19 (03:41 UT (T)), 21 (04:44 UT (T)), 24 (INT, W15, 25, 47, 03:59 UT (T)); Oct 8 (ditto, 03:37 UT (N)), 10 (ditto, 03:38 UT (N)), 15 (INT, W15, 25, 03:13 UT (N)), 17 (INT, W15, 25, 03:40 UT (N)) & 20 (05:03 UT (T)). Limited mostly to weekend viewing, Gray observed on only one of Niechoy’s dates: Oct 10 – Niechoy saw something upon a dark sky till 04:03 UT, but Gray saw nothing when commencing at 05:20 UT in twilight. So there is no confirmation, but also no contradiction.

Gray did not see the AL at any other elongation: he did not cover many of them (Table 1). During 2012E he searched on several evenings against a dark sky, and tried to induce an illusion with his binoviewer attachment and different eyepieces. On no occasion was there any suspicion of the AL, with or without OB. To avoid any effect of the secondary mirror (which, in his Dall-Kirkham Cassegrain (DK Cass.), is attached to an optical window rather than by spider vanes) he also tried a 15cm off-axis mask. As he did

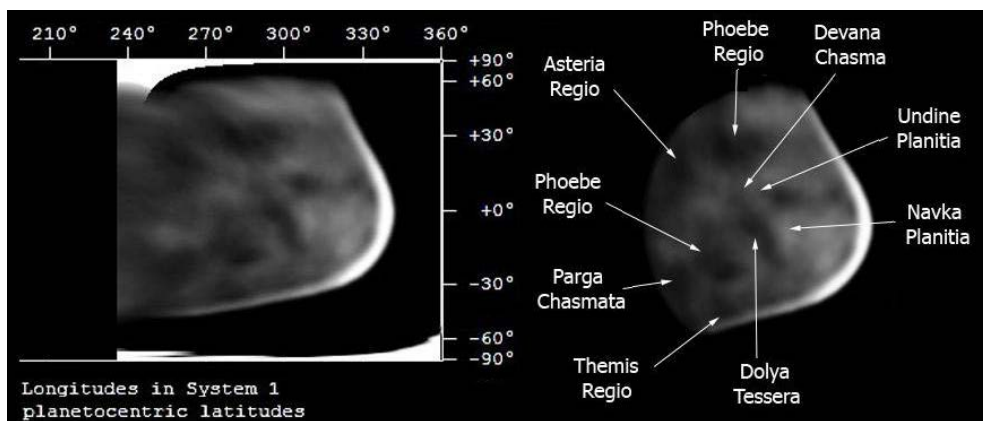


Figure 7. Synthesis of IRTE work for 2009, 2012 & 2017 by D. Gasparri (see Figures 2–3), showing nine identified surface features.

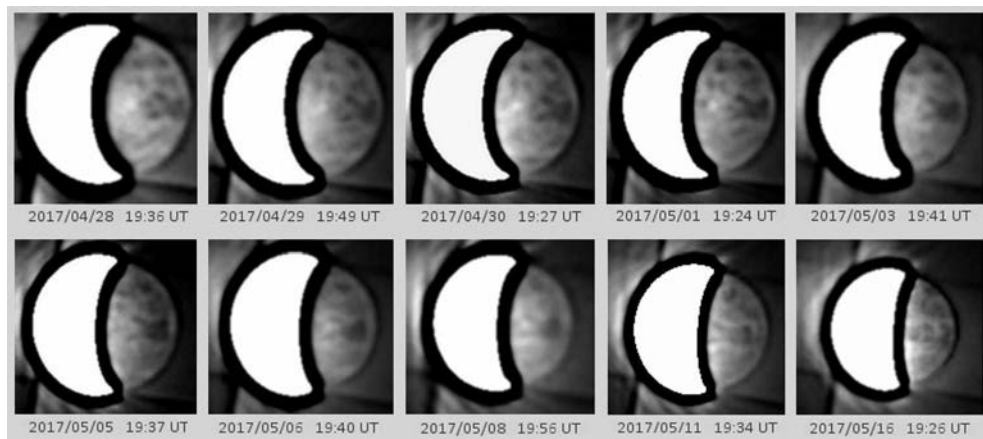


Figure 8. Images by P. Miles and A. Wesley, 2017 April 28–May 16. 508mm refl., GS3-U3-32S4M (mono) camera and 1000–1020nm narrowband IR filter. The sunlit crescent (calculated phase rising from 0.25 to 0.39) is heavily overexposed, and a specific bright feature is visible in the first four frames. Other such features may also be present. North is uppermost.

not change his equipment during the interval, we have to treat his 2007W sightings seriously.

IC 2009 Mar 27

2009E

This elongation offered an excellent chance to search for the AL against a dark sky.

Niechoy's positive records were:

2009 Jan 11 (INT, W25, 16:57 UT (T)), 16 (INT, W15, 17:17 UT (T)), 20 (INT, W15, 17:36 UT (N)), 21 (INT, W15, 17:51 UT (N)), 25 (INT, W15, 25, 47, 16:48 UT (T)), 28 (INT, W25, 47, 17:43 UT (T/N)); Feb 3 (INT, W15, 25, 47, 17:30 UT (T)), 5 (16:42 UT (T)) & Mar 17 (18:12 UT (T)).

Adamoli made several positive sightings against a dark sky, with OB and/or W25 filter: Feb 19 (18:00 UT, faintly and occasionally glimpsed), Feb 27 (18:20 UT, ditto); Mar 6 (18:00 UT, ditto), 9 (18:45 UT, more certain), 12 (18:40 UT, very faint but convincing) & 16 (18:40 UT, glimpsed; clouds interrupted).

It is good that Adamoli was convinced by his sighting of Mar 12, for on that same evening, Gasparri was taking both visible and IR images, with a 235mm SCT & ST-7XME camera.² Using a Schott BG38 filter, with peak transmission *ca.* 550nm and passband 300–700nm, every 1s exposure weakly showed the AL (estimated at *ca.* 12mag/arcsec² with the aid of a field star) and some large-scale detail, though the darker area captured did not precisely match the *Beta Regio–Phoebe Regio* features shown at 1µm. All frames showed the albedo detail, irrespective of the field orientation or the position of Venus upon the camera chip. Gasparri combined the BG38 with an IR blocking filter (see Figure 11).

Baum suspected the AL on Feb 25 (18:10 UT) & 27 (18:15 UT) in twilight. On Mar 20 (18:40 UT) & 21 (19:16 UT) – in twilight – he felt the dark side was lighter than the sky at the unilluminated limb, but this time attributed it to dispersion at low altitude. McKim observed until 19:15 UT on Mar 20 and did not see the AL.

On Mar 10 (19:15 UT), Longshaw found the unilluminated hemisphere slightly visible in the south, but Baum and McKim saw nothing. Longshaw reported a hint of illumination on Mar 18 (18:15 UT): McKim recorded an impression of the dark hemisphere that evening (18:45 UT), but found it to be an illusion. Now that the cusps had become significantly extended (see Part I),¹ such illusion was facilitated. On Mar 23 (18:50 UT), Longshaw reported a coppery tint to the dark side.

In summary, the AL was reported by both Adamoli and Baum on Feb 27; the sky was adequately dark in some of the other positive observations. However, the most remarkable result must be the simultaneous imaging by Gasparri and the eyepiece sighting by Adamoli on 2009 Mar 12.

2009W

Niechoy made one positive sighting, on May 23 (02:53 UT (T)). Macsymowicz observed on May 23 from 03:20 UT onwards, but without seeing the AL upon a brighter sky.

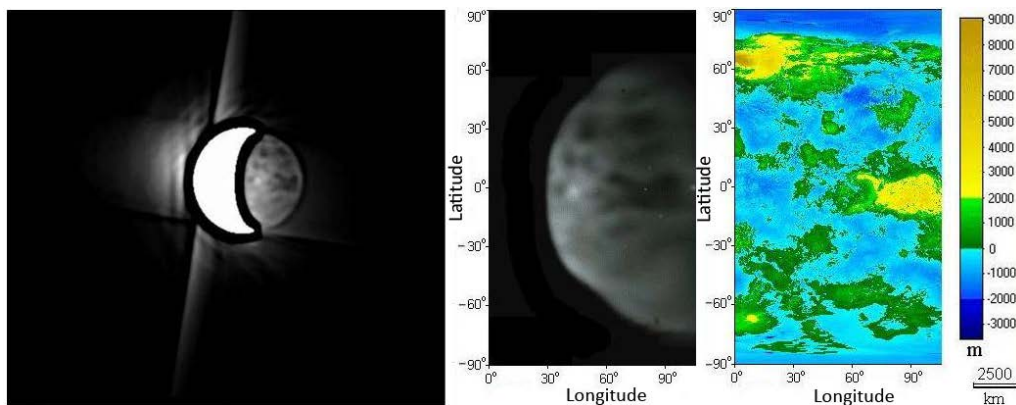


Figure 9. A comparison of the bright feature imaged by P. Miles and A. Wesley on 2017 May 1d 19:24 UT with *Magellan* altimetry: it just follows the central meridian and is located within *Eistla Regiones*. System I longitude at 19:24 UT was 37.1° (*WinJUPOS*). North is uppermost.

IC 2010 Oct 29

2010E

Niechoy's single positive sighting was: 2010 Jul 15 (W25, 20:21 UT (T))

2010W

Niechoy's positive sightings: Nov 12 (05:58 UT (T)); Dec 3 (05:56 UT (T)), 4 (INT, W15, 06:09 UT (T)) & 10 (05:57 UT (T)).

IC 2012 Jun 6

2012E

Niechoy's positive sightings were: 2012 Feb 6 (17:02 UT (T)), Mar 6 (W25, 17:20 UT (T)); Apr 14 (W15, 20:04 UT (N)), 22 (21:00 UT (N)) & 24 (21:50 UT (N)); and May 8 (INT, W15, 25, 20:38 UT (T)). Niechoy was particularly impressed with the effect on Apr 24,¹³ and he immediately e-mailed that another observer – G. Lampert – had confirmed it at 20:00 UT, also with evidence of warm colour. By 21:50 UT, Niechoy could see the whole disk of the planet.

At 21:00 UT on Apr 24, Arditti could not see the AL visually under poor conditions (however, he did not use an OB), while the author's work was curtailed by cloud after 19:00 UT. Following the positive report by Niechoy, an email alert was issued next day, but the visual observers logged negative impressions that evening.

Gray searched on several evenings (Apr 13, 15 & 23; May 4, 5, 12, 15 & 20), without seeing the AL upon an adequately dark sky. Parker heavily overexposed the crescent on Apr 26 with a negative result. With one exception, no-one reported any sighting on those dates.

Venus was well-placed to Adamoli (235mm SCT, ×470). Glimpses of the AL in April were tentative. April 26 (20:15 UT): seen in INT with and without OB; very faint, held only for instants. However, the dark side limb from the N. pole to the equator looked rather sharp, its southern part less so; equally faint in W25; n.v. with W44A. Apr 27 (19:50UT): though very faint, quite definite AL with and without OB; coppery; well defined limb, harder to observe with W25; n.v. in W44A.

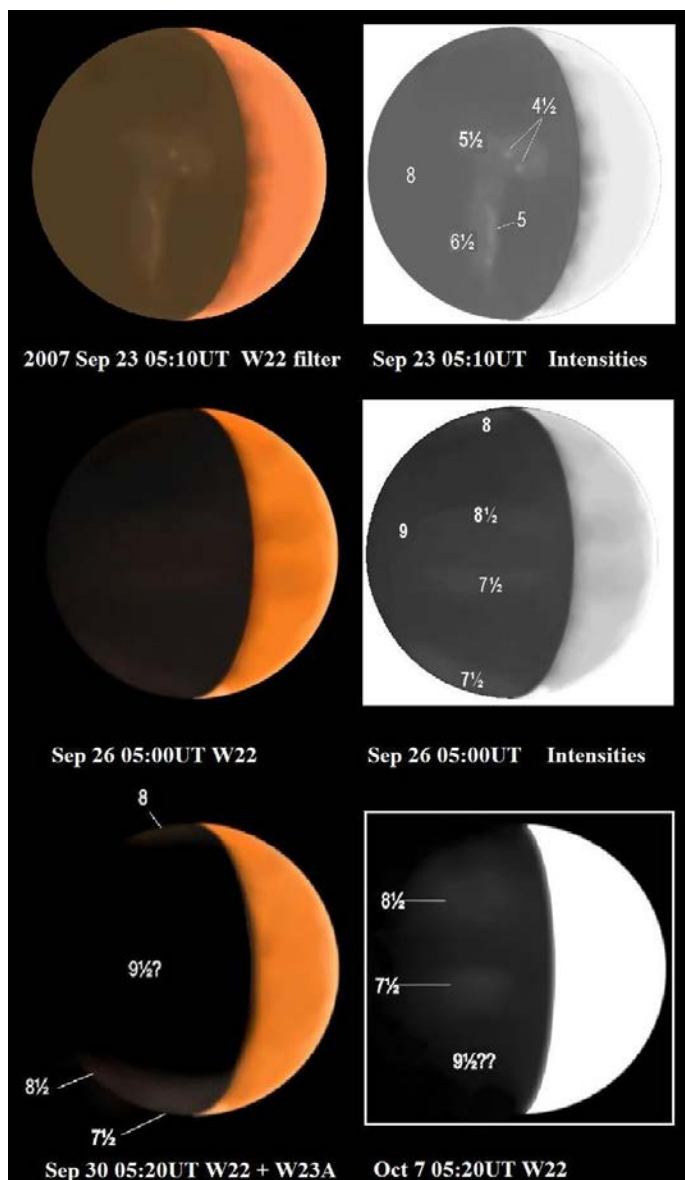


Figure 10. Drawings showing the Ashen Light by D. Gray with 415mm DK Cass. $\times 365$, at the 2007 W. Elongation. The Wratten 22 filter (and, for some, the W23A filter also) was used in conjunction with a Baader Neodymium filter to darken the background sky. South is uppermost.

In early May the AL became more obvious to Adamoli. Its presence was betrayed by the outline of the dark limb against the sky. May 2 (20:10 UT): with OB, AL rather easy, though not prominent; coppery, limb well defined, confirmed but faint with W25. May 4 (20:15 UT): like May 2; dark hemisphere vaguely coppery; mottling suspected, confirmed but faint with W25. The best view was on May 9 (20:00 UT): AL rather obvious, brighter near the terminator (if not an irradiation effect), well-seen with OB, homogeneous, coppery; dark limb distinctly traceable and obvious with W25, but faint with W44A. By moving the scope north–south, keeping the lit crescent just hidden by the OB: ‘the dark limb in motion acquired ‘life’, so to say, better than in a static view’.

Thus the only contradiction with Gray was on May 4, though the planet was higher to Adamoli. A negative report from Dobbins (USA) was not at a comparable time: on April 24, 25 & 26 he observed Venus with a 254mm MKT upon a dark sky without suspecting the AL. However, Brasch and Sheehan (USA) thought the dark side partly visible through a red filter on Apr 29/30 (03:00–

04:00 UT). Withers also had a negative view (356mm SCT, $\times 150$) on May 22 (19:15 UT).

Having succeeded with the IRTE, Kivits began to take deep visual band images, and the author stressed to him the need for a dark sky. He was surprised to obtain a faint image of the entire disk using a broadband red filter (620nm, bandwidth half-maximum (BWHM) 60nm), broadband green filter (540nm, BWHM 60nm) and narrowband green filter (450nm, BWHM 10nm). Originally sceptical, he came to conclude he had imaged the AL.¹⁴ Subsequent laboratory scans (by van Kranenburg) of the narrowband green filter clearly showed a small infrared leak, so I have not included positive sightings with that filter. However, evidence from broadband red and green remains.

Nothing was recorded on May 7, and earlier images were unfortunately not taken upon a dark sky. The AL looks to be visible upon the red and green images from May 11, 12, 13, 14 and possibly May 16 (when he took a red image only); probably not on May 22. On May 14 he also succeeded with a 680nm filter. After the discovery of the IR leak, Kivits considered the image of the dark side with the other visible waveband filters might have been part of the glare from the dayside of Venus, but he could never be certain. The sharpness of the dark limb in several images seems significant to the author.

Concluding, there was some visual evidence of the AL at 2012E, and even some tentative images in red and green light. In the ‘Discussion’ section, a correlation is considered between the 2012 sightings and solar coronal mass ejections.

2012W

Niechoy made no positive sightings, while Adamoli did not observe the planet against a dark sky.

IC 2014 Jan 11

2013E

Niechoy’s positive sightings: 2013 Dec 10 (16:13 UT (T)) & 16 (15:51 UT (T)). Adamoli reported the AL both with and without an OB on Dec 29 & 31 (very faint, dark limb visible). There was no mutual confirmation.

2014W

No definite reports of the AL at twilight or upon a dark sky were received: this elongation was thinly observed.

IC 2015 Aug 15

2015E

Niechoy’s positive sightings: 2015 May 18 (20:59 UT (N)), Jun 24 (INT, W25, 21:00 UT (T)), 29 (20:51 UT (T)) & 30 (W15, W25, 20:17 UT (T)). May 18 is a very unusual time for an objective AL report, occurring before dichotomy. McKim saw nothing earlier that evening, but his sky was not dark enough. On Jun 29 & 30 McKim could not see the AL upon a similar twilight sky.

In full daylight during 2015 Jul 11–Aug 10, Adamoli had the persistent impression of being able to see the dark limb, but dismissed it as illusion.

We conclude that only the May 18 sighting might be objective and the others cannot be accepted.

2015W

Niechoy obtained positive records on Sep 23 (INT, 04:45 UT (T)), Sep 30 (INT, W15, W25, 03:11–03:41 UT (N/T)), when it looked reddish-brown; Oct 1 (INT, W15, W25, W47, 03:44–04:22 UT (T)), Oct 2 (INT, W15, 03:37–04:16 UT (N/T)), Oct 3 (INT, W15, 04:49–05:48 UT (T)), Oct 4 (INT, 05:11 UT (T)), Oct 12 (INT, 02:45–03:29 UT (N) & Oct 13 (INT, 02:49–03:03 UT (N)). A few later sightings close to dichotomy can probably be discounted. Adamoli again was impressed by the dark limb illusion on Aug 30, but there were few other visual observations for this elongation.

IC 2017 Mar 25

2017E

Niechoy did not see the AL upon a twilit or dark sky. Palgrave (UK) searched with a large aperture (0.5m refl.) fitted with an occulting bar, under conditions of nautical twilight or better during Feb 24, 27, 28, Mar 2, 7, 9, 13 & 15. These important results were also entirely negative.

Adamoli (Italy) used a 235mm SCT with OB. Positive AL sightings were obtained on Feb 14 (doubtful), 18, 25; Mar 1 & 10: no overlap with the foregoing negative series. He summarised: ‘My latest Feb–Mar AL sightings were thrilling experiences. They began with doubtful views when the crescent was still rather fat, but the AL appeared more and more convincing in the next weeks, until Venus became too low in the sky and no more observable in a reasonably dark sky.’ In early March he experienced on two occasions ‘the transition from broad twilight – when nothing could be seen – through an intermediate phase of uncertainty; until the sky was much darker, and the AL came up as obvious, I dare to

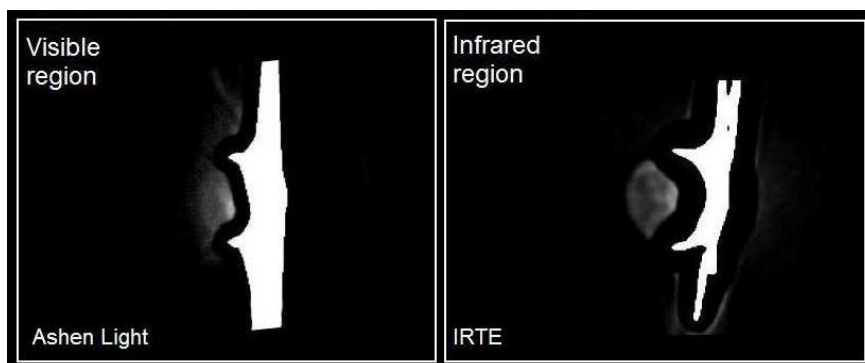


Figure 11. Images of the Ashen Light (left) compared with the IRTE (right) by D. Gasparri, 2009 Mar 12. 235mm SCT, ST-7XME camera with Schott BG38 550nm filter; IR blocking filter (left) and Schott 1000 μ m filter (right). The right-hand image has been degraded in resolution. The white vertical structure is the highly overexposed sunlit crescent. North is uppermost.

say. I started to perceive it in mid-twilight.’ This condition was reached ‘when the Sun was still about 6° below the horizon, say at the start of nautical twilight – other conditions being favourable ...the planet at least 20° high, and good air transparency.’ With OB, the AL was best seen on Feb 18 & 25, appearing as a very faint reddish or purplish glow, with the dark limb traceable (yet no cusp extensions). Earlier in the evening on Mar 1 he had experienced the illusory ‘dark side darker than sky’ effect, but the positive AL effect appeared as the sky darkened.

The advantage of lower latitude is obvious. Giuntoli (Italy) on Mar 11 at 17:30 UT also suspected the AL upon a twilight sky.

McKim did not see the AL during his observation on Feb 18, but he did not have such a dark sky background as Adamoli. In summary, we have no contradiction and no confirmation.

2017W

Niechoy did not see the AL with certainty at the crescent phase. Adamoli noticed the illusion of the dark limb being very faintly visible on Mar 31 & Apr 16, but did not see the true AL.

Discussion of Ashen Light results

Prof F. W. Taylor has recently elaborated his earlier hypothesis that the AL may simply be a weak visible component of the surface IRTE,^{15,16} and reiterates his opinion

that its occasional mottled texture represents absorption by lower clouds of sulphuric acid. Gasparri’s imaging reveals the existence of these variable lower clouds. Taylor and the author insist upon a truly dark sky for any possible detection of this ‘threshold’ phenomenon. As Taylor notes, there is little literature concerning the minimum temperature at which a dark-adapted eye can detect a feebly glowing object.

Glass furnace temperatures would seem a meaningful source for comparison, and the emissivity of glass should resemble that of the silicate-rich Venusian surface. According to Giffin,¹⁷ the

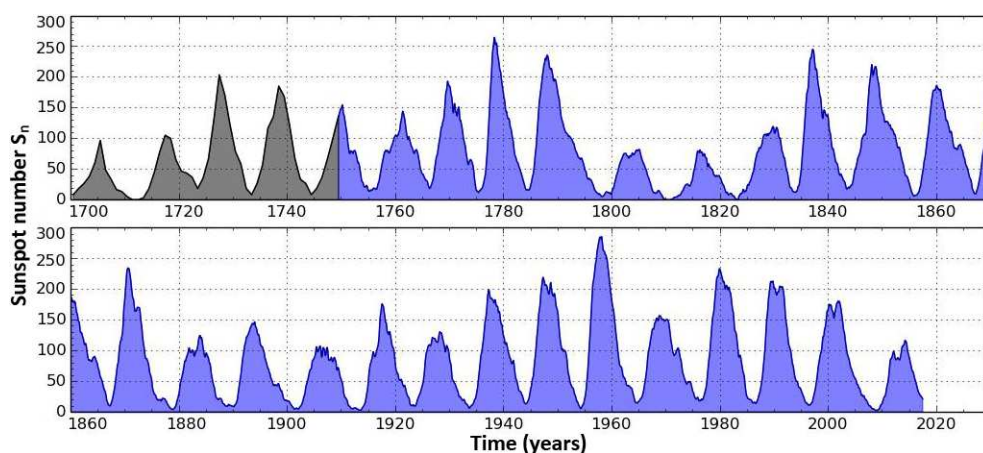
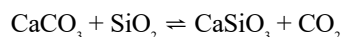


Figure 12. International sunspot number S_n from 1700 up to and including 2018 January. SILSO Graphics (<http://sidc.be/silso>); Credit: Royal Observatory of Belgium.

lowest intensity red glow of the glass furnace is 475°C (or 748K, though the source rounds temperatures to the nearest 5 degrees). The significance to glassmaking of 475°C may be that it is also the temperature at which red lead oxide decomposes; Pb₃O₄ is introduced into the melt in lead glass production, and the oxygen so produced conveniently prevents the unwanted formation of metallic lead.¹⁸ Furnace temperature information can also be found online.¹⁹

Although some surface temperatures earlier reported by spacecraft may be a little too high, being based upon brightness temperatures (assuming 100% emissivity), the mean surface temperature of Venus is reliably quoted as 740K,²⁰ being nearly identical to the ‘lowest visible’ furnace temperature. At this temperature the following reversible reaction contributes to the maintenance of a surface equilibrium pressure of *ca.* 90atm:^{21,22}



This reaction recycles carbonate rocks in oceanic trenches beneath the Earth, and generates slag in our blast furnaces.

Venus Express showed a temporal variation in surface temperatures for some areas, suggestive of ongoing volcanism. Any enhanced activity might attain the threshold temperature for visibility. Very recent studies, announced in 2014,²³ indicate that there may be active lava flows (warmer than their surroundings) upon the surface even today. From *VEX* data Shalygin *et al.* (2015) found considerably higher local temperatures in infrared bright areas,²⁴ thought to be lava fields from active volcanoes. Taylor comments: ‘It seems possible that there might be enough of these ‘hot spots’ scattered across the disk to produce the light that observers see from the Earth’.²⁵ The variations in the AL (and, sometimes, its complete absence) would then be explained by a combination of sporadic volcanic activity, cloud thickness variations, and observational selection. To this background we can now add the remarkable observations of Miles and Wesley at IC in 2017,⁴ which revealed several compact bright spots which might provide further evidence for ongoing volcanic activity.

If the above is not the explanation of the AL, we are forced to consider airglow, lightning, or auroral effects. It has been known since *Venera* in 1975 that dayside photolysis of carbon dioxide generates atomic oxygen radicals. Transported to the nightside, they recombine into oxygen molecules with the emission of visible and infrared radiation.²⁶ The question is whether this radiation, or the alternative scenario involving lightning, could ever be intense enough to see from Earth.

We received very few convincing reports of the Ashen Light (AL) in the last few decades, although the strong evidence gathered in the past by many observers, particularly in 1953, 1956 & 1957–'58, cannot be easily discredited. Hedley Robinson demonstrated for 1956–'72 that there was no direct relationship between the *annual* sunspot number and the *annual* number of AL sightings,²⁷ but we cannot discount the effect of *specific* solar events.

A solar maximum occurred in 2014, but Figure 12 shows that it was unusually weak. In any case, Venus was badly placed for our observers in 2014. Even in some years of high solar maxima the AL was reported rarely, but during the exceptional 1957–'58 maximum the Section received the highest ever number of sightings, with ten or more observers, often with multiple reports each evening, for a fortnight from 1957 Dec 29 onwards.²⁸ In their work on solar flares, Smith & Smith (1963) wrote:²⁹ ‘During the record

maximum in 1957–'58, the Sun’s visible hemisphere produced a detectable flare every 20 to 25 minutes’, though great flares were much less common. Such an association of the AL with the 1958.2 solar maximum could be significant, as has often been suggested in the past, but with observational selection playing such a strong role it could also be fortuitous. Several sources list solar maxima and other statistics.³⁰

The 558nm green emission line of oxygen in the atmosphere of Venus is known to be very variable, and according to Gray *et al.* (2013),³¹ can become especially strong when a coronal mass ejection (CME) causes the solar magnetotail to become extended beyond the planet. The authors refer to the detection of the green emission line just after a CME impact on 2012 Apr 22, and note that the line was typically seen in the Venusian atmosphere a short time after a CME. Flare events that did not lead to CME did not excite the emission line. This gives greater significance to the positive AL sighting by Niechoy and Lampert of 2012 Apr 24, as well as to Adamoli’s of Apr 26–May 9. A later CME event from 2012 July occurred post-IC, when our coverage of the 2012 W. elongation was patchy.

As to other interpretations, older studies of Venus yielded still more exotic solutions.^{32,33}

The Ashen Light has been dismissed by many contemporary writers (and even by some observing groups) as 100% illusory, but realistic explanations exist. For the glowing surface theory, which the Director favours, we have the imaging work of Gasparri and the parallel visual sighting by Adamoli on 2009 Mar 12, while for the oxygen green emission line theory we have the strong correlation between a CME impact of 2012 Apr 22 and the visual sightings. The remarkable terminator projections observed on Mars during 2012,^{34,35} involving the illumination of material at altitudes of up to 200km, are now widely attributed to the impact of CME events (effective even at the distance of Mars from the Sun).

Only dedicated continued observation will bring a final solution to the long-standing Ashen Light mystery.

Acknowledgements

The many observers who contributed to these and earlier reports by the author are thanked for their tireless contributions that sometimes extended over decades. The ephemerides generated by Jean Meeus were also of great value. The reader will be forgiven for thinking that there were three different planets under observation here: the Venus revealed by IR imaging, the one revealed in UV work, and the one seen through the eyepiece. But each type of observation yields different information, so each is relevant and welcome.

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

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