The Planet Venus: ALPO Observations and Programs

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Value of Amateur Planetary Observations

- Complete freedom to observe whenever desired for extended periods of time.
- Standardized systematic observations provide long-term continuous records for further study by professional astronomers.
- Earth-based monitoring by amateurs of changing atmospheric features on Venus often help professionals select targets for high-resolution spacecraft imaging.
- Skilled observers routinely produce excellent digital images at various wavelengths that are useful to professional astronomers.
- The ALPO serves *to encourage and coordinate regular, systematic investigations of the Sun, principal planets, and other members of our solar system with instrumentation readily available to amateur astronomers*.

Suggested Instrumentation for Observing Venus

- Telescopes with good, well-aligned optics with minimum apertures such as:
  - 7.5cm (3.0in) or greater for refractors.
  - 10.2 cm (4.0 in) for Newtonians and Catadioptrics
- Sturdy equatorial mount with slow-motion controls and a clock-drive.
- Color filters of known wavelength transmission are useful, for example:
  - *Low-transmission filters improve contrast while limiting effects of irradiation.*
  - *Blue (W38A) & violet (W47) filters enhance views of low-contrast detail of yellowish atmospheric clouds of Venus.*
  - *Variable-density polarizers improve visibility of faint markings by reducing glare when Venus is seen against a dark sky.*
- For achromatic refractors, include a filter that suppresses the secondary spectrum.
- *Astronomical Almanac* or similar printed or electronic ephemeris.
- Digital imaging equipment (IR blocking filters are suggested).
- Laptop (PC or Mac) with software for capturing and processing of images.

Some Keys to Meaningful Results

- Start observing each apparition when Venus first becomes visible before sunrise or just after sunset & keep watching through greatest elongation until inferior or superior conjunction.

- Use standard observing forms for recording data (available on ALPO Website) & submit images, drawings, & supporting data regularly.

- The high *albedo* of Venus produces excessive glare against a dark background sky, making low-contrast atmospheric features very hard to detect visually.
  - Use color filters & variable-density polarizers to enhance contrast & reduced glare

- Because atmospheric features on Venus are so elusive, *simultaneous observations* become even more important, especially for visual work.

- If possible, try to observe Venus during twilight or daylight hours because:
  - Most of the prevailing glare associated with the planet is reduced.
  - When Venus is higher in the sky atmospheric effects that cause poor seeing can be avoided.
  - Contrast conditions usually improve when Venus is seen against a light background sky.

ALPO Venus Observing Programs

- Visual numerical relative intensity estimates of atmospheric features in Integrated Light & with color filters.
- Disk drawings of atmospheric phenomena seen or suspected on Venus.
- Routine digital imaging of Venus at visual, ultraviolet (UV), and infrared (IR) wavelengths.
- Observation of cusps, cusp-caps, cusp-bands, and cusp extensions.
- Monitoring the extent and visibility of the Bright Limb Band.
- Systematic patrol of the dark hemisphere of Venus for the elusive Ashen Light.
- Observation of terminator geometry (monitoring for any irregularities).
- Documenting Schröter's Effect (i.e., difference between predicted vs. observed date of dichotomy).
- Routine *simultaneous observations* using visual and digital imaging methods.
- Contribution of observational data and digital images to the *Venus Express (VEX) Mission*.

Sample ALPO Venus Observing Form

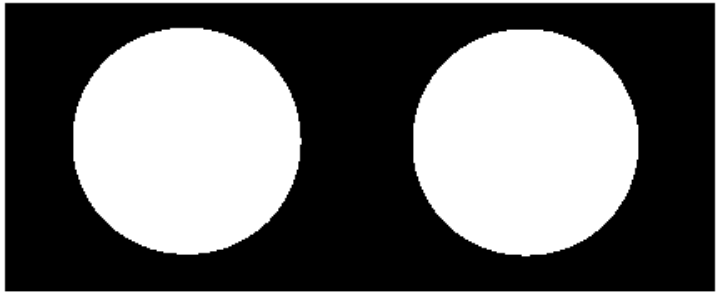
Although regular imaging of Venus is extremely worthwhile, observers should not neglect to make careful drawings of Venus and visual numerical relative intensity estimates of any suspected atmospheric features.

Association of Lunar and Planetary Observers (A.L.P.O.): Venus Section

A.L.P.O. Visual Observation of Venus

Drawing Blank — S

Intensity Estimates Blank — S



N (*all coordinates are IAU*) N

Observer_____Location_____

UT Date _____ UT Start _____ UT End _____ D = _____" k_{m} = _____ k_{c} = _____

m_v = _____ Instrument _____ Magnification(s) _____ x_{min} _____ x_{max}

Filter(s) IL(none) _____ f_1 _____ f_2 _____ f_3 _____ Seeing _____ Transparency _____

Sky Illumination (*check one*): [ ] Daylight [ ] Twilight [ ] Moonlight [ ] Dark Sky

Dark Hemisphere (*check one*): [ ] No dark hemisphere illumination [ ] Dark hemisphere illumination suspected [ ] Dark hemisphere illumination [ ] Dark hemisphere darker than sky

Bright Limb Band (*check one*): [ ] Limb Band not visible [ ] Limb Band visible (complete cusp to cusp) [ ] Limb Band visible (incomplete cusp to cusp)

Terminator (*check one*): [ ] Terminator geometrically regular (no deformations visible) [ ] Terminator geometrically irregular (deformations visible)

Terminator Shading (*check one*): [ ] Terminator shading not visible [ ] Terminator shading visible

Atmospheric Features (*check, as applicable*): [ ] No markings seen or suspected [ ] Radial dusky markings visible [ ] Amorphous dusky markings visible [ ] Banded dusky markings visible [ ] Irregular dusky markings visible [ ] Bright spots or regions visible (exclusive of cusp regions)

Cusp-Caps and Cusp-Bands (*check, as applicable*): [ ] Neither N or S Cusp-Cap visible [ ] N and S Cusp-Caps both visible [ ] N Cusp-Cap alone visible [ ] S Cusp-Cap alone visible [ ] N and S Cusp-Caps equally bright [ ] N and S Cusp-Caps equal size [ ] N Cusp-Cap brighter [ ] N Cusp-Cap larger [ ] S Cusp-Cap brighter [ ] S Cusp-Cap larger [ ] Neither N or S Cusp-Band visible [ ] N and S Cusp-Bands both visible [ ] N Cusp-Band alone visible [ ] S Cusp-Band alone visible

Cusp Extensions (*check, as applicable*): [ ] No Cusp extensions visible [ ] N Cusp extended (angle = _____°) [ ] S Cusp extended (angle = _____°)

Conspicuousness of Atmospheric Features (*check one*): [ ] 0.0 (nothing seen or suspected) [ ] 3.0 (indefinite, vague detail) [ ] 5.0 (suspected detail, but indefinite) [ ] 7.0 (detail strongly suspected) [ ] 10.0 (detail definitely visible)

IMPORTANT: Depict morphology of atmospheric detail, as well as the intensity of features, on the appropriate blanks at the tope of this form. Attach to this form all supporting descriptive information, and please do not write on the back of this sheet. The intensity scale is the *Standard A.L.P.O. Intensity Scale*, where 0.0 = completely black <> 10.0 = very brightest features, and intermediate values are assigned along the scale to account for observed intensity of features.

The Elusive Atmospheric Features of Venus

- Analysis of visual observations over many years suggests rough categories for atmospheric features on Venus (also seen on images at different wavelengths, especially UV):
  - *Banded Dusky Markings*: Parallel dusky streaks across the illuminated disk of the planet, perpendicular to the line of the cusps.
  - *Radial Dusky Markings*: A curious "spoke" pattern converging at the sub-solar point (especially noticeable on UV images).
  - *Irregular Dusky Markings*: Elongated or roughly linear dusky streaks having no specific orientation.
  - *Amorphous Dusky Markings*: Shaded features that exhibit no form, definitive shape, or pattern.
  - *Bright Spots or Regions*: Exclusive of cusp regions, areas that appear much brighter than the surrounding illuminated disk.
- The contrast of dusky markings on Venus is typically wavelength dependent:
  - Contrast drops off rapidly at 380nm (near lower limit of the average human eye).
  - Observers have varying wavelength & contrast sensitivity thresholds.
  - Contrast conditions are often improved when observing Venus against a light background sky.

Geocentric Phenomena in Universal Time (UT)

Current 2013-14 Eastern (Evening) Apparition

Superior Conjunction	2013	Mar 28 (angular diameter = 9.8″)
Predicted Dichotomy (k = 0.500)		Oct 31.14 (theoretical half phase)
Greatest Elongation East		Nov 01 (Venus will be 47º East of the Sun)
Greatest Illuminated Extent		Dec 06 (–4.9m_v)
Inferior Conjunction	2014	Jan 10 (angular diameter = 63.1″)

- Venus is an *inferior planet* exhibiting phases like the Moon, attaining a maximum elongation from the Sun of ~47° during any given apparition.

- For the current 2013-14 Eastern (Evening) Apparition the following circumstances exist:
  - Venus is visible in the Western sky after Sunset (East of the Sun).
  - Progression is from Superior Conjunction → Greatest Elongation East → Inferior Conjunction.
  - Angular diameter increases continuously from ~9.8″ to ~60.0″.
  - Brilliancy of Venus (visual magnitude) slowly increases (becomes – 4.9m_v).
  - Observers are witnessing waning phases (100% illuminated → *Dichotomy* → 0% illuminated).
  - Venus *loses* altitude on any given night following sunset against a *darkening* sky.

Current Professional-Amateur Cooperation

- The *Venus Express (VEX)* mission began systematically monitoring Venus at UV, visible (IL) & IR wavelengths in May 2006, requesting cooperation of ALPO observers.
- Observers began submitting digital images taken in the near-UV & near-IR, as well as other wavelengths & with polarizing filters.
- Observers should continue to be submit *.jpg (JPEG) format images to the ALPO Venus Section as well as to the *VEX* website at:

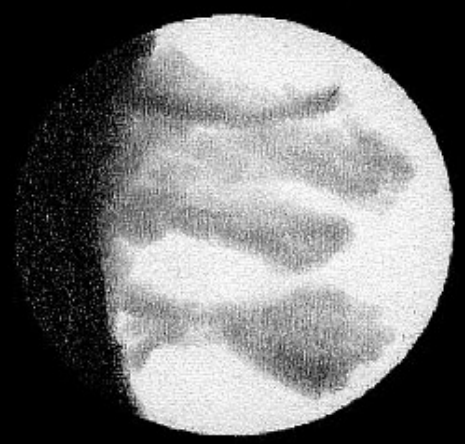
  http://sci.esa.int/science-/www/object/index.cfm?fobjectid=38833&fbodylongid=1856

- Systematic observations of Venus are needed while *VEX* is observing the planet.
- On November 19, 2010 *ESA's Science Program Committee* approved extension of *Venus Express (VEX)* mission operations until December 31, 2014.

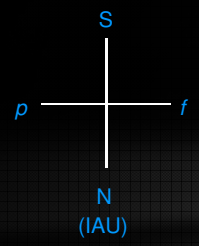
Selected ALPO Visual Observations and Digital Images of Venus

Recent Drawings of Venus

Drawings from the previous 2012-13 Western (Morning) Apparition



2012Oct29 04:20UT DNiechoy 20.3cm SCT 166X IL
Dia=13.6" k=0.799 Visual Magnitude= -4.02



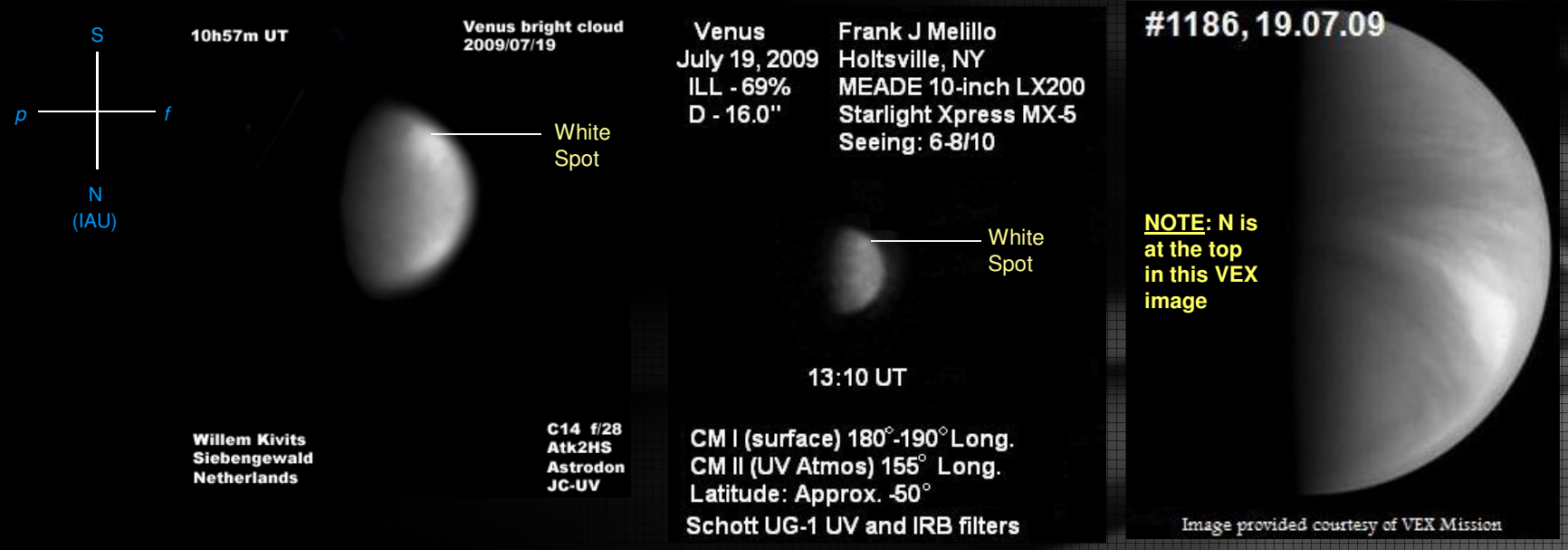
2012Nov14 06:17UT DNiechoy 20.3cm SCT 225X W15
Dia=12.6" k=0.843 Visual Magnitude=-4.0

Direction of Rotation (retrograde)

Drawings like these by experienced observers are a vital part of our Venus observing program.

Simultaneous Observations of Venus

Compare the images by Kivits and Melillo in these two near simultaneous observations during 2009-10



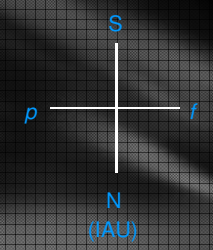
Direction of Rotation (retrograde)

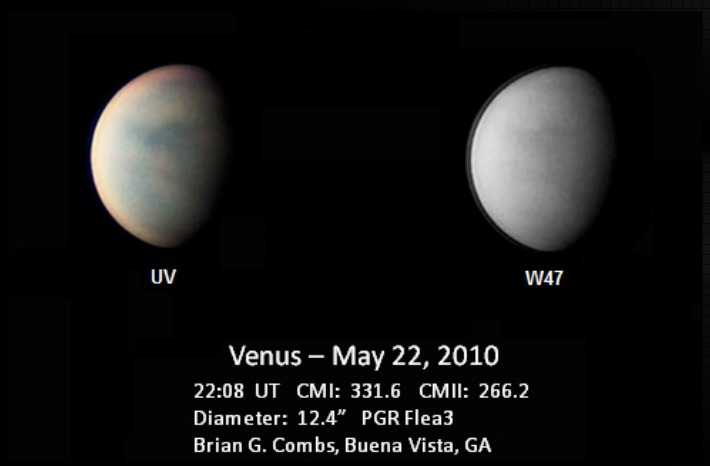
An unusually bright White Spot was observed during the 2009-10 Western (Morning) Apparition:

- It was first reported by Kivits and Melillo on July 19, 2009 (this was not the first such brightening recorded on Venus).
- *Venus Express* (*VEX*) imaged the bright spot in the planet's southern hemisphere 4 days before Kivits and Melillo imaged it.
- The bright spot spread out with time, rapidly stretched out by the high-velocity winds of Venus' dense atmosphere.
- Although cloud properties somehow changed, the cause of the spot remains a mystery.
- VEX scientists have not linked the feature to any volcanic activity on the planet.

Multi-wavelength Images of Venus

The appearance of atmospheric features on Venus changes in different wavelengths of light



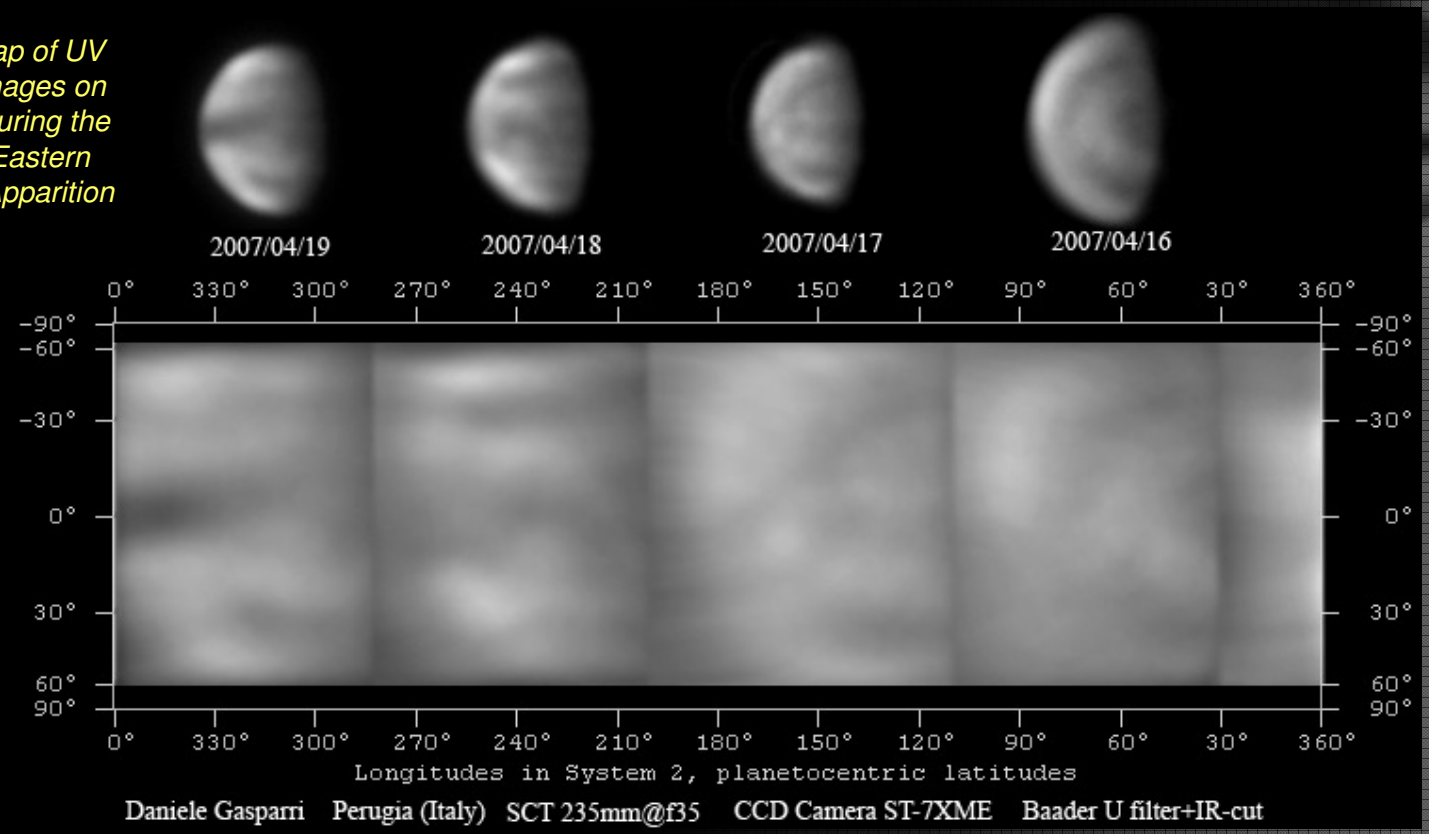


Direction of Rotation (retrograde)

Some Gleanings from Long-term UV Imaging of Venus

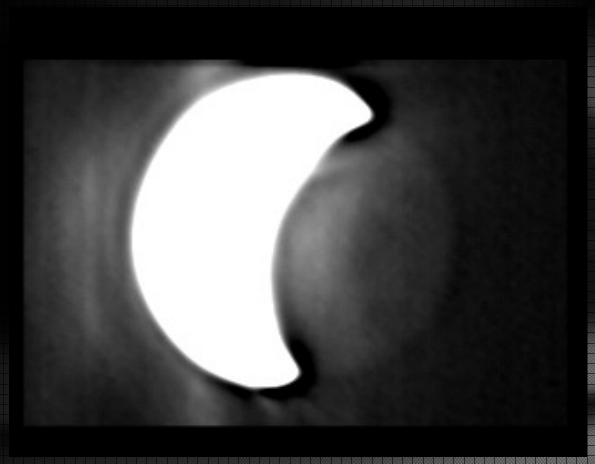
- UV images taken over nearly three decades show horizontal *V, Y, or Ψ (psi) shaped dusky clouds* usually aligned along the planet's equator & moving W at 110m s^{-1} in a planetary-wide rotation.
- The more intense & distinctly *V-shaped features* last several weeks, but smaller-scale cloud patterns can change substantially after each successive rotation in 4^d around the planet.
- Over several years, the polar areas are sometimes covered by whitish clouds, typically lasting only a few weeks or months, evolving independently for the two poles.

Sample map of UV features images on Venus 4^d during the 2006-07 Eastern (Evening) Apparition



Dark Hemisphere of Venus Imaged in the near-IR

2004 May 12 20:04-20:43UT
35.6 cm (14.0 in) SCT
ATK-1HS Camera @ 1000nm IR
C. Pellier (France)



2004 May 18 20:22UT
35.6 cm (14.0 in) SCT
ATK-1HS Camera @ 1000nm IR
C. Pellier (France)

- These are historically unprecedented amateur images of the illuminated dark hemisphere of Venus.
- This is thermal emission from the surface of Venus in the near-IR (1000nm) penetrating the dense atmosphere.
- Subtle mottlings in the images are <u>not</u> atmospheric features; they are warm surface areas emitting in the IR.
- Since the instrumentation Pellier employed was rather uncomplicated, Venus observers have been doing similar imaging work in recent apparitions.

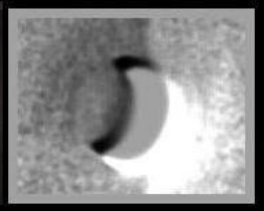
Recent Images of the Dark Hemisphere of Venus in near-IR

Venus' Dark Side
March 4, 2009
23:28 UT
ILL - 15.5%
D - 48"

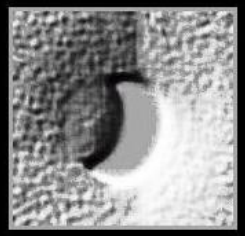
Frank J Melillo
Holtsville, NY
MEADE 10- inch LX200
Starlight Xpress MX-5
Seeing: 7/10

1/2 sec. exposure at f/10 (1000nm filter)

3 - 8 sec. at f/10



Emboss



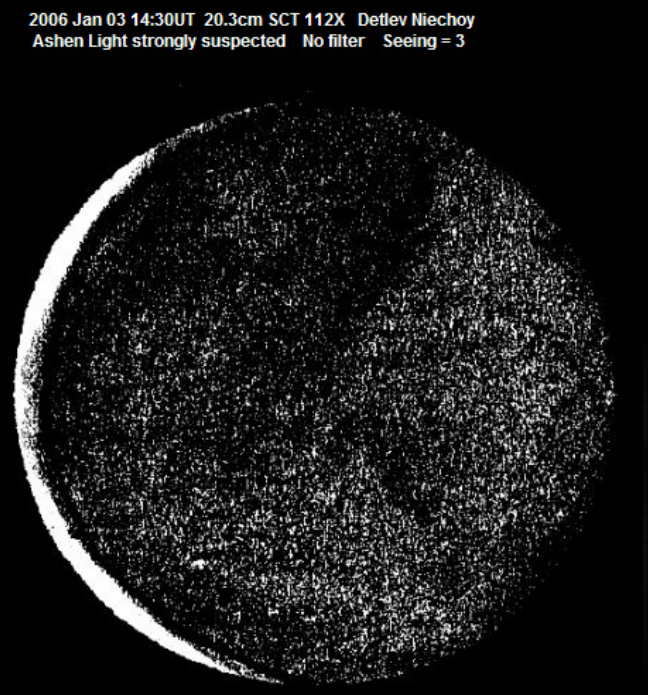
Emboss (enhanced)

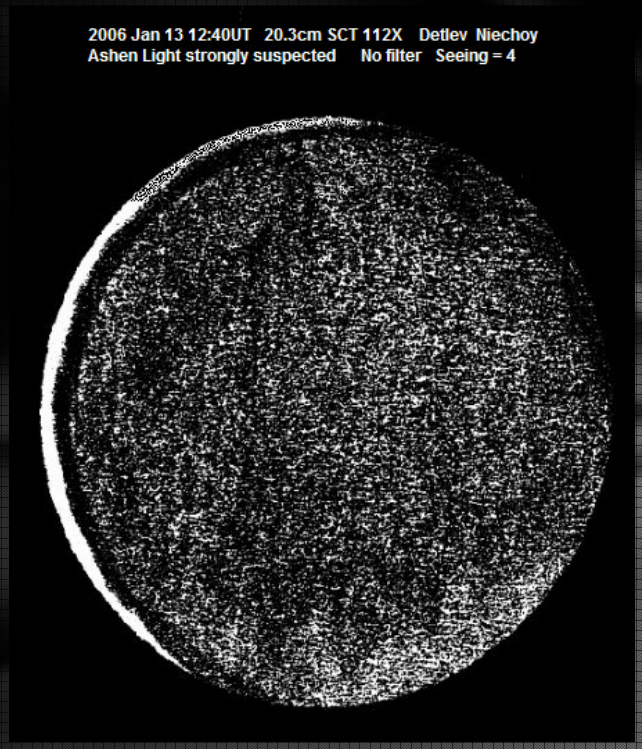
Thermal Emission of the dark side

1.25X resampled
1 - micron filter (1000nm)

CM - 315 degrees longitude (surface)

Example of Visual Ashen Light Observations





- Observers are urged to try to image the elusive Ashen Light in a simultaneous observing program when it is reported by visual observers.

- The cause of the phenomenon has been a mystery for over 400 years since it was first reported in 1643.
  - Some say it's due to CO_2 in the atmosphere of Venus being split by UV radiation, emitting a greenish glow.
  - Others attribute it to lightning storms in the atmosphere of the planet.
  - Still others say it's merely an illusion, since no spacecraft have yet detected the Ashen Light.

Schröter's Phase Effect at Dichotomy

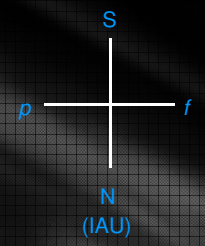
- The *predicted phase* of Venus, ***k***, found in an ephemeris, does not always correspond with the *observed phase* on the date of observation.
- This is particularly the case at the time of *dichotomy* (half phase, when the terminator is exactly straight from pole to pole, such that k = 0.500 or 50%). This discrepancy is known as *Schröter's Effect* after the scientist who first recognized it.
- The observed date of dichotomy varies from the predicted date by an average of about 7 to 8 days. A fully convincing explanation as to its real cause is yet to be found.

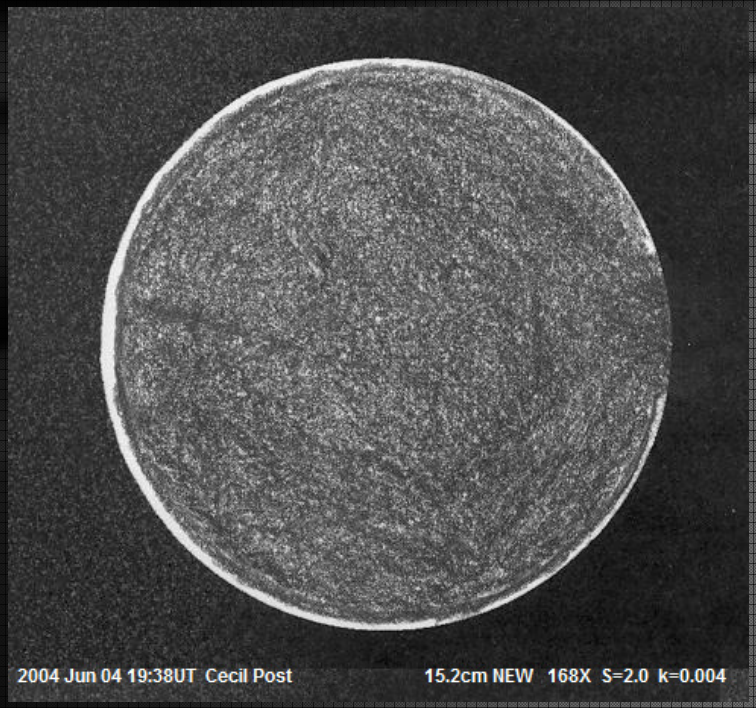
Observed vs. Predicted Dichotomy of Venus: 2009-10 Western (Morning) Apparition			
QUANTITY	**OBSERVERS**		
	D. Niechoy	**J. Benton**	
Observed (O)	2009 Jun 05.31^{d}	2009 Jun 07.75^{d}	(***k*** = 0.500)
Predicted (P)	2009 Jun 06.61	2009 Jun 06.61	(***k*** = 0.500)
Difference (O-P)	–01.30^{d}	+1.14^{d}	

Cusp Extensions

When Venus approaches inferior conjunction, the cusps can often extend dramatically into a beautiful ***halo*** encircling the dark portion of the planet's disk.

This effect is caused by sunlight reflecting through the planet's atmosphere forming a ring of light as it appears to us in our telescopes on Earth.





Spectacular Occultation of Venus on May 16, 2010

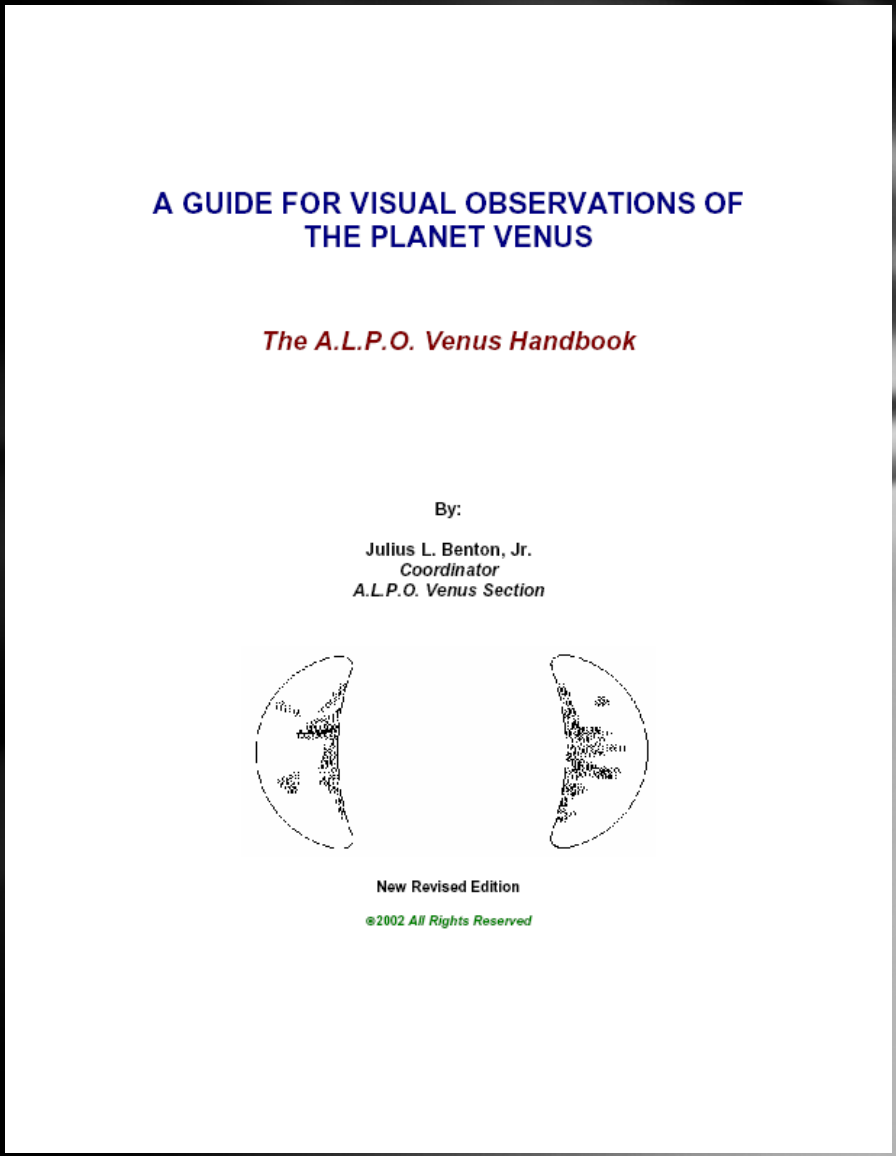
Transits of Venus

- The last transit of Venus occurred on June 5-6, 2012 (detailed report forthcoming in *JALPO*).
- As a testament to the rarity of such events, the next transit won't occur until December 11, 2117.

Image courtesy of Rik and Dolores Hill of the Transit of Venus near sunset on June 6, 2012 north of Tucson, AZ using a Questar 3.5"

More About Observing Venus

Those who wish to learn more about how to observe Venus and record useful data are encouraged to get a copy of the *ALPO Venus Handbook* from the ALPO Venus Section. It is available in printed form or as a *.pdf file.



A GUIDE FOR VISUAL OBSERVATIONS OF THE PLANET VENUS

The A.L.P.O. Venus Handbook

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Coordinator
A.L.P.O. Venus Section

New Revised Edition