The 2019–'20 eastern elongation of Venus, Part I: Observations of the dayside

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A report of the Mercury & Venus Section. Director: P. G. Abel

This report covers observations of Venus made by Section members during the 2019–'20 eastern elongation. Part I covers observations of the dayside; various features are discussed, including cloud formations and unusual atmospheric phenomena which occurred during this time. Using phase estimates, a date for dichotomy is established, and observations made near inferior conjunction are examined.

Introduction

The 2019–'20 eastern elongation of Venus was an excellent one for observers based in the northern hemisphere. From January to early May, the planet dominated in the evening skies and its high altitude made it easily accessible. With most people confined to their homes due to the COVID-19 coronavirus pandemic, amateur astronomers made good use of their enforced increase in telescope time, which resulted in a large volume of observations being communicated to the Director.

The elongation began on 2019 Aug 14, when Venus passed through superior conjunction. The planet was visible in the evening skies for the last part of 2019, when it was rather low down for UK observers, but well placed for southern hemisphere astronomers. By the start of 2020 it was becoming better placed, and observations started to increase. The planet reached greatest eastern elongation on 2020 Mar 24, with theoretical dichotomy predicted for 2020 Mar 26. As we shall see, observed dichotomy took place four days earlier.

The planet then continued to move back towards the Sun, until it came to inferior conjunction on 2020 Jun 3. It subsequently reappeared in the morning sky, marking the start of the 2020–'21 western elongation, when the planet was well placed for observation in the morning sky for northern hemisphere observers.

Coverage of the 2019–'20 eastern elongation was particularly good; regular observations were received from 48 Section members. Their names, along with details of the instrumentation and locations, are given in Table 1. It is pleasing to see a small increase in the number of visual observers for this elongation, and the Director is happy to report that a number of members new to the Association contributed UV images. Many high-quality IR and UV images were communicated to the Director throughout the elongation, as were some well-executed drawings.

Upon reviewing and analysing the observations received, it became clear that Venus has been unusually dynamic during this elongation. Various anomalous atmospheric phenomena were recorded, along with unusual appearances of the terminator and cusps. A small number of experienced observers obtained striking images close to inferior conjunction and some also had success in imaging the nightside of the planet.

With so much material to cover, it has been necessary to split this report into two parts. The first deals with the analysis of observations concerning the sunlit hemisphere, while the second will be devoted to observations of the nightside.

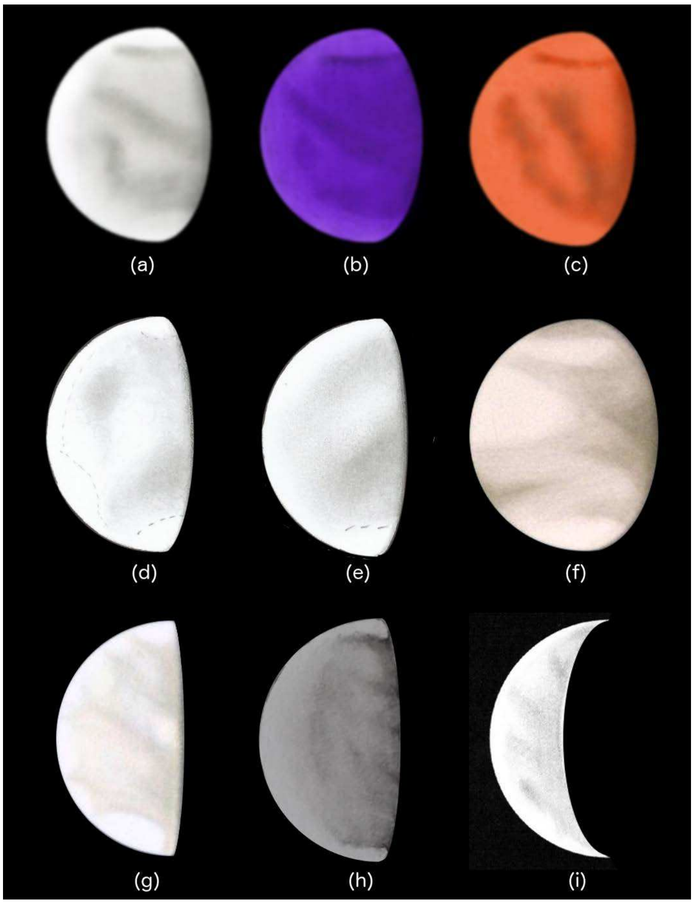

Figure 1. A selection of drawings showing some interesting cloud formations.

(a), (b) & (c) 2020 Jan 15, 203mm Newtonian reflector, ×111. Respectively: 16:32 UT (IL), 16:39 UT (W47) and 16:50 UT (W21). *Paul G. Abel*

(d) & (e) Respectively: 2020 Feb 27, 17:35 UT and 2020 Mar 1, 17:25 UT. 76mm OG, ×120. *Richard McKim*

(f) & (g) Respectively: 2020 Jan 12, 16:00 UT and 2020 Mar 8, 18:00 UT. 300mm SCT, ×378. *Chris Nuttall*

(h) 2020 Feb 29, 16:30 UT; 230mm MCT, ×200. *David Graham*

(i) 2020 Apr 24, 17:10 UT; 216mm Newtonian, ×153 & 276. *David Fisher*

The images and drawings presented here are a small number of those submitted to the Section. However, many 'raw' observations (ones which have not been analysed in any way) can be found in the Section newsletter, *Messenger*, covering this period.[1,2] Unless otherwise stated, the convention of putting south at the top is followed in all images and drawings.

Cloud features

In earlier times, Venus acquired a reputation for being a bland world, with little to see in the way of features. While it is true that those visual observers sensitive to shorter wavelengths are more likely to see any compelling atmospheric details, in the last few years a number of UV filters have become available, allowing imagers with modest apertures to capture striking cloud formations in the Cytherean atmosphere.

Both visual and digital observers recorded unusual cloud formations. The cloud markings on Venus tend to be a mixture of streaks, brighter spots, variations on well known 'Ψ markings',[3] and occasionally more subtle features. During this elongation, it seems to have been the case that the more subtle markings and cloud structures were observed visually along with a number of brighter spots, as can be seen in Figure 1.

The atmospheric features of Venus are most accessible at shorter wavelengths and, as a result, imagers who possess UV filters generally capture the most detail. Many of the Section's digital observers do possess such filters and as a result, unusual, intricate cloud formations were captured during the elongation.

Figure 2 gives a selection of the more notable cloud patterns. Wesley's images (Figure 2b & c) show some of the most striking formations the Director has seen in amateur photographs. Two colour images of the planet were made by Casquinha and Peach (Figure 2k & l).

On 2020 Mar 22, Manos Kardasis communicated to me his observations of a highly unusual wave-like structure in the atmosphere of Venus, which he had imaged on the previous day (Figure 3). This remarkable bow-shaped wave had previously been recorded by the Japanese *Akatsuki* spacecraft; an analysis of the observations made by Kardasis and other amateur imagers can be found in a 2020 paper by McKim, Kardasis and the Director.[4] In that paper we note the very slow drift of the feature with respect to the surface and conjecture a volcanic origin for the phenomenon.

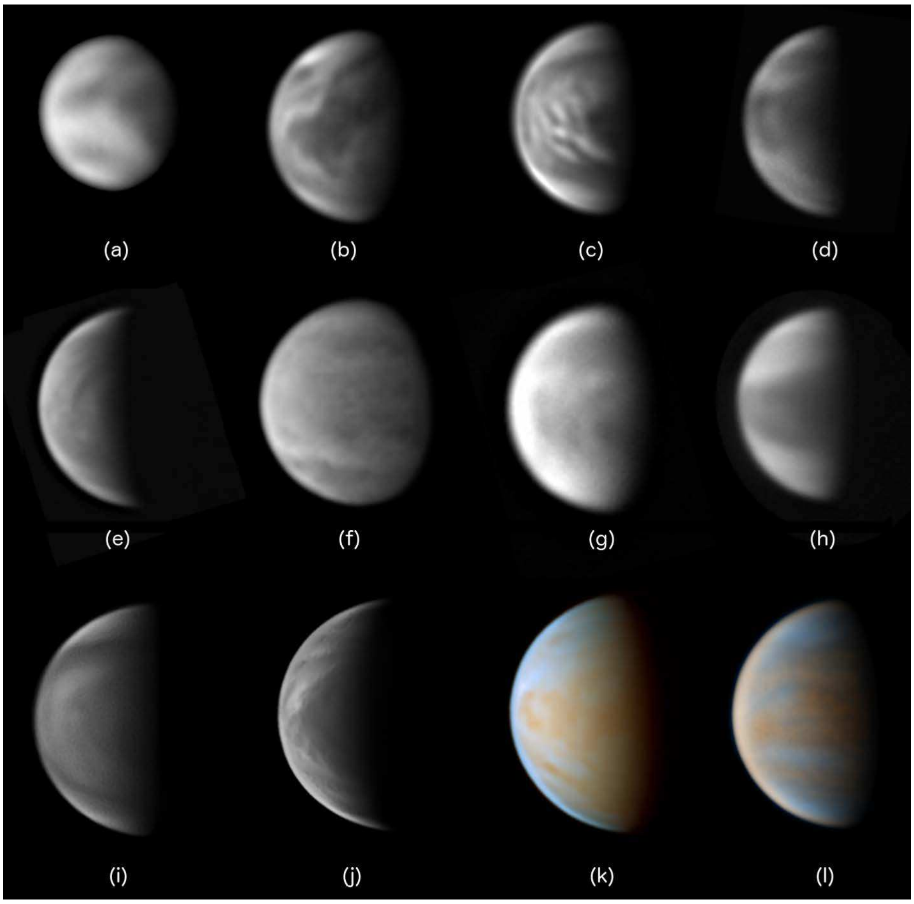

Figure 2. A selection of UV images made by Section members, showing some striking cloud formations in the Cytherean atmosphere.

(a), (b) & (c) Respectively: 2019 Nov 24, 08:14 UT; 2020 Feb 1, 08:36 UT and 2020 Feb 17, 08:39 UT. 410mm Newtonian reflector, UV (325–375nm). *Anthony Wesley*

(d) 2020 Mar 9, 18:43 UT; 279mm SCT and Astrodon UV filter. *Miguel Araújo*

(e) 2020 Apr 4, 18:27 UT; 180mm Mak–Cass. and Baader UV filter. *Chris Dole*

(f) 2020 Jan 20, 15:04 UT; 356mm SCT. *Simon Kidd*

(g) 2020 Feb 6, 17:19 UT; 300mm SCT and Baader UV filter. *Bill Leatherbarrow*

(h) 2020 Mar 5, 18:03 UT; 300mm SCT and Baader UV filter. *Bill Leatherbarrow*

(i) 2020 Mar 16, 19:03 UT; 220mm Newtonian and Baader UV filter. *Craig Towell*

(j) 2020 Apr 9, 18:48 UT; equipment as given for (i). *Craig Towell*

(k) 2020 Feb 26, 17:56 UT; 356mm SCT. *Paulo Casquinha*

(l) 2020 Feb 26, 00:08 UT; Chilescope. *Damian Peach*

Terminator

Throughout the elongation, the terminator appears to have been geometrically regular in both images and visual observations. It is not uncommon for some observers to report slight irregularities to it near the time of dichotomy; this is thought to arise due to the presence of dark clouds on or near it at that time.

The most interesting phenomenon concerning the terminator during this elongation was the presence of the 'cusp terminator anomaly' – a name first introduced by the Director. Usually, the terminator follows a well-defined ellipse from pole to pole; however, during April and early May there was a notable deviation at the cusps, whereby it appeared much flatter there than usual. This was the anomaly and observations of it are given in Figure 4.

The Director first observed the phenomenon on 2020 Apr 24, when the effect was quite notable, visible in both white light and

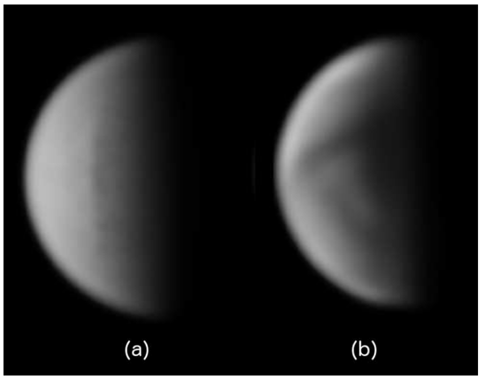

Figure 3. The wave-like phenomenon in the atmosphere of Venus. The wave was only visible in IR as can be seen in these two images obtained by Manos Kardasis on 2020 Mar 21. **(a)** 17:35 UT, IR (0.9μm). **(b)** 17:42 UT, UV.

with a W15 (Wratten number) filter (Figure 4d & e). The Director contacted Leatherbarrow, who had clear skies in Sheffield: He was able to confirm the effect visually and successfully capture an image of the phenomenon, as can be seen in Figure 4b. Leatherbarrow also produced an over-exposed IR image which greatly emphasises the effect, as shown in Figure 4c. McKim observed the planet earlier in the evening and his drawing appears to show a similar, albeit somewhat more muted, effect (Figure 4f). The anomaly also seems to be faintly present in an observation made by Aerts on 2020 Apr 20 (Figure 4a).

The Director next observed the phenomenon on 2020 May 6 and it seemed to be strongest in the W21 (orange) filter, particularly at the southern cusp (Figure 4h–k). Interestingly, Foulkes took an image in IR on the previous evening (2020 May 5) which appears to show the anomaly quite nicely (Figure 4g). These observations would seem to imply that the anomaly was most apparent in IR and longer wavelengths. This appearance of the cusp caps is not new – upon reviewing past elongation reports, one can find many instances of the phenomenon, usually when the phase of the planet is between 40 and 50%.

There are a number of possible explanations for the anomaly. We know that the polar areas of Venus are very dynamic regions and recent discoveries using the ESA *Venus Express* spacecraft have revealed the existence of powerful atmospheric waves there.[5] Other observations from *Venus Express* imply the existence of anomalous cloud particles. Wilson *et al.* (2008),[6] based on data from the VIRTIS-M instrument, find cloud particle sizes increase sharply in the polar vortices. The authors also note that there is variation in the composition

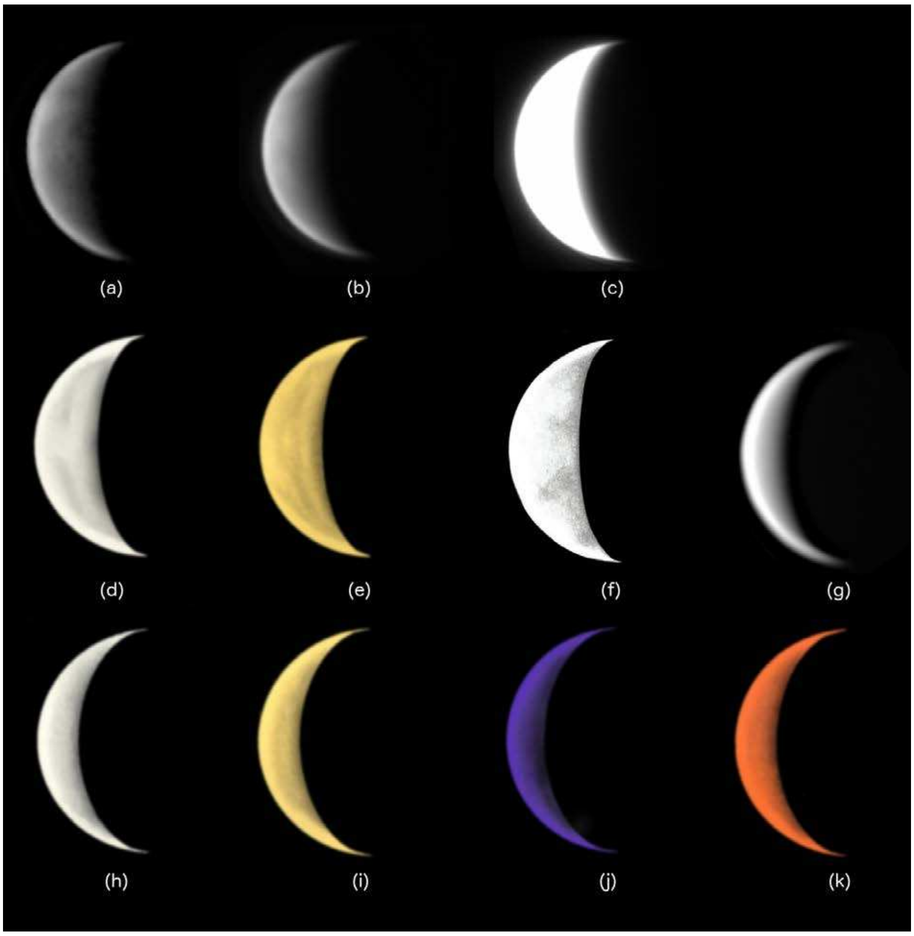

Figure 4. Drawings and images of the cusp terminator anomaly.

(a) 2020 Apr 20, 19:01 UT; 356mm SCT, UV filter. *Leo Aerts*

(b) 2020 Apr 24, 19:05 UT; 300mm Mak–Cass., UV filter. *Bill Leatherbarrow*

(c) 2020 Apr 24, 19:14 UT; 300mm Mak–Cass., IR over-exposed to show the cusp terminator anomaly. *Bill Leatherbarrow*

(d) 2020 Apr 24, 19:21 UT; 203mm Newtonian, ×111. *Paul G. Abel*

(e) 2020 Apr 24, 19:27 UT; ×111, W15 filter. *Paul G. Abel*

(f) 2020 Apr 24, 18:30 UT; 76mm OG, ×120. *Richard McKim*

(g) 2020 May 5, 19:31 UT; 203mm SCT, IR filter. *Mike Foulkes*

(h), (i), (j) & (k) 2020 May 6, 203mm Newtonian, ×111. Respectively: 18:02 UT, IL; 18:42 UT, W15; 18:29 UT, W47 and 18:35 UT, W21 (effect best seen with this filter). *Paul G. Abel*

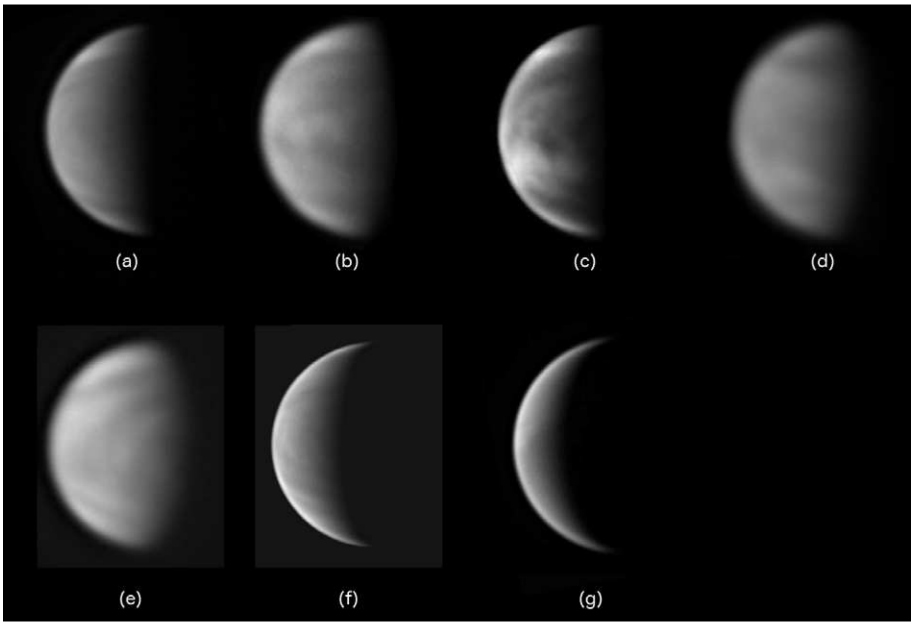

Figure 5. UV images showing a large, bright southern cusp cap at higher phase, and a more muted appearance of the polar region when the phase was below dichotomy.

(a) 2020 Mar 26, 18:14 UT; 180mm Mak–Cass., Baader UV filter. *Chris Dole*

(b) 2020 Feb 27, 17:45 UT; 300mm Mak–Cass., Baader UV filter. *Bill Leatherbarrow*

(c) 2020 Mar 19, 18:20 UT; 250mm Newtonian, UV filter. *Alan Clitherow*

(d) 2020 Feb 23, 18:32 UT; 280mm SCT, Astrodon UV filter. *Miguel Araújo*

(e) 2020 Feb 7, 15:44 UT; 350mm. *Raffaello Braga*

(f) 2020 Apr 19, 18:35 UT; 444mm Newtonian, Baader UV filter. *Martin Lewis*

(g) 2020 Apr 30, 19:06 UT; 180mm Mak–Cass., Baader UV filter. *Chris Dole*

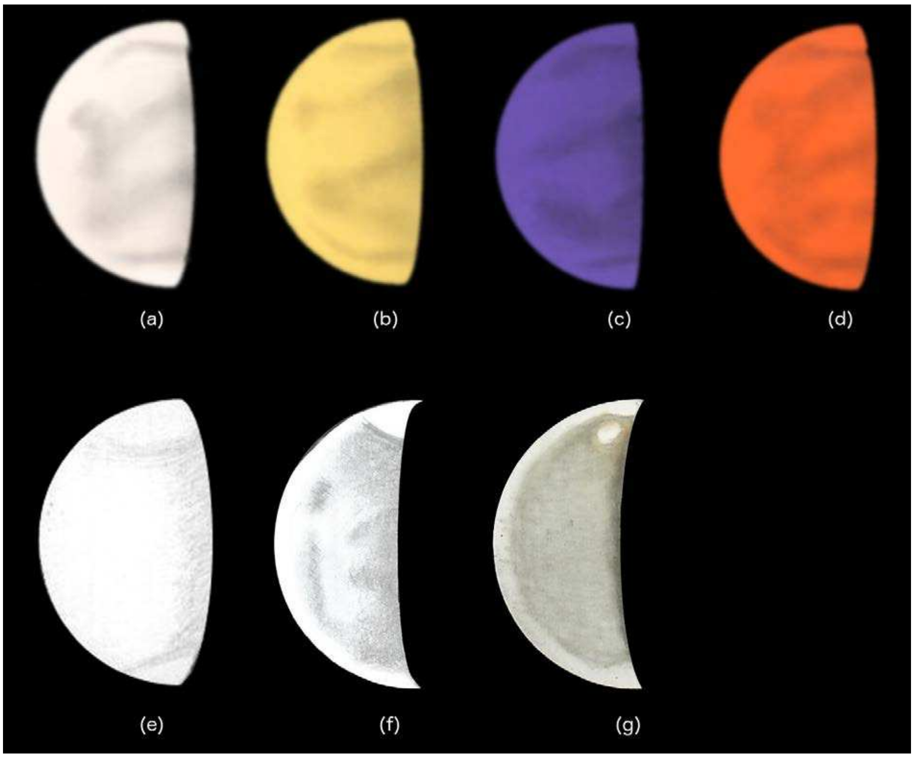

Figure 6. Drawings showing the brilliant southern cusp cap.

(a), (b), (c) & (d) 2020 March 02, 203mm Newtonian reflector, ×111. Respectively: 17:02 UT, IL; 17:12 UT, W15; 17:24 UT, W47 and 17:31UT, W21. *Paul G. Abel*

(e) 2020 Mar 4, 12:05 UT; 125mm Mak–Cass., ×150. *Gianluigi Adamoli*

(f) 2020 Apr 10, 18:32 UT; 76mm OG, ×120. *Richard McKim*

(g) 2020 Mar 23, 18:45 UT; 203mm SCT, ×200. *Alan W. Heath*

of cloud particles at the pole. Could it be that this affects the appearance of the terminator for a short period of time when the phase is between 40 and 50%?

The cusp caps & collars

As noted in the previous section, the polar regions of Venus play host to a number of dynamic weather phenomena. Telescopically, the poles are marked by bright polar cusp caps and the darker cusp collars. These are usually evident both in images and upon visual telescopic inspection of the planet. The appearance of the cusp caps and collars can vary greatly over the course of an elongation; the changing phase alters their brightness and visibility, but they are variable in their own right.

The cusp caps and collars are most evident when the planet is between 50 and 80% illuminated. Based on images and drawings received during this elongation, it seems that, in general, the southern cusp cap was the larger and brighter of the two. UV images seem to show that when the planet was greater than 50% illuminated, the southern cusp cap was frequently very large and bordered by a dark southern cusp collar, as can be seen in Figure 5a–e. In contrast, the northern cusp cap seems to have rarely been bright or striking, although the northern cusp collar could appear fairly dark at times. Visual observations have a similar narrative (Figure 7).

UV images of Venus taken after dichotomy show that both cusp caps became less prominent and the collars much less conspicuous; indeed, it would seem that the southern cusp cap may have shrunk back during this time (see Figure 5f & g). On 2020 Mar 23, veteran observer Heath reported observing a brilliant white spot close to the southern cusp cap, as can be seen in his drawing given in Figure 6g.

The Director had an unusual view of the cusp caps on 2020 Mar 2. On this date, the southern cusp cap appeared to be exceptionally large and brilliant, and the terminator appeared to be deformed around it (Figure 6a–d). The effect was confirmed visually by Leatherbarrow, but he was unable to obtain an image due to the poor seeing conditions in Sheffield. Dole in Newbury had a similar impression on 2020 Mar 3, although the effect was not present in his UV image from that evening. It seems that it was most likely an optical illusion brought about by viewing a particularly bright cusp cap in average seeing conditions.

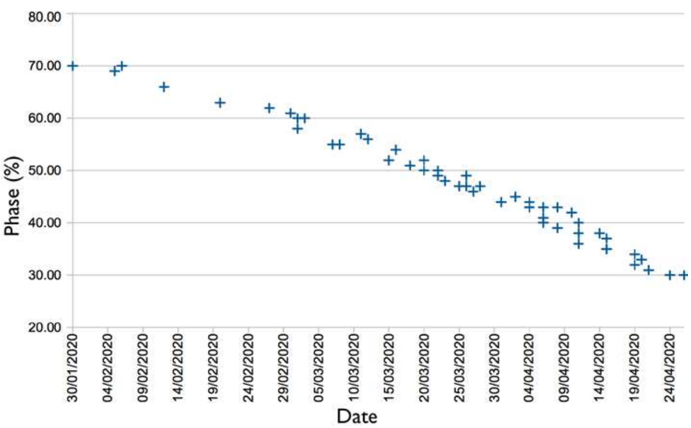

Figure 7. A plot of phase against time, based on estimates supplied by Abel, McKim, Giuntoli and Heath. The data allow an approximate date for actual dichotomy to be made.

Dichotomy

Venus was due to reach dichotomy (*i.e.*, 50% illumination) on 2020 Mar 26. However, as experienced students of the planet will

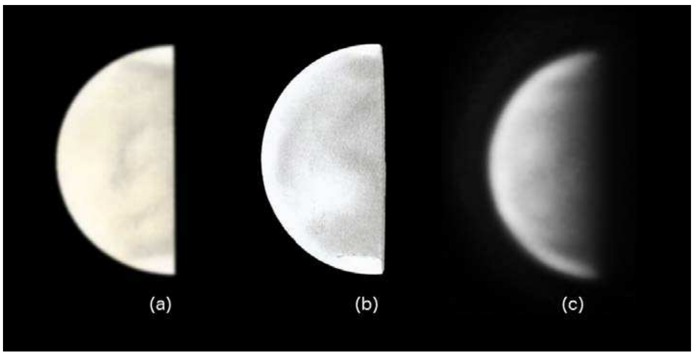

Figure 8. Three observations showing Venus at dichotomy on 2020 Mar 22. **(a)** 18:51 UT, 203mm Newtonian, ×111. *Paul G. Abel.* **(b)** 18:00 UT, 76mm OG, ×120. *Richard McKim.* **(c)** 18:05 UT, 356mm SCT, Baader UV filter. *Peter Tickner*

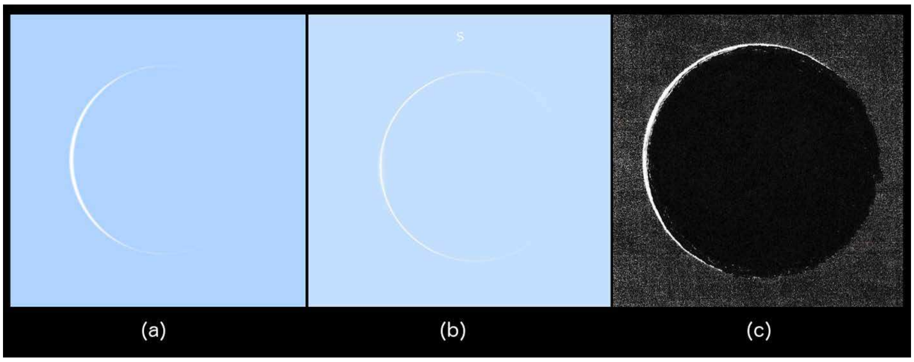

Figure 9. Three drawings by visual observers, showing the cusp extensions.

(a) 2020 May 27, 11:16 UT; 305mm Newtonian, ×67. *Paul G. Abel.*

(b) 2020 Jun 2, 11:20 UT; 300mm SCT, ×156. *Chris Nuttall.*

(c) 2020 Jun 1, 11:45 UT; 130mm Newtonian, ×93. *Massimo Giuntoli*

know, it actually reaches dichotomy before the predicted date due to the Schröter effect. The true date of dichotomy can be estimated from visual observations; in fact, it is much harder to do this from images due to the softness of the terminator. The following observers made regular estimates of the phase: Abel, McKim, Giuntoli and Heath; a plot of their estimates is given in Figure 7.

Using these observations, a reasonable estimate of the date upon which actual dichotomy occurred would be 2020 Mar 22. In particular, both McKim and the Director observed Venus on this date and at similar times; the planet appeared to be at 50% illumination to both observers (Figure 8a & b). A UV image by Tickner on the same date also shows the planet to be at dichotomy (Figure 8c).

Cusp extensions & inferior conjunction

As Venus approaches inferior conjunction, the cusps start to extend around the nightside. At a time very close to inferior conjunction, the planet appears as a thin halo; however, observing this phenomenon is a difficult task due to the close proximity of the Sun. In this particular case, inferior conjunction took place on 2020 Jun 2 with Venus less than half a degree away from the Sun. In spite of this, a small number of experienced observers did manage to observe the planet during this time.

Visually, the cusp extensions are an impressive sight – the thin line of light creeping around the edge of the dark side is a phenomenon unique to the planet Venus. A number of visual observers were able to obtain drawings of the cusp extensions and some of these observations are given in Figure 9.

Lawrence made an excellent series of observations every day from 2020 May 15 to 2020 Jun 2, showing the changing aspect of the planet as it approached conjunction (Figure 10). The most impressive observation by him was made on 2020 Jun 2, when he successfully captured the full atmospheric ring (Figure 11). This is one of the most challenging of observations to attempt, and the image was featured on the Astronomy Picture of the Day website (**apod.nasa.gov**) on 2020 Jun 8.

If one examines the atmospheric ring in Figure 11, it can be seen that there is a thinning of it at about the 2 o’clock position. Three other observers – Didier Favre,[7] Thierry Legault and Shahrin Ahmad[8] – seem to have captured the same effect in images also taken on 2020 Jun 2. One possible explanation for this is the presence of darker clouds on the limb reflecting less, making the crescent look thinner.

Dole, Tickner and James succeeded in capturing the cusp extensions at the end of May (Figure 11a–c) and Hooker, Mercury Coordinator, obtained a splendid series showing cusp extensions and the full atmospheric ring on 2020 Jun 2 (Figure 11d). These observers are to be congratulated.

Table 1. Observers of the 2019–’20 eastern elongation

Observer	*Location*	*Instrument(s)*
Paul G. Abel (V)	Leicester, UK	203mm Newtonian, 305mm Newtonian
Gianluigi Adamoli (V)	Verona, Italy	125mm Mak–Cass., 130mm Newtonian, 235mm SCT
Leo Aerts	Belgium	130mm SCT, 356mm SCT
Miguel Araújo	Évora, Portugal	279mm SCT
David Basey (V)	Norfolk, UK	358mm Newtonian
Raffaello Braga	Milan, Italy	90mm OG, 115mm OG, 210mm Dall–Kirkham
Colin Briden (V)	York, UK	102mm OG
Paulo Casquinha	Palmela, Portugal	356mm SCT
Alan Clitherow	Fife, UK	250mm Newtonian
Maurice Collins	Palmerston North, NZ	203mm SCT
Emilio Colombo	Gambarana, Italy	80mm OG
Jon Culshaw	Ormskirk, UK	150mm SCT
James Dawson	Nottingham, UK	279mm SCT
Chris Dole	Newbury, UK	180mm Mak–Cass.
David Fisher (V)	Kent, UK	216mm Newtonian
Murray Foster	Essex, UK	150mm OG
Mike Foulkes	Henlow, UK	203mm SCT
Massimo Giuntoli (V)	Montecatini Terme, Italy	120mm OG, 130mm Newtonian, 203mm SCT
David Graham (V)	Barton, UK	230mm Mak–Cass.
Alan W. Heath (V)	Long Eaton, UK	203mm SCT
Rik Hill	Arizona, USA	150mm SCT
Chris Hooker	Newbury, UK	254mm Newtonian
Nick James	Chelmsford, UK	150mm SCT
Philip Jennings	York, UK	203mm SCT
Ron Johnson	Surrey, UK	279mm SCT
Geoffrey Johnstone	Leamington Spa, UK	200mm SCT
Manos Kardasis	Athens, Greece	356mm SCT
Simon Kidd	Cottered, UK	356mm SCT
Steve Knight	Banbury, UK	300mm Newtonian
Pete Lawrence	Leicestershire, UK	102mm OG, 356mm SCT
Bill Leatherbarrow	Sheffield, UK	300mm Mak-Cass.
Raffaello Lena	Italy	180mm Mak–Cass.
Martin Lewis	St Albans, UK	222mm Newtonian 444mm Newtonian
Niall MacNeill	New South Wales, Australia	356mm SCT
Philip Masding	Manchester, UK	250mm SCT
David McCraken	Skellingthorpe, UK	203mm SCT
Richard McKim (V)	Peterborough, UK	76mm OG, 406mm Dall–Kirkham
Frank Melillo	New York, USA	250mm SCT
Detlev Niechoy	Göttingen, Germany	203mm SCT
Chris Nuttall (V)	Bishopthorpe, UK	300mm SCT
Ron Palgrave	Stanley, UK	355mm SCT
Damian Peach	Southampton, UK	Chilescope
Trevor Smith (V)	Derbyshire, UK	406mm Newtonian
John Sussenbach	Houten, NL	356mm SCT
Brad Thomas	Surrey, UK	203mm Newtonian
Peter Tickner	Reading, UK	356mm SCT
Craig Towell	Essex, UK	220mm Newtonian
Anthony Wesley	Rubyvale, Australia	410mm Newtonian

(V) indicates visual observer. Mak–Cass. and SCT = Maksutov–Cassegrain and Schmidt–Cassegrain telescopes, respectively.

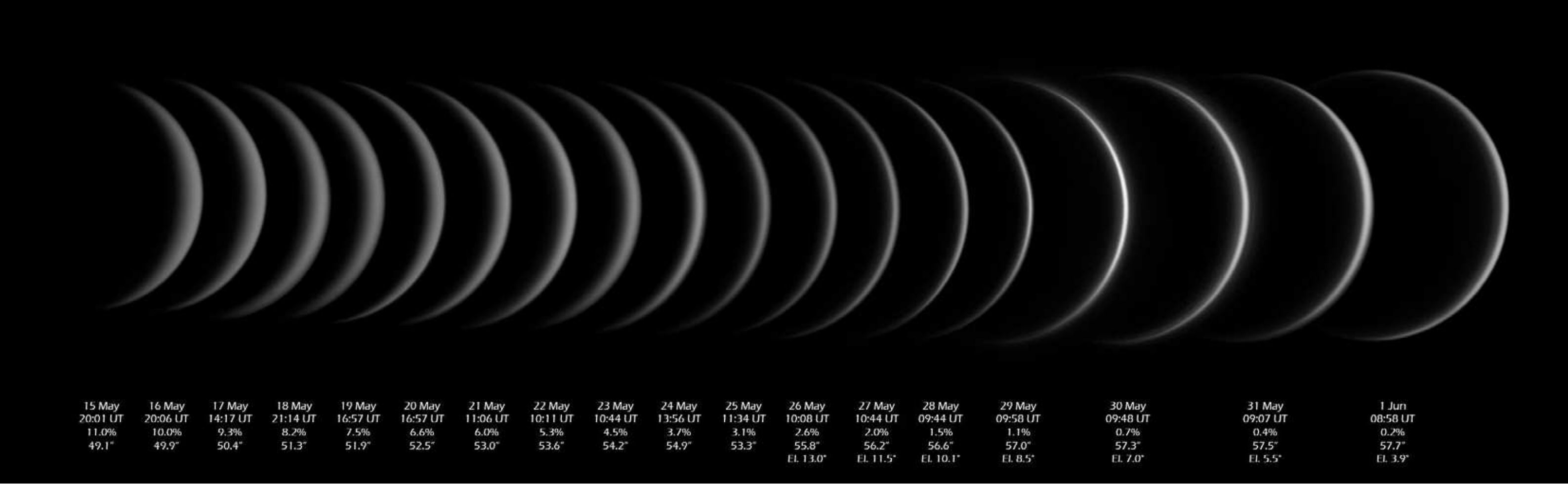

Figure 10. Sequence taken by Pete Lawrence showing the changing aspect of Venus from 2020 May 15 to 2020 Jun 2 (north is up in this image). C14 *f*/28 telescope and ASI174MM camera; 742nm.

Summary & conclusions

Figure 11. The full atmospheric ring, imaged by Pete Lawrence on 2020 Jun 2 at 08:00 UT.

The 2019–'20 eastern elongation of Venus was very well observed and the observations communicated to the Director indicated the existence of a variety of interesting atmospheric phenomena.

Visually, various conspicuous cloud patterns were recorded and these seemed to have counterparts in the unusual and sometimes striking cloud formations captured in UV images. The most remarkable feature during this elongation was the atmospheric wave imaged by Kardasis and others. One is led to speculate on the nature and origin of the wave and it seems reasonable to conjecture that volcanic activity may be responsible.

The terminator was geometrically regular, but the cusp terminator anomaly was observed both visually and digitally when the planet was between 40 and 50% illumination. Images and drawings of the anomaly were made on the same evening, both by the Director and Leatherbarrow.

The cusp caps themselves showed some interesting variability – earlier in the elongation the southern cusp cap seemed to be large and brilliant, while for most of the time the northern cusp cap was fairly dull. Both the north and southern cusp collars were present, with both drawings and images showing them to be quite dark and conspicuous on occasions.

As expected, dichotomy occurred earlier than predicted during the elongation. Using phase estimates it has been established that dichotomy took place on 2020 Mar 22. Both McKim and the Director made drawings on the evening of that date showing the planet to be at dichotomy.

A number of experienced observers were able to capture the cusp extensions as the planet approached inferior conjunction. Lawrence managed to capture the atmospheric ring, which is particularly difficult to observe. On 2020 Jun 3, Venus passed through inferior conjunction and embarked on the 2020–'21 western elongation, reaching superior conjunction on 2021 Mar 26. The Director hopes every effort is made to continue monitoring the planet, particularly in light of some of the observations made during the 2019–'20 eastern elongation. The Section continues to communicate observations and ideas through the newsletter.

Finally, the Director would like to thank all those observers in Table 1 who regularly communicated their observations in a timely manner, and in particular to the new members of the Association who have made a very promising start to their Venus observing careers.

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References

1 *Messenger*, Issue 3, 2020 April: **https://britastro.org/downloads/19479#**
2 *Messenger*, Issue 4, 2020 June: **https://britastro.org/downloads/19479#**
3 McKim R. J., Abel P. G. & Leatherbarrow W., 'The eastern and western elongations of Venus, 2007–'17. 1. The sunlit hemisphere', *J. Brit. Astron. Assoc.*, **129**(3), 73–88 (2019)
4 McKim R. J., Abel P. G. & Kardasis E. I., 'Remarkable waves observed in the atmosphere of Venus, 2015–'20', *J. Brit. Astron. Assoc.*, **130**(4), 228–233 (2020)
5 Müller-Wodarg I. C. F. *et al*., '*In situ* observations of waves in Venus's polar lower atmosphere with *Venus Express* aerobraking', *Nat. Phys*, **12**, 767–771 (2016)
6 Wilson C. F. *et al*., 'Evidence for anomalous cloud particles at the poles of Venus', *J. Geophys. Res*, **113** (2008)
7 Phillips T., Spaceweather.com archive article: **https://spaceweatherarchive.com/2020/06/02/inferior-conjunction-of-venus-2/**
8 Dickinson D., Phys.org article: **https://phys.org/news/2020-06-spying-rare-venus-inferior-conjunction.html**

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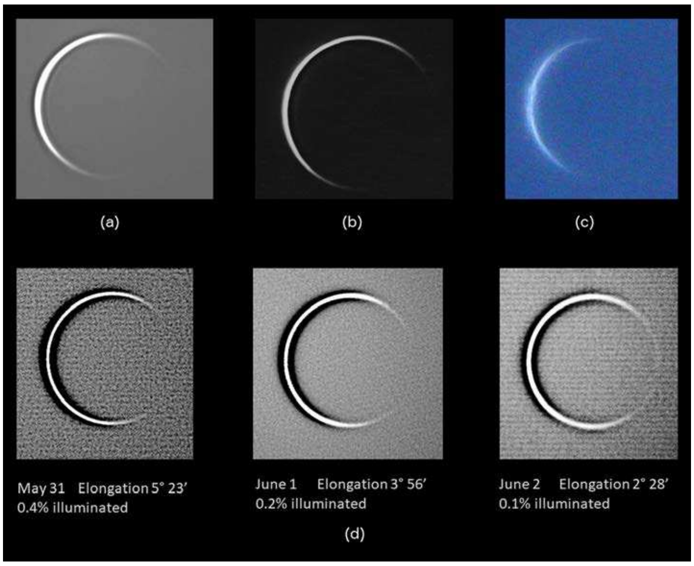

Figure 12. The cusp extensions. **(a)** 2020 May 31, 11:30 UT; 180mm Mak–Cass., Baader 685nm filter. *Chris Dole.* **(b)** 2020 May 31, 15:44 UT; 356mm SCT. *Peter Tickner.* **(c)** 2020 May 25, 12:16 UT; 180mm SCT. *Nick James.* **(d)** Observing details given in figure. *Chris Hooker*