The prodigious halo of the other Huygens

Gunther P. Können

Sophialaan 4, NL-3761DK Soest, The Netherlands (konnen@planet.nl)

Received 16 July 2014; accepted 9 November 2014;
posted 12 November 2014 (Doc. ID 216958); published 9 January 2015

At the height of the ceremony in the Principality of Orange of the restoration of the sovereignty of the House of Nassau in 1665, a ceremony led by Christiaan's father, Constantijn Huygens, a "solar crown" appeared in the sky, apparently a divine sign of approval. A nearly forgotten contemporary color engraving of this miraculous event has survived. Constantijn seized the opportunity by using to his advantage the general euphoria among the citizens caused by the appearance. We argue that Constantijn knew exactly what was going on in the sky because of his son's work on halo theory. Given its brightness and its time of appearance, it seems plausible that the most prominent halo in the Orange halo display was a circumscribed halo rather than the more familiar but bleaker circular 22° halo. The same probably holds for most of the other high-sun halos that caused general consternation, dating from the Octavian halo of 44 BC, to the Chernobyl halo of 1986, and indeed up to bright high-sun halos of the present.

OCIS codes: (000.2850) History and philosophy; (010.2940) Ice crystal phenomena; (010.1290) Atmospheric optics; (010.3920) Meteorology.

http://dx.doi.org/10.1364/AO.54.00B185

1. Observation (7 May 1665) and Contemporary Interpretation

Figure 1 shows the ceremony of the general pardon and the subsequent Oath of Allegiance of the citizens of the Principality of Orange (44° 8′ N, 4° 48′ E) on 7 May 1665 during the formal restoration of the sovereignty over Orange of William III of Nassau [born 1650, later to become Dutch Stadtholder (from 1672 until his death in 1702) and from 1689 King William III of England]. The Principality, a Protestant enclave in Catholic France located about 15 km N of Avignon (SE France) and since 1530 in possession of the Counts of Nassau, had been annexed in March 1660 by the French King Louis XIV (1638–1715). Despite its small size (300 km^2) the country was of great importance to the House of Nassau, as its possession provided them with the high-profile title Prince. Hence, the French annexation meant that the House of Nassau was about to lose this important title.

With so much at stake Princess Dowager Amalia (1602–1675), the ambitious grandmother of the orphaned 9-year-old Prince William, sent in November 1661 the elderly statesman, poet and composer Constantijn Huygens, Lord of Zuylichem (1596–1687) to France in order to negotiate for restoration. In these early days of his personal reign, Louis XIV was still cultivating his European reputation and therefore wanted to prevent that "the annexation would be regarded as a cowardly robbing of a defenceless minor by a royal adult" [1,2]. After three years of negotiation Louis XIV, then aged 26, gave in and agreed to restore the sovereignty of the 14-year-old William III of Nassau over the Principality of Orange.

The ceremony of the transfer of power took place on 7 May 1665 at the Place du Cirque, which is in front of the 37 m high wall of the ancient Roman theater, at the time that the sun was at its highest point ([1], line 857; see also [3]). So the solar elevation was about 62.5° [4]. The program was lead by Constantijn Huygens, who was seated 2 m before the (empty) golden throne of the Prince. After the general pardon, just at the start of the solemn collective Oath of Allegiance by the citizens of the Principality

1559-128X/15/04B185-09$15.00/0

Fig. 1. Engraving by Johannes Visscher (1633–1692), after a drawing by Pieter Jansz. Post (1608–1669) of the event of 7 May 1665 in Orange. The text on top reads: *Position and preparation of the Oath of Allegiance by the city and citizens of the Principality of Orange, to his Highness the Lord Prince William Henry of Nassau, their sovereign, in the presence of the Lord of Zuylichem [i.e., Constantijn Huygens, the person seated in the middle of the podium] who had gathered with the entire Parliament on a platform erected in front of the ancient and wonderful wall of the Roman theatre; when at that very moment a very bright crown appeared in the sky over the platform, being apparently an omen promising a happy future because of the deed just going on. Orange, 7 May 1665*. Below are two poems, the right one underscoring the magic of the moment of appearance of the sign from heavens indicating a bright future for the restored Principality (texts: see [7]). (Collection Museum Atlas van Stolk, Rotterdam, inventory number 11193; dimensions 53.8 cm × 35.7 cm.)

of Orange, a "heavenly crown" appeared straight over the princely throne. The Calvinist Minister of Orange Jacques Pineton de Chambrun (1635–1689), who witnessed the event, put it like this ([3], pp. 148–149):

> *But it would not be right if I would keep silent about an extraordinary event that happened during this public ceremony. As Mister Solicitor General [i.e., Jean Sylvius, person m in Fig. 1] pronounced the solemn words [of general pardon], a shout of astonishment sounded out of the crowd and everyone who became curious to know what caused the commotion was completely informed when one saw in the sky a crown which was exactly positioned above the throne erected for the Prince, as is truthfully depicted in the accompanying figure [i.e., the B/W version of our Fig. 1]. Of course I know quite well that this kind of coronas, also called halos or auras, occur quite often and that the sun regularly creates such structures in the thinnest clouds. However here was something miraculous happening, as at the very moment that the Prince granted general pardon to his people and received from them the Oath of Allegiance, a crown appeared above his throne. Without doubt God had wanted to show that he approved the clemency and that he crowned the throne in order to show the people that this Prince would once rule a large empire.*

The heavenly sign, which appeared according to Huygens in a seemingly cloudless sky ([1], lines 856–859; see, however, [5]), caused a great euphoria among the deeply religious people of Orange and inspired many to compose epigrams ([1], line 865), among them Huygens himself [2,3], who composed on the following day (8 May) a verse in Latin celebrating the miracle [6]. Other poets did the same, including Jan Vos (1610–1667), whose poems are printed on the bottom of Fig. 1 [7]. The engraving of the event enjoyed popularity in circles of the monarchist party in the Low Countries, who at the time sought for restoration of the Stadtholderly power in The Netherlands.

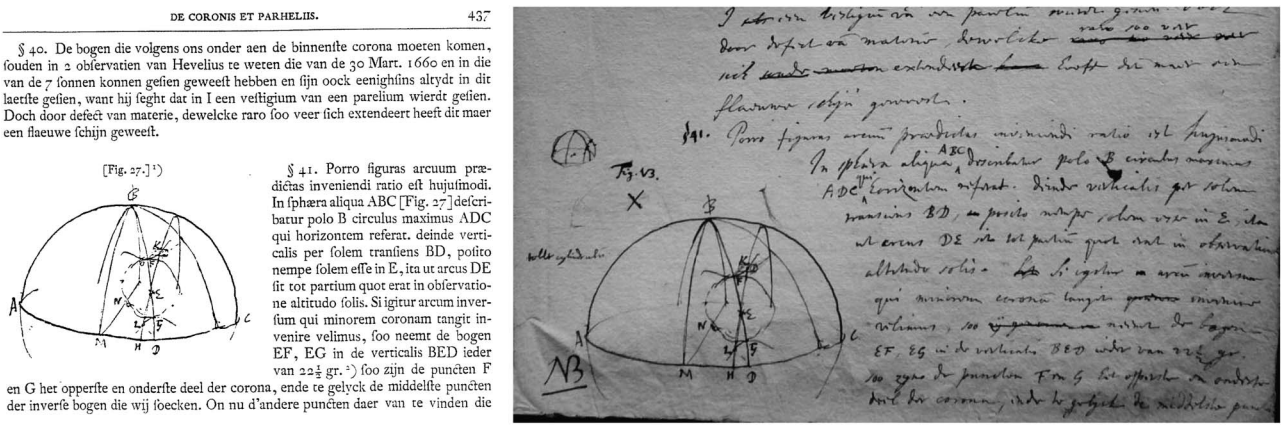
2. Popular Belief and Scientific Facts

However, it is clear that Huygens knew exactly what was going on in the sky of Orange. In fact, his own son Christiaan Huygens (1629–1695) had developed just three years earlier the first-ever successful quantitative theory of halo formation [8]. Although Christiaan eventually got the microstructure of the scattering particles wrong [9,10], the domain of the deflection function of his assumed icy cylinders with opaque cores corresponds well to that of the real particles—hexagonal ice crystals—which allowed realistic calculations of the shape (not of the radiance distribution, though) of halos [9]. Christiaan had successfully simulated the shapes of various refraction halos, including that of the tangent arcs to the 22° halo (Figs. 2 and 3). Ironically, his theory relied heavily on two famous and commotion-creating Rome halo displays thirty years earlier [11,12]. In his calculations Christiaan made use of the Bravais index of refraction for skew rays, which is now named after its rediscoverer Auguste Bravais (1811–1865) [13], who was born almost 200 years after Christiaan.

It is unthinkable that Constantijn did not know about the success of his son, as father and son lived at the time in the same house and were on excellent terms. Actually, Constantijn freely admitted 13 years later in his autobiography ([1], lines 861–865):

> *I knew, like everyone else with some knowledge about it, that it [the appearance of the halo] was just a freak of nature. But the fact that this happened on that very moment seemed to many people a kind of omen that caused the epigram-blood in the veins of poets to flow.*

As mentioned, "the veins of the poets" included those of the seasoned diplomat Constantijn himself, who cleverly stirred the popular sentiment of the superstitious audience up by composing the day after the event his own epigram [2,6] and reemphasized the supernatural origin of the phenomenon in another autobiographic poem, composed two years later [14].


DE CORONIS ET PARHELIIS. 437

§ 40. De bogen die volgens ons onder aen de binnenſte corona moeten komen, ſouden in 2 obſervatien van Hevelius te weten die van de 30 Mart. 1660 en in die van de 7 ſonnen konnen geſien geweeſt hebben en ſijn oock eenighſins altydt in dit laerſte geſien, want hij ſeght dat in I een veſtigium van een parelium wierdt geſien. Doch door defect van materie, dewelcke raro ſoo veer ſich extendeert heeft dit maer een ſlaeuwe ſchijn geweeſt.

[Fig. 27.] [1])

§ 41. Porro figuras arcuum prædictas inveniendi ratio eſt hujuſmodi. In ſphæra aliqua ABC [Fig. 27] deſcribatur polo B circulus maximus ADC qui horizontem referat. deinde verticalis per ſolem tranſiens BD, potito nempe ſolem eſſe in E, ita ut arcus DE ſit tot partium quot erat in obſervatione altitudo ſolis. Si igitur arcum inverſum qui minorem coronam tangit invenire velimus, ſoo neemt de bogen EF, EG in de verticalis BED ieder van $22\frac{1}{2}$ gr. [2]) ſoo zijn de puncten F en G het opperſte en onderſte deel der corona, ende te gelyck de middelſte puncten der inverſe bogen die wij ſoecken. On nu d'andere puncten daer van te vinden die

Fig. 2. Diagram from 1663 of the calculation of the shape of the upper tangent arc to the 22° halo, drawn by Christiaan Huygens. Left: as printed in the Vollgraff edition [8]. Right: in Huygens' hand-written manuscript of *Traité de couronnes et des parhélies*. (Leiden University Library, HUG 31, fol. 114 r.)

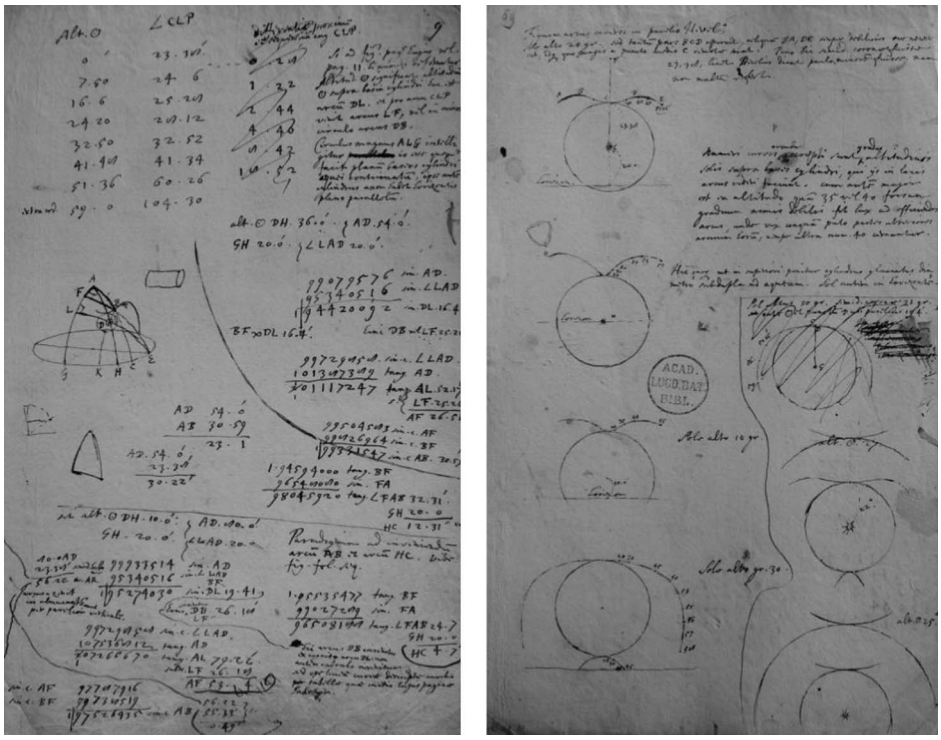


Fig. 3. Handwriting of Christiaan Huygens of his *Traité de couronnes et des parhélies,* showing part of his tangent arc calculations (left) and the results (right). The diagrams in the right panel are reproduced as Figs. 60–64 in the Vollgraff edition [8]. Figure 64 of the printed edition [8] shows less detail than Huygens' original drawing. [Leiden University Library, HUG 31, fol. 67 v (left) and 69 r (right).]

3. Two Comparable Cases: Octavian's Halo (44 BC) and the Chernobyl Halo (AD 1986)

The story leaves the question unanswered as to why this particular halo triggered the superstition, although halos were already in those day known as common features, as even the Minister Pineton de Chambrun admitted in his eyewitness report [3]. To gain some insight, we now compare the popular reaction with two similar cases, mutually separated by 2000 years, namely, with the "Octavian halo" (44 BC) and with the so-called "Chernobyl halo" (1986).

A. Octavian Halo (Early May 44 BC)

Perhaps the best known [15] description of this halo is by the Roman historian Lucius Cassius Dio (ca. AD 160—after 229):

> *Nevertheless, he [18-year-old Octavian, the future Emperor Augustus] was not thought to have planned badly, because he proved to be successful. Heaven, however, indicated in no obscure manner all the confusion that would result to the Romans from it; for as he was entering Rome [1½ months after the assassination of Julius Caesar], a great halo with the colors of the rainbow surrounded the whole sun* [16].

One century earlier, Gaius Suetonius Tranquillus (ca. AD 70—ca. 130) had mentioned the appearance of the halo in his chapter *Augustus* in his list of good omens about the future life of Augustus:

> *As he was entering the city on his return from Apollonia after Caesar's death, though the heaven was clear and cloudless, a circle like a rainbow suddenly formed around the sun's disc, and straightway the tomb of Caesar's daughter Julia was struck by lightning* [17].

Velleius Paterculus (ca. 19 BC – after AD 31) said in his Chapter 2.59.6:

> *…he was already at Brundisium when he learned the details of the assassination and the terms of his uncle's [i.e., Julius Caesar's] will. As he approached Rome an enormous crowd of his friends went out to meet him, and at the moment of his entering the city, men saw above his head the orb of the sun with a circle about it, colored like the rainbow, seeming thereby to place a crown upon the head of one destined soon to greatness* [18].

Seneca the Younger (4 BC—AD 65) mentions more soberly in Book 1, Chapter 12, 2 of his Encyclopedia:

> *Let us now see how the brightness is produced that sometimes envelops the heavenly bodies. History has put on record that, on the day of the late Emperor Augustus entrance into Rome on his return from Apollonia, a parti-colored circle, such as is wont to be seen in a rainbow, appeared round the sun. The Greeks call this a halo; our most appropriate name for it is a crown* [19].

Julius Obsequens (4th century) cites the now-lost account by Livy (59 BC—AD 17) about the halo as follows:

> *And when at the third hour of the day, amidst an immense crowd, he came marching into Rome, the sun's*

light framed around him a sizable disk of pure and serene heavenly shine, enclosed within a circular rim that resembled a bow as it may appear spanned up against rain-bringing clouds [20].

Paulus Orosius (ca. 375—after 418 AD) wrote without mentioning his source:

In the first place, when Augustus was entering the city on his return from Apollonia after the murder of his uncle C. Caesar, though the sky was clear and cloudless at the time, about the third hour a circle resembling a rainbow suddenly formed around the sun's disk. This phenomenon apparently indicated that Augustus alone was the most powerful man in this world and alone was the most renowned in the universe; it was in his time that Christ would come, He who alone had made and ruled the sun itself and the whole world [21].

The appearance of the halo (with reference to Seneca's Enclopedia) is also briefly mentioned by Pliny the Elder (AD 23–79) in his Naturis Historia, Book 2, Chapter 28 [22] and by the Byzantine historian Johannes Lydus (AD 490—ca. 560) [23].

The exact date of Octavian's entrance to Rome is not mentioned by the ancient authors [24,25]. Eck [26] fixes it on 6 May, but without further explanation; De Vries [27], however, regards on the basis of Cicero's letters [28,29] 1–2 May as the most likely date. The range 1–6 May in dates implies for Rome a culmination height of the Sun between 63°–65°. The time of the arrival (the third hour of the day), as mentioned by Livy (via Obsequens) and by Orosius, corresponds to a local (solar) time between 7:20 am and 8:30 am—thus to a solar elevation between 25° and 39° (see also [30,31]).

B. Chernobyl Halo (17 May 1986)

This halo of unusual brilliance and vivid colors owes its fame to its association with the Chernobyl nuclear disaster. The halo reached maximal development over The Netherlands and appeared in an even cirrostratus deck preceding a warm front, which approached from the southwest. The display is described in detail by Hattinga Verschure [32], who was (like me, GPK) among its many eyewitnesses. Its most spectacular phase persisted for about 2 h, on Saturday 17 May 1986, from 11:00–13:00 UT, at sun elevation between 53° and 57°.

On that 17 May, the daily news in the country was still dominated by the effects of the explosion of the nuclear plant in Chernobyl (Ukraine), which had occurred three weeks before. The radioactive cloud released by the blast (on 25 April 1986, 22:23 UTC) had reached The Netherlands by 2 May and the people were still nervous. The day of the halo was the day before Pentecost and thus part of a short national holiday; the fair weather conditions had caused many people to stay outside. Thus, the halo was noticed by thousands of people. Its appearance caused commotion: the Royal Netherlands Meteorological Institute was flooded by hundreds of telephone calls from concerned persons telling that they had seen a "curious, colored circle around the sun" and feared that the phenomenon was a manifestation of the presence of radioactive particles in the air.

Fig. 4. Chernobyl halo, 17 May 1986 on 11:59 UTC over Deventer, The Netherlands (52° 15′ N, 6° 9′ E). The solar elevation is 56.7°. The halo was mistaken by many as being caused by the presence of radioactive particles in the high atmosphere. Photograph by Peter Paul Hattinga Verschure (www.pphv.eu).

Although the halo display consisted of many exceptional halo forms [32], the broad public noticed only the presence of a bright 22° halo—or rather of the even brighter circumscribed halo (Fig. 4), which was well developed because of the high solar elevation.

4. Discussion: Possible Nature of Widely Observed High-Sun Circular Halos

The reports about the Orange halo, the Octavian halo, and the Chernobyl halo have several features in common:

1. The halo was reported to appear in a seemingly cloudless sky (Orange, Octavian) or in an even cloud deck (Chernobyl).
2. The feature was reported to be circular in shape and apparently clear from the horizon. No mention is made of a parhelion (all).
3. The feature was reported to be vividly colored (all).
4. The solar elevation (amply above 45°) was high enough to produce a pseudo-circular feature because of the complete merging of the upper and lower tangent arcs into a circumscribed halo with the absence of prominent parhelia (Orange, Chernobyl).

There are several reasons to believe that the reports of all these high-sun halos primarily refer to the observation of the circumscribed halo. The appearance in a "cloudless sky" hints toward the presence of an even and little conspicuous cirrostratus deck, easily overseen by the layman. If the cloud particles consist of randomly oriented hexagonal ice crystals, a circular 22° halo could be generated. However, it is hard to imagine that this halo should be bright and vividly colored, as it is known that the

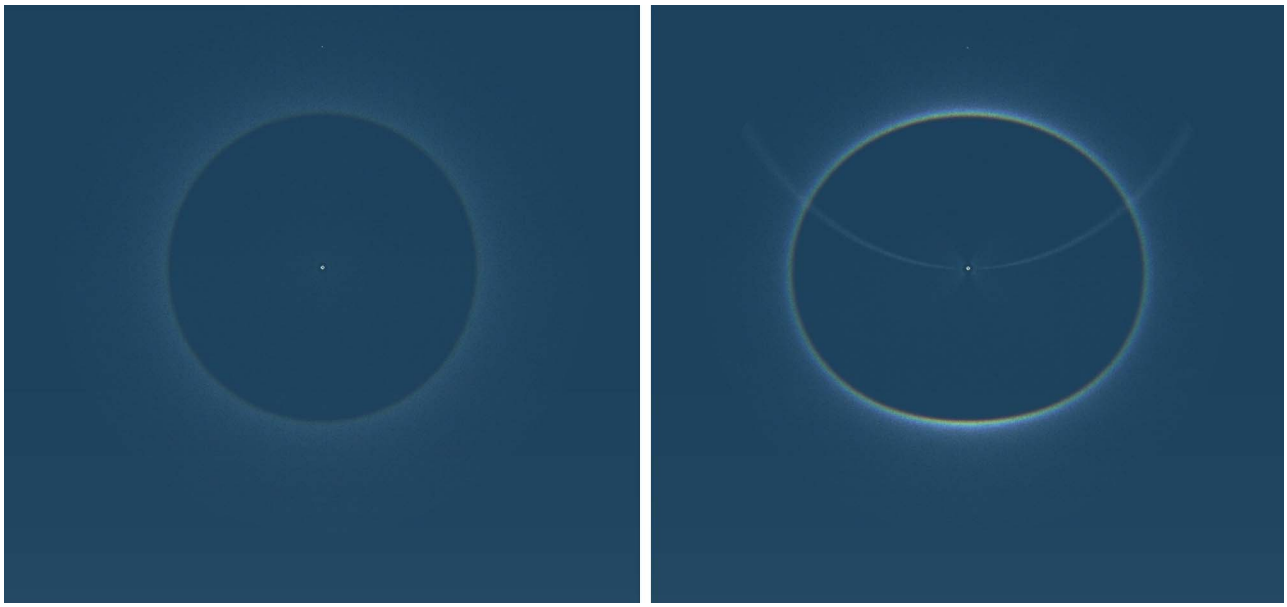


Fig. 5. Left: computer simulation of the circular 22° halo (all crystals in random orientation). Right: circumscribed halo for solar elevation 60° (all crystals in column orientation). The crystal density is for both simulations the same. The aspect ratio c/a of the crystals is 2. At its sides, the radiance of the circumscribed halo is 4 times larger than the circular halo; at its top and bottom, 5 times larger than the circular 22° halo.

radiance distribution of the circular 22° halo is very flat compared to halos due to preferentially oriented crystals [33,34]. On the other hand, when the crystals assume column orientation (i.e., crystal C-axes horizontally orientated), the radiance distribution of the resulting circumscribed halo peaks more to the inner locus, which results in a much brighter feature with purer color. Figure 5 shows the difference for solar elevation 60°: if a set of crystals changes its orientation from random to column, the circular 22° halo changes into the near-circular circumscribed halo which is near its inner edge four to five times brighter than the circular 22° halo.

The strongly colored circumscribed halo is usually accompanied by the bleaker circular 22° halo. This was clearly the case with the Chernobyl halo (Fig. 4) and, if our conjecture is correct, was also the case with the Orange halo and Octavian halo. In such a combined halo display, the real circular 22° halo is often a minor feature (Fig. 6) that may remain unnoticed by inexperienced observers. This happened indeed with the Chernobyl halo. Interestingly, despite the elliptical shape of a high-sun circumscribed halo, it is often described as a circular feature due to a well-known optical illusion [32].

In case of the Octavian halo, a weak point in its present identification seems the reported time of the day, indicating a solar elevation too low for producing a well-developed near-circular circumscribed halo. However, no one knows how persistent the Octavian halo had been. If the halo had persisted for 1 h after Octavian's arrival (until 9:30 am) the sun had climbed to 50°, a stage at which a circumscribed halo is fully developed.

We believe that reports of appearances of "round, rainbow-like colored circles around the sun attracting broad attention" refer in most cases primarily to high-sun circumscribed halos rather than to the circular 22° halo. This holds for reports from the remote past, among them the Orange and Octavian halos, as well as for halo appearances up to the present day. This interpretation applies to halo appearances at solar elevations for which the circumscribed halo is developed to a more or less

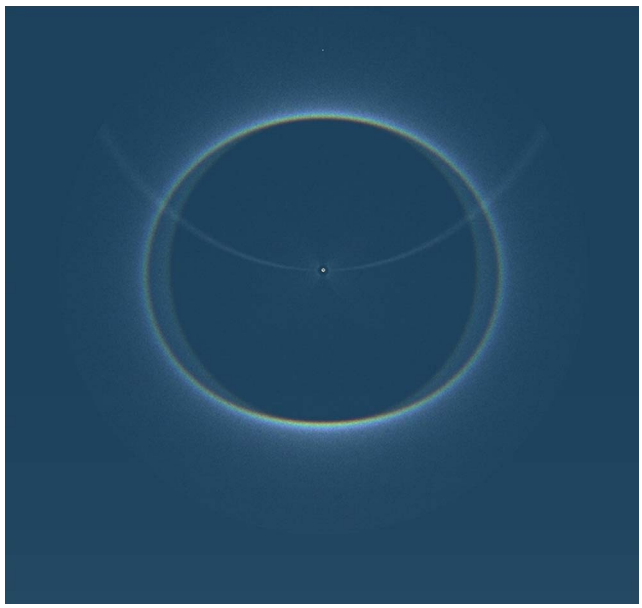


Fig. 6. Halo display generated by a mix consisting of identical crystals ($c/a = 2$) of which 50% is randomly orientated and 50% is in column orientation. This combination of the two simulations shown in Fig. 5 demonstrates why in high-sun halo displays generated by a mix of these orientations, the circular 22° halo is often a minor feature.

circular feature, hence for solar elevations exceeding ~45°.

For solar elevations below ~35°, when parhelia are prominent and the tangent arcs disconnected, or when the 22° halo is cut off by the horizon, a halo display usually looses the impression of being circular even to the layman. Then, the halo complex will only rarely be reported as being a circle. In those instances, the display may be taken for crosses in the sky. This happened for instance to the mountaineer Edward Whymper during the descent after his disastrous expedition to Mount Matterhorn (14 July 1865 at 6 pm LT, solar elevation 15°) [35,36] and probably also to the Roman Emperor Constantine the Great in late winter or spring 310, when he had his legendary "vision" which is brought in connection with his change in attitude against Christianity [37,38].

In times of strong emotions the appearance of a bright halo has been often interpreted as an omen or a sign of heaven. Interestingly, the tendency of the broad public to invoke supernatural explanations lasts through present time. A recent example occurred in 2004 in Bavaria (Germany), when an extremely bright lunar halo was seen by people while leaving the churches after the Midnight Mass of 24 December. The appearance of the halo was widely regarded as a heavenly sign portending the massive tsunami that struck southeast Asia 24 h later [39,40].

5. Aftermath of the Orange Halo

Nowadays, the engraving of the Orange halo seems more or less forgotten. A black-and-white print without the texts is in public exhibition of Huygens museum *Hofwijck* in Voorburg, The Netherlands; the rare colored version (Fig. 1) is kept in store by *Atlas van Stolk*, Rotterdam [41]. The decline of popularity of the engraving may be explained by the further events in Orange in the 17th century: the Principality was again occupied by Louis XIV during 1672–1678, once again during 1682–1697 (with harsh prosecution of the Protestants [42,43]), and finally absorbed by France in 1702—after which all Protestants were thrown out. All of this happened despite the "promise of welfare from the high throne of heavens [7]" depicted in Fig. 1.

I. Huysman (Huygens Institute for the History of The Netherlands, The Hague, The Netherlands) helped me out with the 17th century literature; A. Leerintveld (National Library of The Netherlands, The Hague, The Netherlands) explained the meaning of the lines of *Zeestraet* quoted in [14], provided a translation of these lines from old Dutch into modern Dutch, and pointed me to the existence of the color version of Fig. 1. F. Blom (University of Amsterdam, Humanities Faculty—Centre for the Study of the Dutch Golden Age) provided me with details about the Orange story; V. Pineton de Chambrun provided genealogical information about her ancestor (third cousin, eight times removed) Jacques. Dutch historian G. H. de Vries guided me through the antique Roman texts; S. Y. van der Werf translated Obsequens' Latin text; D. den Hengst (University of Amsterdam, Humanities Faculty) translated the 17th century Latin poem in Chambrun's [3] book; B. M. Kamp and H. Rowaan solved puzzling sentences in ancient French. P. van der Ploeg (Huygensmuseum Hofwijck, Voorburg, The Netherlands) assisted in obtaining Fig. 1; C. M. de Bruyn (Conservator Museum Huis van Gijn, Dordrecht, The Netherlands) provided me with a file of the black-and-white version of Fig. 1, kept in their collection (inventory number VG 1740). R. Bishop (Acadia University, Canada) brought via L. Cowley the Shapiro reference [10] to my attention. C. Hinz informed me about the story of the "tsunami halo" of 2004. The halo simulations (Figs. 5 and 6) are generated with the HaloSim program by Cowley and Schroeder [44].

References and Notes

1. C. Huygens, *De vita propria, sermonum inter liberos (1678)*. (Autobiography of Constantijn, written as a Latin poem consisting of 2162 dactylic hexameters. Part II, lines 856–865 of the poem refers to the Orange halo). The original Latin text and a line-to-line translation into Dutch is given in F. R. E Blom and C. Huygens, *Mijn leven, verteld aan mijn kinderen*, Vol. 1: Introduction, Text, and Translation (Promotheus/Bert Bakker, 2003). Also available from http://home.medewerker.uva.nl/f.r.e.blom/bestanden/Mijn%20leven%20dl.%202.pdf.
2. F. R. E. Blom and C. Huygens, *Mijn leven, verteld aan mijn kinderen*, Vol. 2: Comments and Annotation (Promotheus/Bert Bakker, 2003). (An extensive line-to-line comment to the events and their backgrounds described in Huygens's autobiography [1]; in Dutch.)
3. J. Pineton de Chambrun, *Relation de ce qui c'est passé au restablissement d'Orange: Ensemble les Discours et Harangues qui ont esté faictes pour le mesme subject* (Eduard Raban, Orange, 1666). Here, pp. 147–150 refer to the appearance of the halo. Available: http://books.google.nl/books?id=PP08AAAAcAAJ&printsec=frontcover&dq=pineton+de+chambrun+relation+de+ce+qui&hl=nl&sa=X&ei=8o9vVILnLYjUObb7gLAC&redir_esc=y#v=onepage&q=pineton%20de%20chambrun%20relation%20de%20ce%20qui&f=false.
4. The wall extends in compass directions 76°–256°, so its south-facing normal points at direction 166°, which is SSE. If the drawing is correct, local solar time was 11:33 and solar elevation was 62.5°—hence just 0.5° below its culmination height.
5. Contrary to Huygens's statement, Fig. 1 shows scattered clouds in the sky. If this detail in the engraving depicts reality rather than being an artist's interpretation, then it could have been that the halo was initially hidden behind a cloud deck which rapidly broke up. This would explain a "sudden appearance" of the bright halo.
6. Huygens's poem about the Orange halo reads: *Dum stat Arausiacae confirmatura Coronae / Antiquam Populi laeta Corona fidem; / Non dubie Coelo placuit quod utrique Coronae, / Tertia de Coelo missa coronat opus* [3]. This translates as: *While the happy crown of people was about to confirm / their everlasting loyalty to the crown of Orange / was Heavens unmistakably pleased that these two crowns / were crowned by a third crown from heavens.*
7. Text below Fig. 1 left reads: *About the inauguration ceremony: Orange, Williams heritage, starts breathing again, / As the legal Head rules to the glory of the State. / A freeborn Prince ordains free laws of freedom. / Never will the Sun of happiness, which now rises, / be splattered by war with blood and tears of the citizens. / Who received the Principality from God, deserves nothing but prosperity.* Right: *About the appearance of the Solar Crown: When William was inaugurated, appeared in the clouds, / a bright Solar Crown straight above the*

ceremonial podium. / A comet appears to foretell disasters; / but this (the sign) promised welfare from the high throne of heavens. / Orange now awaits the benefits of prosperity for her States. / A glorious Prince rules for the welfare of his people.

8. C. Huygens, *Traité de couronnes et des parhélies (1662 or 1663) in Oeuvres Complètes de Chr. Huygens* J. A. Vollgraff, ed., Martinus Nijhoff (The Hague, 1932), Vol. 17, pp. 364–515. Available: http://www.dbnl.org/tekst/huyg003oeuv17_01/huyg003oeuv17_01_0047.php and http://gallica.bnf.fr/ark:/12148/bpt6k778667.
9. W. Tape, "When Huygens and Mariotte agree," Appl. Opt. **47**, H85–H90 (2008).
10. A. E. Shapiro, "Newton and Huygens' explanation of the 22° halo," Centaurus **24**, 273–287 (1980).
11. W. Tape, E. Seidenfaden, and G. P. Können, "The legendary Rome halo displays," Appl. Opt. **47**, H72–H84 (2008).
12. E. Seidenfaden, "Found: a diagram of the 1630 Rome halo display," Appl. Opt. **50**, F60–F63 (2011).
13. A. Bravais, "Mémoire sur les halos et les phénomènes optiques qui les accompagnent," J. de l'École Royale Polytechnique **31**, Cahier 18, 1–280 (1847).
14. The Orange episode is quoted in lines 39-42 of his 1024-lines-long Dutch poem "Zeestraet" (Sea street) from 1667. Available: http://www.dbnl.org/tekst/huyg001zees01_01/huyg001zees01_01_0002.php. The translation of these lines reads: *I went through storms and fair weather / To bring the property of the Child back into his power: / In case humans [i.e., the Princess Dowager Amalia] would fail to do so, God provided a reward: / God crowned it, in the middle of the day.*
15. R. Meyer, *Die Haloerscheinung*, C. Jensen and A. Schwassmann, eds., Vol. XII of Probleme der Kosmischen Physik (Verlag Henri Grant, 1929).
16. L. Cassius Dio (AD 219), *Romaïkè Historia*, E. Cary, trans., Book 45, Chap. 4:4 [Cassius Dio, *Roman History*, Vol. 4 of Loeb Classical Library, Greek texts and facing English translation (Harvard University, 1916)]. Available: http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Cassius_Dio/home.html.
17. G. Suetonius Tranquillus (AD 121), *De vita Caesarum*, Augustus 95 [Loeb Classical Library, J. C. Rolfe, trans. (Harvard University, 1913)]. Available: http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Suetonius/12Caesars/home.html.
18. V. Paterculus (ca. AD 30), *Historiarum Libri Duo* [Loeb Classical Library, F. W. Shipley, trans. (Harvard University, 1924)]. Available: http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Velleius_Paterculus/home.html.
19. L. Annaeus Seneca (AD 65), *Naturales Quaestiones*, Book 1, Chap. 12:2 [J. Clarke, trans. (Macmillan and Co, 1910)]. Available: http://naturalesquaestiones.blogspot.com/2009/08/book-i-tr-john-clarke.html.
20. J. Obsequens (4th century), *Liber de prodigiis* (Book of Prodigies, describing wonders and portents that occurred in Rome 249 BC–12 BC, as extracted from an epitome, or abridgment from Livy's *Ab urbe condita libri*), Chap. 68. (French translation, p. 141. English translation available: http://www.liberprodigiorum.org/. German translation available: http://aillyacum.de/Obsequens.html. The quoted passage was originally in Livy's lost Book CXVII, available: http://oll.libertyfund.org/?option=com_staticxt&staticfile=show.php%3Ftitle=1758&chapter=92709&layout=html&Itemid=27.)
21. P. Orosius (AD 418), *Historiae Adversum Paganos* (A History Against the Pagans), Book 6, Chap. 20:5. English translation available: http://sites.google.com/site/demontortoise2000/orosius_book6.
22. G. Plinius Secundus (AD 77), *Naturalis Historia.* [Translated from Latin by John Bostock, M.D., F.R.S. H.T. Riley, Esq., B.A. (Taylor and Francis, 1855)]. Available: http://www.perseus.tufts.edu/hopper/text?doc=Plin.+Nat.+2.28&fromdoc=Perseus%3Atext%3A1999.02.0137.
23. J. Lydus (ca. AD 550), *De Ostentis* (About Celestial Phenomena), Book 10b.
24. G. H. de Vries, translator and annotator of Cassius Dio [G. H. de Vries, *Samenzwering en verraad, de strijd om de macht na de moord op Julius Caesar* (Atheneum-Polak & Van Gennep, 2006), ISBN 90 253 08813, pp. 67–68 and note 10 to Book 45], comments that Octavian's entrance in Rome was actually a very informal event (see also [25]). It is known that at that point Octavian was not yet regarded as an important political factor by his fellow citizens, including Cicero. Octavian's mother Attia had insisted that he keep a low profile: *Be careful, no provocations*.
25. Lucius Cassius Dio writes in Book 45, Chap. 5:2: *He entered the city as if for the sole purpose of succeeding to the inheritance, coming as a private citizen with only a few attendants, without any display.* Octavian's entrance is neither mentioned in the Res Gestae nor included in the Fasti. The insignificance of the event explains why its exact date is not recorded.
26. W. Eck, *Augustus und seine Zeit* (C. H. Beck, 1998), p. 13, ISBN-13: 9783406418846. [English translation: The Age of Augustus (Blackwell Publishing, 2003), ISBN 0 631 22958 2.]
27. Estimate by G. H. de Vries (personal communication, 5 Sept. 2011) on the basis of two of Cicero's letters to Atticus [28,29], in which Cicero mentions that Octavian arrived on 21 April in Puteoli (currently called Pozzuoli), where he stayed for about 10 days in his stepfather's villa, which was next to Cicero's. The journey by horse from Puteoli to Rome takes one day.
28. M. T. Cicero, Ad Atticum XIV, 11: …modo venit Octavius et quidem in proximam villam Philippi mihi totus deditus. [*Octavius just arrived, he stays in Philippus country house, next to us. He is completely at my side.*] [Written in Cumae (6 km WNW of Puteoli), 21 April 44 BC.]
29. M. T. Cicero, Ad Atticum XIV, 12: …Nobiscum hic perhonorifice et peramice Octavius. [*Octavius came here to pay us his respect and to offer his friendship.*] (Written in Puteoli, 22 April 44 BC.)
30. Kleinstück [31], taking 9 am as representative for the "third hour" calculated a solar elevation of 35° at azimuth SE. He notes that Octavian proceeded in April to Rome from the SE along the Via Appia, which means that the sun and halo were straight over him and could therefore not be missed by the "enormous crowd of friends who went out to meet him" [18].
31. H. Kleinstück, "Antike Beobachtungen zur meteorologischen Optik," Philologische Wochenschrift **52**, 238–244 (1932).
32. P.-P. Hattinga Verschure, "An outstanding display of the circumscribed halo," Weather **43**, 370–376 (1988).
33. G. P. Können, "Polarization and intensity distributions of refraction halos," J. Opt. Soc. Am. **73**, 1629–1640 (1983).
34. G. P. Können, "A note on the radiance distributions of halos due to scattering by randomly orientated crystals," Appl. Opt. **54**, B177–B184 (2015).
35. M. G. J. Minnaert, *Light and Color in the Outdoors* (Springer-Verlag, 1993), par. 147.
36. E. Whymper, *Scrambles Amongst the Alps in the Years 1860-'69* (J. P. Lippincott, 1872), Chap. 22. Available: http://archive.org/details/scramblesamongs00whymgoog.
37. The date of the "vision" is traditionally put at 27 October 312, being the day before the Battle on the Milvian Bridge. However, Weiss [38] reaches the conclusion that the halo appeared 2.5 years before this decisive battle.
38. P. Weiss, "The vision of Constantine," J. Roman Archaeol. **16**, 237–259 (2003). The paper also lists a number of halo reports from the antiquity.
39. C. Hinz and W. Hinz, "Die halos im Dezember 2004," Meteoros **8**, 45–46 (2005).
40. Personal communication by Claudia Hinz (9 April 2012). It was an extremely bright 22° circular halo without a circumscribed halo; the brightness of this lunar halo was so great that its colorization was clearly visible to the naked eye [39]. It was 1.5 days before full moon; at midnight the moon was 64° above the horizon with 97% of its visible disk illuminated. On 26 December, a regional radio broadcast brought the halo in connection with the tsunami, after which several newspapers followed, among them the Münchner TZ, the Oberbayrischen Volksblatt, and the Süddeutschen Zeitung.
41. Color versions of the engraving (Fig. 1) seem very rare. Black-and-white versions of it are kept in the stores of a few museums, among them the Museum van Gijn (Dordrecht), Rijksmuseum (Amsterdam), and in Vienna, London, and Paris. The black-and-white engraving may also be found in libraries keeping the antique book by Pineton de Chambrun [3], as it is reproduced as a folded illustration at the

back of luxury editions of that book, however, not in the regular editions (e.g., not in the one digitized by Google Books). A black-and-white version with French texts on top but no poems below is kept in the stores of several museums, including Atlas van Stolk (Rotterdam).
42. J. Pineton de Chambrun, *Les Larmes de Jacques Pineton de Chambrun (The Tears of Jacques Pineton de Chambrun)*, Jeuxte le Copie (The Hague, 1688). Published one year before his death in 1689 of the since 1686 exiled author in London. Shortly before his death in 1689, the refugee had received from the Prince of Orange—just risen to King William III of England—a canonicate in Windsor [43]. Available: http://books.google.com/books?id=aNc7AAAAcAAJ&printsec=frontcover&hl=nl&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false (reprint from 1726). http://books.google.com/books?id=S1SVIDCPOFYC&pg=PA8&hl=nl&source=gbs_toc_r&cad=4#v=onepage&q&f=false (reprint from 1854 with an introduction by Ad. Schaefer).
43. E. Haag and É. Haag, *La France protestante, ou Vies des protestants français qui se sont fait un nom dans l'histoire depuis les premiers temps de la réformation jusqu'à la reconnaissance du principe de la liberté des cultes par l'Assemblée* (J. Cherbuliez, 1858), Vol. VIII, pp. 245–248. Available: http://gallica.bnf.fr/ark:/12148/bpt6k6103157h/.
44. L. Cowley and M. Schroeder, "HaloSim simulation program," Available: http://www.atoptics.co.uk/halo/halfeat.htm.