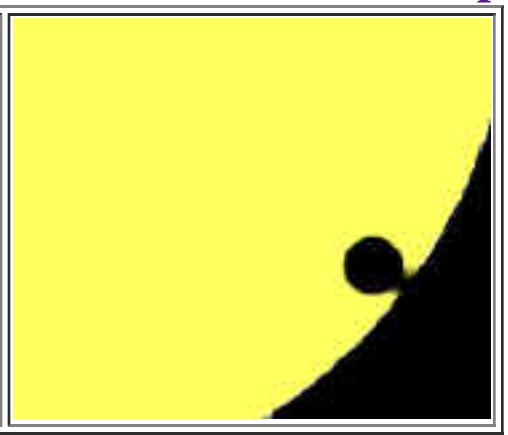
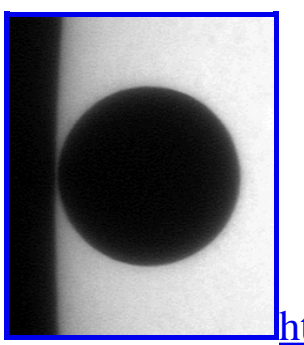
The "Black Drop" Effect

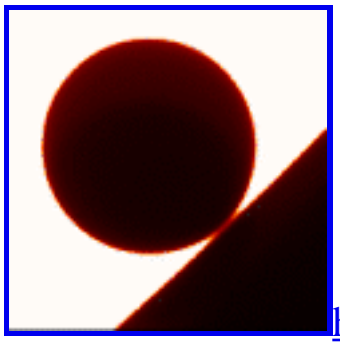


To quantify the distance from earth to the sun, known as the Astronomical Unit (A.U.), astronomers embarked on global expeditions to time the transit of Venus from widely separated latitudes. However, for centuries the "black drop" effect--the stretching out of Venus near internal contact--confounded astronomers when they tried to discern the exact moment when Venus touched the inside edge of the sun. Note that some of the interpretations below on what causes the "black drop" effect are dated or subject to debate.


http://skyandtelescope.com/news/article_1277_1.asp
Sky & Telescope magazine asks, "Where Was the Black Dot?" after the 2004 transit of Venus.


fingers.jpg
To simulate the appearance of the "black drop" effect, almost pinch your thumb and forefinger together against a bright background. Near contact the ligament between them appears.


http://www.lhl.lib.mo.us/pubserv/hos/voyages/cook.html
Cook's and Green's illustrations of "black drop" effect; from Linda Hall Library collection.


http://vestige.lmsal.com/TRACE/transits/venus_2004/
Images and movies from the TRACE spacecraft are among many new perspectives of the 2004 transit of

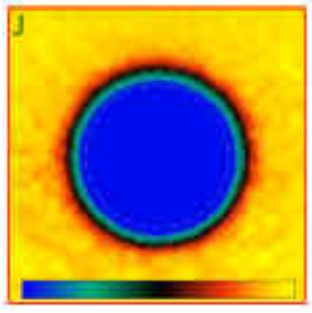
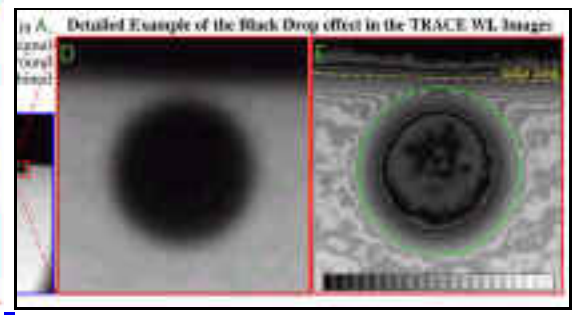
Venus. Additional views are at images.htm.

http://home.hetnet.nl/%7Esmvanroode/venustransit/eng/eng_parallax.html#BD
At the critical moment when observers try to time when Venus touches the inside edge of the sun, strange phenomena such as the black drop effect suddenly emerge. This site guides observers in discerning at what instant internal contact occurs; from Steven van Roode.

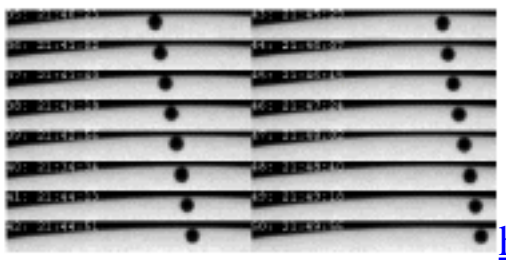
http://www.phys.uu.nl/~vgent/venus/venus_text2.htm#black%20drop
Bibliography: *The Black Drop and Related Phenomena*, from R.H. van Gent.


http://star.arm.ac.uk/history/transit.html
Drawings of the Transit of Venus by Captain James Cook and Charles Green; from the Armagh Observatory.

http://www.metaresearch.org/home/Viewpoint/blackdrop.asp
In noting "an irradiation effect – the apparent spreading of light from bright areas onto any adjacent dark areas," author Tom Van Flandern asserts that the well-understood black drop effect "provides a timing advantage rather than a disadvantage."

http://nicmosis.as.arizona.edu:8000/POSTERS/TOM1999.jpg
Poster on the 1999 transit of Mercury "definitively solves the problem of the black-drop effect that plagued past transits of Venus;" by Jay Pasachoff, Glenn Schneider and Leon Golub; from the American Astronomical Society's Division of Planetary Science meeting in 2001.


http://arxiv.org/pdf/astro-ph/0310379.
Report by Schneider, Pasachoff, and Golub (see poster above) "separates the primary contributors to [the "Black Drop" Effect], solar limb darkening and broadening due to the instrumental point spread function...for the 1999 transit of Mercury, seen in high spatial resolution optical imaging with NASA's TRACE spacecraft."

Question:

Can you suggest what an observer could expect of the black drop effect as seen through an H-

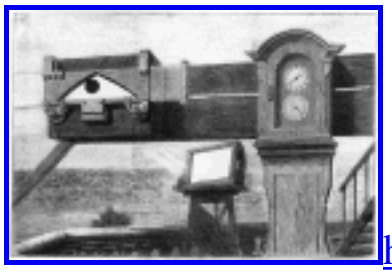
alpha filter, particularly if there is a prominence on the limb of the sun near Venus at 2nd or 3rd contact?

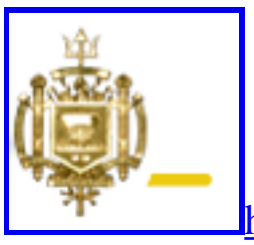
Answer (courtesy of Jay Pasachoff):

There is limb darkening in H-alpha, visible on Big Bear Solar Observatory posted daily images (and elsewhere; see www.williams.edu/astronomy/sun for links to daily-image Websites). The reason for H-alpha limb darkening is somewhat different from the reason for continuum limb darkening, since H-alpha is a spectral line rather than continuum and, at least at its center, is optically thick. What is called the "source function" changes with height in H-alpha, causing its limb darkening.

If there were no limb darkening, only the point-spread function part would remain. Since the PSF effect has to do with the light/dark change, if the planet comes in right over a prominence (as I think you are suggesting) then we would be able to time its contact accurately since the black-drop effect wouldn't form then.

In any case, in H-alpha we always see the chromospheric spicules outside the dimension of the visible limb, so at the moment of contact with the visible limb, it won't be in contact with an H-alpha limb so there should not be a black-drop effect then, depending on how wide the chromosphere is compared with the extent of the black-drop effect. That represents a generalization of your prominence question. There could, then, be a black drop at the time that Venus is about to exit the chromosphere rather than when it exits the photosphere.


http://home.hetnet.nl/~smvanroode/blackdrop.html
Describes history of black drop effect through modern understanding of the phenomenon and implications for observers. Cites literature that concludes "the true time of interior contact is halfway between the formation of the black drop and the breaking of the thread." Courtesy of Steven van Roode.


http://usna.edu/Users/physics/huddle/Beat%20the%20Black%20Drop.pdf
Jim Huddle of the U.S. Naval Academy proposes "a variation of Halley's method that avoids the complications of the Black Drop Effect...and requests collaborators to test the method during the transit of Venus on 8 June 2004." Observers simply photograph Venus at fifteen minute intervals, noting the times of the photos. (PDF file)


http://rathnasree.htmlplanet.com/blackdrop_effect.htm
Ongoing discussion about the black drop effect; list monitored by Nehru Planetarium, New Delhi.

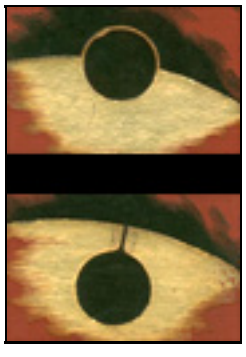
http://www.aas.org/publications/baas/v32n4/aas197/785.htm
Abstract describes physical cause of "black drop" effect; B. E. Schaefer (Univ. Texas Austin) at 2001 AAS meeting.

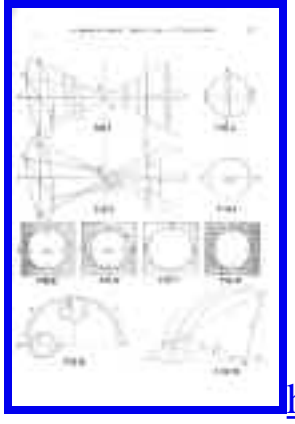
http://www.metaresearch.org/home/Viewpoint/blackdrop.asp
Tom Van Flandern proposes that the black drop effect is a "manifestation of irradiation, the spreading of photons by rapidly moving air cells."

From footnote 28 of Chapter 7 of *Sky and Ocean Joined: U.S. Naval Observatory, 1830-2000,* by Steven J. Dick, (Cambridge University Press, 2003):

> "The physical cause of the black drop phenomenon has been the subject of considerable controversy. Bradley Schaefer reviews the controversy in "The Transit of Venus and the Notorious Black Drop," BAAS, 32 (2000), 1383-1384. He concludes that the phenomenon is not caused by diffraction, illusion or atmospheric refraction, but by terrestrial atmospheric smearing that blurs the image."

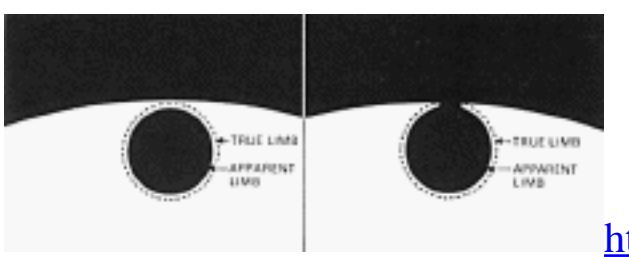

http://www.astro.univie.ac.at/~wuchterl/Kuffner/2004/Venustransit/russell_vt.html
Illustrations (plates) from the book *Observations of the Transit of Venus, 9th December 1874*, by Henry Chamberlain Russell; from the Institute for Astronomy at the University of Vienna.


http://www.bo.astro.it/~biblio/sma/page/venere_05_06_1761.html
Bibliographical and archival records from the Department of Astronomy of the University of Bologna (Italy), featuring manuscripts of observations made in Bologna by Eustachio Zanotti; includes images and resources from transits in addition to the 1761 records. (Italian; a link with some English translation is at http://www.bo.astro.it/~biblio/Archives/copertina.html.)

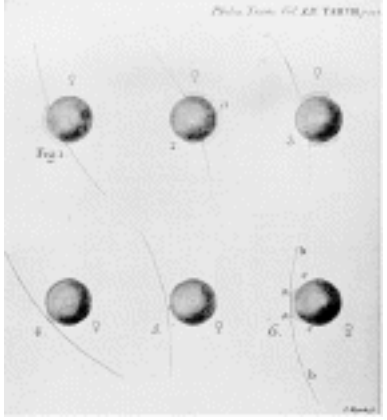

http://www.bo.astro.it/~biblio/Horn/Blackdrop.htm
A detailed 1922 assessment of the black drop effect suggests "instrumental astigmatism should be considered the cause of some aspects of the *photographed* ligaments." GUIDO HORN D'ARTURO The "black drop" phenomenon and astigmatism. Università di Bologna, Dipartimento di Astronomia, (Pubblicazioni dell'Osservatorio astronomico della R. Università di Bologna, vol. I, n.3, 1922).

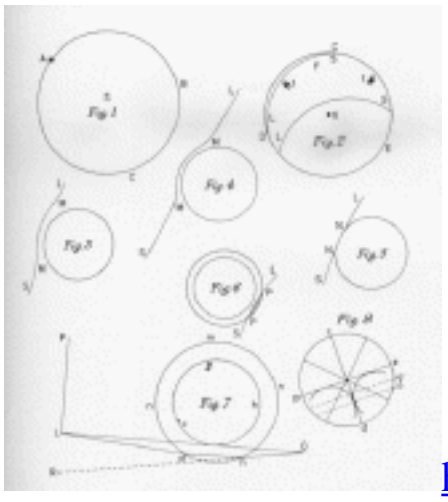

http://www.bo.astro.it/~biblio/Horn/Blackdrop.htm
Images excerpted from GUIDO HORN D'ARTURO The "black drop" phenomenon and astigmatism. Università di Bologna, Dipartimento di Astronomia , (Pubblicazioni dell'Osservatorio astronomico della R. Università di Bologna, vol. I, n.3, 1922).

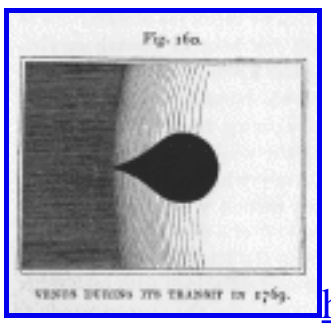
http://carnap.umd.edu/phil250/transits/transits.html
Images related to determining the distance of the earth to the sun; "black drop" effect illustrations. Shown at left is "Close-up of Bergman's Drawing of the Blackdrop Effect;" from *The Astronomical Unit, Stellar Parallax, & the Transits of Venus, Determining the Distance of the Earth from the Sun, From Eudoxus of Cnidos to Harold Spencer Jones*.



http://carnap.umd.edu/phil250/transits/images/blackdrop.gif
"The Black Drop Effect at the Limb of the Sun."

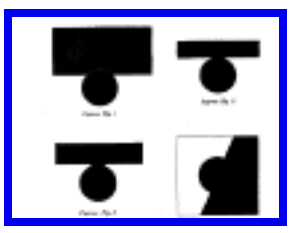

http://carnap.umd.edu/phil250/transits/images/bergman_drawing.gif
"Torbern Bergman's Drawings of the 1769 Venus Transit."

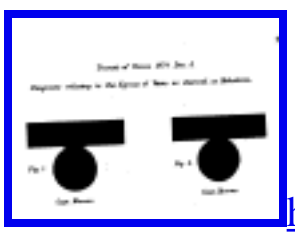

http://carnap.umd.edu/phil250/transits/images/losmonov_drawing.gif.
" Lomonosov's Drawings of the 1769 Venus Transit."

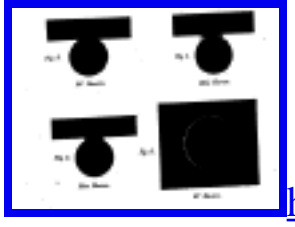


http://www.astronomy.org.nz/aas/MonthlyMeetings/MeetingApr2003.asp
Figure of Black Drop Effect in article by Grant Christie; from Auckland Astronomical Society.

Original publications scanned by Stanford University Libraries & Academic Information Resources and offered online, including the following from http://dlib.stanford.edu:6520/text1/dd-ill/transit-1874-2.pdf:


http://dlib.stanford.edu:6520/text1/dd-ill/transit-1874-2.pdf
"Point Coton, Rodriguez, by Commander W.J.L. Wharton, RN, with a telescope 2 3/4 inches aperture, power 160."


http://dlib.stanford.edu:6520/text1/dd-ill/transit-1874-2.pdf
"Transit of Venus 1874 Dec. 8. Diagram relating to the Egress of Venus as observed at Mokattam;" observations by Capt. Browne. (Mokattam Hills is near Cairo.)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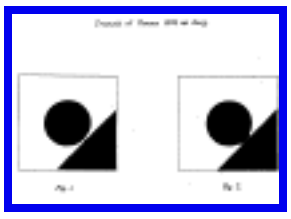
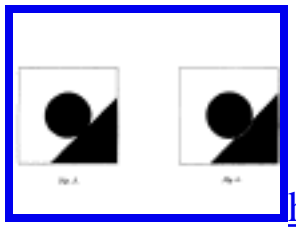
"Transit of Venus 1874 Dec. 8. Diagram relating to the Egress of Venus as observed at Mokattam;" observations by Miss Newton and Mr. Newton.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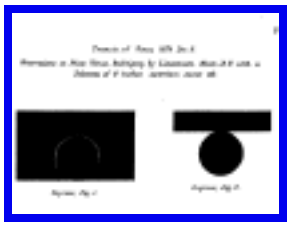
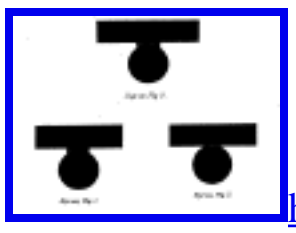
"Transit of Venus 1874 at Suez;" figures 1 & 2 (left) and figures 3 & 4 (right).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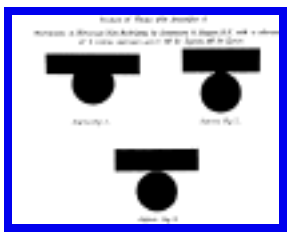
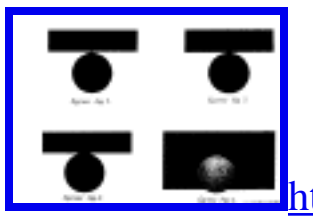
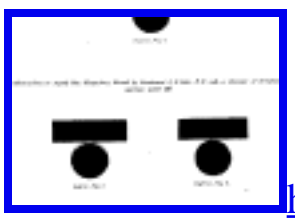
"Transit of Venus 1874 Dec. 8; Observations at Point Venus, Rodriguez by Lieutenant Neate, R.N. with a Telescope of 6 inches aperture power 152." Ingress Fig. 1 and 2 (left); Ingress Fig. 3 and Egress Fig. 1 & 2 (right).



http://dlib.stanford.edu:6520/text1/dd-ill/transit-1874-2.pdf
"Transit of Venus 1874 December 8. Observations at Hermitage Islet, Rodriguez by Lieutenant R. Hoggan, R.N. with a telescope of 4 inches aperure, power 120 ingress, 160 egress." Ingress figures 1, 2, & 3 (left); egress figures 1, 2, 3, & 4 (right).


http://dlib.stanford.edu:6520/text1/dd-ill/transit-1874-2.pdf
"Transit of Venus 1874 December 8. Observations at Supply Bay, Kerguelen's Island by Lieut. C Corbel witha telescope of 4 1/2 inches aperture, power 145." Ingress figures 1, 2, & 3.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Observations at Supply Bay, Kerguelen's Island by Lieutenant G.E. Coke, R.N., with a telescope of 3 1/2 inches aperutre, power 150." Ingress figures 4 & 5.

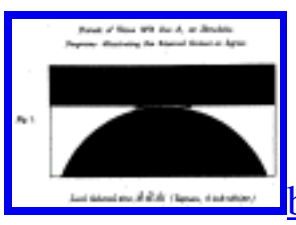
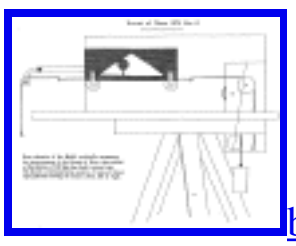
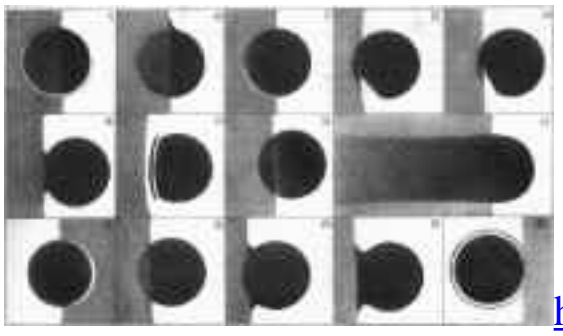

bde-honolulu.gif

Illustration of internal contact, 1874 December 8, Honolulu; Tupman 6-inch refractor; 20h, 46m, 14.5s; from *Account of Observations of the Transit of Venus*...; edited by Sir George Biddell Airy, K.C.B.


bde-honolulu2.gif
Illustration of internal contact, 1874 December 8, Honolulu; Tupman 6-inch refractor; 20h, 46m, 32.5s; from *Account of Observations of the Transit of Venus*...; edited by Sir George Biddell Airy, K.C.B.

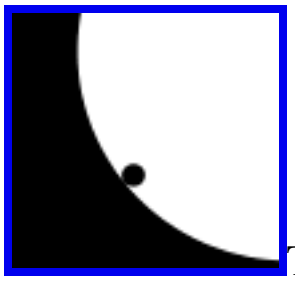

bde-artificial.gif
"Front elevation of the Model artificially representing the circumstances of the Transit of Venus when place a the distance of 400 feet. One-fourth natural size. The planet is represented in the position of Internal Contact with Sun's limb (nearby); its motion is from left to right." 1874 December 8, Honolulu; G.L. Tupman.


http://www.vt-2004.org/Background/Infol2/EIS-F7.html
Belgian astronomers view "black drop" effect from Chile in 1874; from Hilmar W. Duerbeck.

From email:

- "Has anyone given thought to how the shadow of a sphere wrapping around the edge of a significantly larger sphere would be shaped? Try it. It is not such a mystery." -Siteartist

- Having just watched the UK TV coverage of yesterday's Transit of Venus, which discussed the "black drop effect" I tried an experiment using my graphics program. Placing a small black circle inside and just in contact with a large white one (on a black background), I found that the degree of black drop increased when I zoomed out and decreased when I zoomed in. Likewise, viewing the screen from a distance I found that the black drop effect increased as I moved further away. I then reversed the colours of the image and produced an corresponding "white drop effect". To me the cause seems obvious. Namely that the eye's resolution is limited, so that the smaller the image the less discernible is the boundary between adjacent objects. The same probably applies to optical apparatus; if not to the lenses themselves, then certainly to the media upon which images are displayed. My conclusions lead me to believe that the effect is not caused by cosmic interventions, but simply by our powers of perception.

  
  Try this test: open the blackdrop.gif file. If you zoom in you will see that there is a distinct white separation between the two circles. As you zoom out this becomes less visible, and by

zooming out (say) 8 times a marked black drop effect appears. Alternatively, have the image on your screen at a zoom level that makes the separation just perceptible, then view the screen from, say, 15-20 feet away. -John Rushby-Smith


The black drop effect for the 1878 transit of mercury is attributed to "a very variable amount of irradiation of bright images on the retina," though with caveats.


http://analyzer.depaul.edu/paperplate/Transit%20of%20Venus/Internet%20caveat.htm
Caveat about believing everything you see on the Internet (*including here*).

www.transitofvenus.org

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