

WILL KYSELKA

Solar Eclipses in Hawai‘i

ECLIPSES, COMETS, supernovae, meteors—all are celestial show-pieces that might have moved the Polynesians into a sprightly view of the universe. Yet accounts by early historians ascribe fear as the dominant reaction of the Hawaiians to solar eclipses rather than awe.

Adding to that splendor in the sky is the moon’s whirling 36,000 times across the heavens in the 3,000 years of Polynesian habitation, waxing and waning, and meeting monthly with each of the planets. Close encounters? Those, too, with Venus and Jupiter rendezvousing 4,000 times, often graced with a thin crescent moon—all in the “natural” universe of a sea-faring people for whom survival rested upon a knowledge of the heavens.

Yet so sanguine a view of Polynesian naturalness was not held by early writers in Hawai‘i. The Reverend Hiram Bingham assured his people that the eclipse of June 26, 1824 was a “natural” event. S. M. Kamakau tells the story, although his date of June 21 is in error:

About noon on June 21 an eclipse of the sun took place which covered the land with darkness. The next day Mr. Bingham explained how the eclipse was caused by the moon getting between the earth and the sun. The people asked him what event it was a sign of, and he told them it was not a sign of anything about to happen, accord-

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ing to the ideas of his country, but an occurrence which happened naturally from time to time and was not everywhere visible at the same time. They told him that it was the Hawaiian belief that this was a sign from God foretelling some great event like war, the overthrow of the government, the death of a ruling chief, and that they believed war was imminent.¹

Were descriptions of eclipses encoded in chant and dance, stored in a collective memory, then forgotten? Or did the people of old handle eclipses quite "naturally" as grand events evoking feelings of awe and wonder, even humor?

An *eclipse* is the obscuring of light from one heavenly body by another. When the moon blocks the sun we have a *solar* eclipse; when it goes into the earth's shadow we have a *lunar* eclipse. Solar and lunar eclipses occur with about the same frequency, about twice a year. Everyone on the darkened side of earth can see a lunar eclipse because the earth casts a large shadow. In a solar eclipse, however, the moon's shadow is only a few miles in diameter, and only a relatively few observers are in the path of totality.

Solar eclipses are of three kinds. In a *total* eclipse the moon completely covers the sun, revealing solar streamers and coronal flashes. For a thousand miles or more on either side of the path of totality is a region of *partial* eclipses where the moon takes a bite out of the sun without swallowing it. And in an *annular* eclipse the moon appears smaller than the sun because its elliptical orbit takes it farther from the earth. Then it is too far to completely cover the sun, so the moon is ringed with a thin rim of sunlight.

Thirty-two notable solar eclipses have occurred in Hawai'i in the last 300 years. *Notable?* We consider an eclipse notable when the moon covers at least half the sun. That happens when the path of the center of the moon's shadow (path of centrality) lies within a thousand miles of Hawai'i.

Three Centuries of Notable Solar Eclipses in Hawai'i (and the Periodic Visits of Comet Halley)

The 18th Century

1701 Feb. 7

1716 Mar. 22

1735 Oct. 15

1740 Dec. 18

1756 Feb. 29

1756 Aug. 25

1759 Mar. 13 Comet Halley

1767 Jul. 25

1770 May 25

1795 Jan. 20

1799 May 4

The 19th Century

1810 Apr. 12

1822 Feb. 21

1824 Jun. 26

1825 Dec. 9

1829 Sep. 27

1835 Nov. 16 Comet Halley

1839 Sep. 7

1850 Aug. 7

1853 Nov. 30

1864 May 6

1876 Mar. 25

1880 Jan. 11

1883 Oct. 30

1893 Oct. 9

The 20th Century

1910 Apr. 20 Comet Halley

1915 Aug. 10

1926 Jul. 9

1930 Apr. 28

1947 Nov. 12

1950 Sep. 11

1977 Oct. 12

1981 Jul. 30

1986 Feb. 9 Comet Halley

1991 Jul. 11

1992 Jan. 4

Hawai'i averages an eclipse a decade. Using a figure of 10 per century, we find that 150 have occurred in Hawai'i in its 1,500

years of human habitation. Adding Easter Island, New Zealand, Tonga, and Tahiti to that figure, and extending time back 3,000 years to the arrival of the first settlers, we find that 1,500 solar eclipses have taken place in Polynesia over the last 30 centuries.

Fifteen-hundred solar eclipses and an equal number of lunar eclipses in 3,000 years—where is the cultural expression of the phenomena? Particularly that awesome experience—*totality*?

An hour and a half before totality the advancing moon nicks the western edge of the sun. The bite grows larger and the sun grows smaller as the moon moves eastward across its face. Crescent images of the sun cover the ground in the spaces between shadowed leaves.

Fifteen minutes until totality. The sky is strangely dark as if before an impending storm. Final seconds, and shadow bands race across the ground while the leading edge of the moon breaks the rim of the sun into a chain of Baily's Beads—the last rays of sunlight flashing through spaces between craters on the moon. One remaining small dot of light shines like a diamond, then winks out.

Then totality—that profound moment of connection, a moment so well expressed by astronomer Jack Zirker who has spent a lifetime in eclipse study:

I look up. Incredible! It is the eye of God. A perfectly black disk, ringed with bright spiky streamers that stretch out in all directions.²

Hawai‘i has had two total eclipses in the last 300 years, one in 1850 and another in 1991. The next total will occur at 5:49 on the morning of May 3, 2106. South Point will be at the edge of totality, so for best viewing, travel 60 miles farther southward to be in the path of centrality.

Shown in the pages that follow are 10 of the 32 notable solar eclipses visible in Hawai‘i over the past three centuries. Data is from Oppolzer’s *Canon of Eclipses*³ and Meeus’ *Canon of Solar Eclipses*.⁴ Reconstruction of eclipses was worked out using the Voyager II⁵ program on a Macintosh computer; drawings by the

author. The viewing place is Honolulu, Longitude $157^{\circ} 52'$ W, Latitude $21^{\circ} 18'$ N.

THE 18TH CENTURY

Hawai'i had 10 notable solar eclipses in the 18th century, each a partial. Twice the sun rose eclipsed; three times it set eclipsed, and at mid-century a near-total occurred. At about the time of the birth of Kamehameha I, two solar eclipses took place and a comet appeared. The comet's return had been predicted by Edmond Halley, and its appearance verified the universality of Newtonian physics. First seen in the fall of 1758, it brightened as it moved toward the sun, reaching greatest brilliance in May of 1758 when its tail stretched in great splendor halfway across the sky.

Also of historical interest in that period was Venus crossing the face of the sun. It was the observation of this "transit of Venus" that brought Captain James Cook to Tahiti in 1769. Halley had suggested that the uncertainty in the distance of the sun, then about 30 per cent, might be reduced to 0.2 per cent by observing Venus's passage across the solar disk from various locations on earth. The Cook expedition set up instruments on Point Venus in Tahiti, as part of this first world-wide coordinated scientific effort, and observed the tiny black dot of Venus traveling across the solar disk. The transit began at 9:37 in the morning of June 3, 1769 and ended at 2:57 that afternoon.

February 29, 1756

Hawai'i had two solar eclipses in 1756, one at sunset and the other at sunrise.

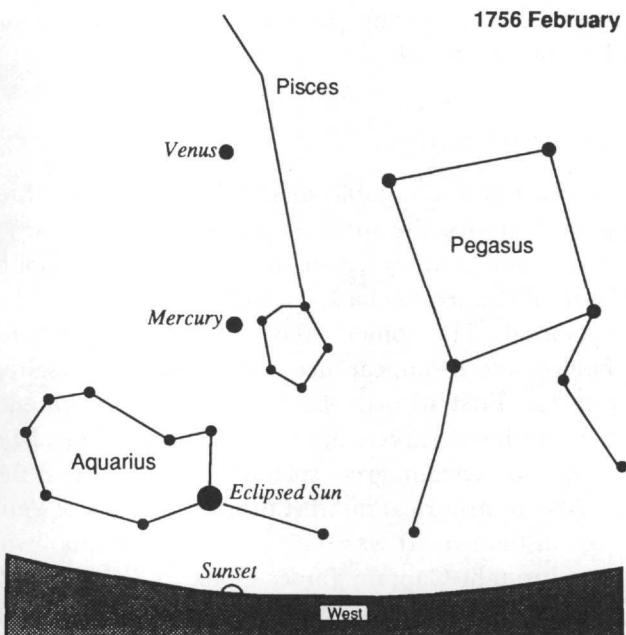
The sun was in Aquarius on that extra February day, nearing the western horizon when the unseen moon moved up (eastward) across its face, hiding 80 per cent of it. The sky grew dark as if the sun were setting 40 minutes ahead of time. Brightening as it neared the horizon, it set, still a quarter of it covered. Observers 300 miles south of Hawai'i in the path of centrality would have seen a dark moon ringed with sunlight, for this was an annular eclipse.



Maximum, 5:59 p.m.



Sunset, 6:31 p.m.



Mercury and Venus lingered for a brief time in the twilight, leaving the sky with plunging Pegasus.

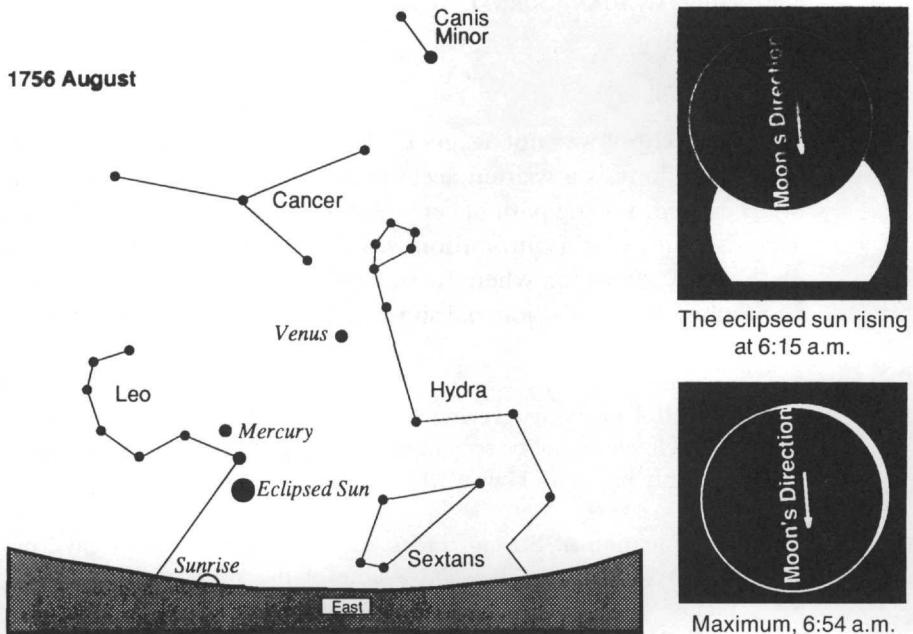
August 25, 1756

Six months later that event was mirrored in the morning sky. Rising almost as usual—only slightly nicked—the day darkened as the sun climbed higher into the sky. Moving eastward (downward), the moon covered three-fourths of the sun, three-quarters of an hour after sunrise. A hundred miles north of Kaua'i along the path of centrality the eclipse was annular. The sun was in Leo; Mercury and Venus were nearby.

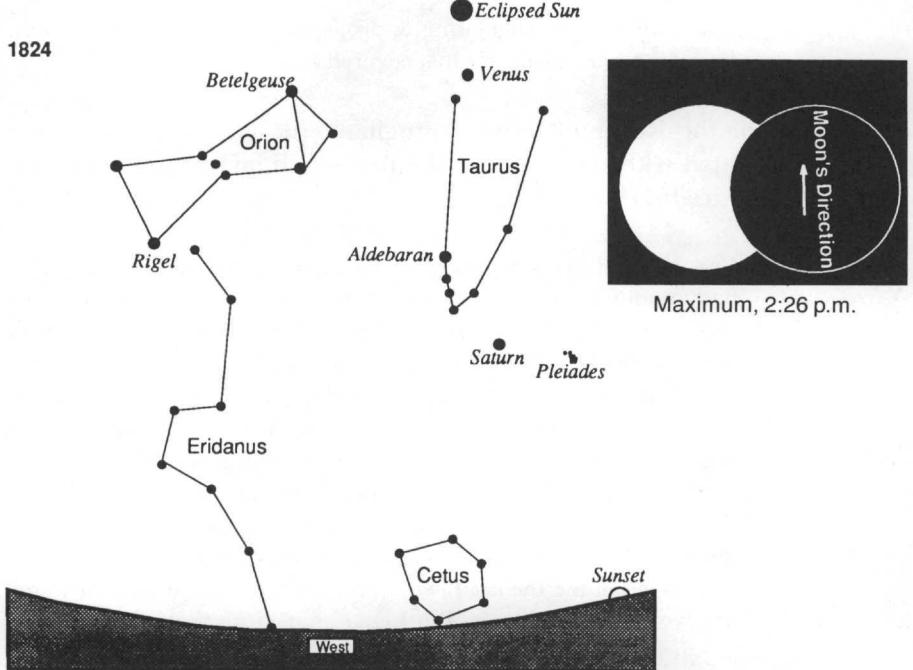
THE 19TH CENTURY

Thirteen notable solar eclipses occurred in the 19th century, one of which was total. Jupiter and Venus put on a good display early in the century, drawing so close on the morning of January 3, 1818 that for a moment they blended into a single bright point of light. Comet Halley returned in 1835.

1756 August



1824



June 26, 1824

The 1824 eclipse was not a “good” one, but it was the first eclipse for which there is a written account. Less than half the solar disk was covered, for the path of centrality was 1,300 miles north of the islands. But its light diminution was conspicuous, for it happened in the early afternoon when the sun was high in the sky.

Stephen Reynolds’ journal shows his interest in the event:

Friday 21.

Beautiful morning. Trying to project the Eclipse for 26th June, found it would not be seen at this place. [Meaning, perhaps, that it was only partial in Hawai‘i.]

Saturday 26

Continuation of Strong trades. Gov [Kuakini] Adams gave me seventy two piculs of wood—some of the sticks weighing three piculs—all very large was so engaged could not see but very little of the Eclipse—about one third of the sun was covered. In making my calculations the moon’s Latitude, or Spectators path were wrong—Path

Monday 28

Spent the day in calculating & projecting the Eclipse of the 26th, found the sun was nearly half covered.⁶

For the Reverend Hiram Bingham, the gloom of the eclipse resonated with the gloom of the time—a time of “difficulty, distrust, disaffection and danger”:

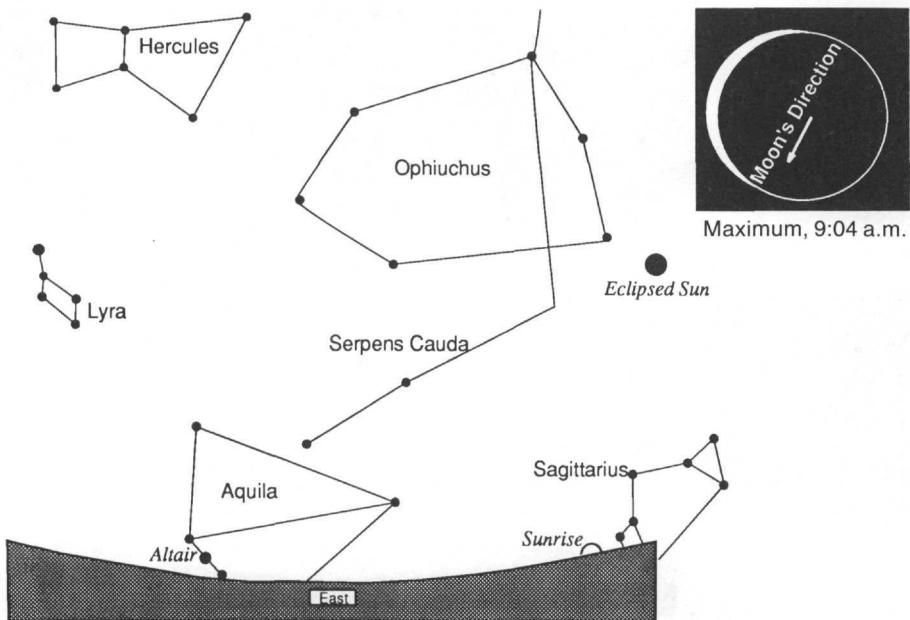
Previous to [the new governor, Kahalaia’s] arrival [on Kaua‘i], I had announced to the people that there would be an eclipse of the sun at mid-day on the 26th of June, at fifty-seven minutes after twelve o’clock, [maximum at 1:57 p.m.] and gave a brief account of its extent and duration, with which the event accorded. During its progress, this phenomenon, which they had been accustomed to regard with superstitious awe and forebodings of evil, I endeavored to explain as the mere passing of the moon between us and the sun, so as to throw a shadow upon us for a time. Some, supposing me to be able perhaps to take the place of their old astrologers, demanded of me the *ano* [awe, holy], purport of wonder, or to tell the event indicated by it. But I could not, from that phenomenon, predict either *war* or *peace*, famine or plenty, death or prosperity, as

their pretending astrologers had been accustomed to do. Some, however, prognosticated war, and this was thought by others to be an indication that war was desired, or was already meditated. The gloom of the moon's shadow on the islands corresponded with the political gloom that then hung over Kauai, while many of the inhabitants lived in apprehension of evils, against which they had no competent protection. Some dared oppression from the windward chiefs, should their control be undisputed. Others feared oppression or destruction from Kauai chiefs, now divided into parties. Some, decidedly favoring the new order, provoked the envy and hostility of those who disliked to yield to windward supremacy. The want of integrity, and of the means of intelligence and inter-communication, magnified the difficulty; and distrust, disaffection and danger, seemed to envelope the island in clouds.⁷

December 9, 1825

More dramatic than the 1824 eclipse was the one that took place the following year, yet there is no written account of it. Partial in Hawai'i, it was total 300 miles to the south. The moon's shadow

1825



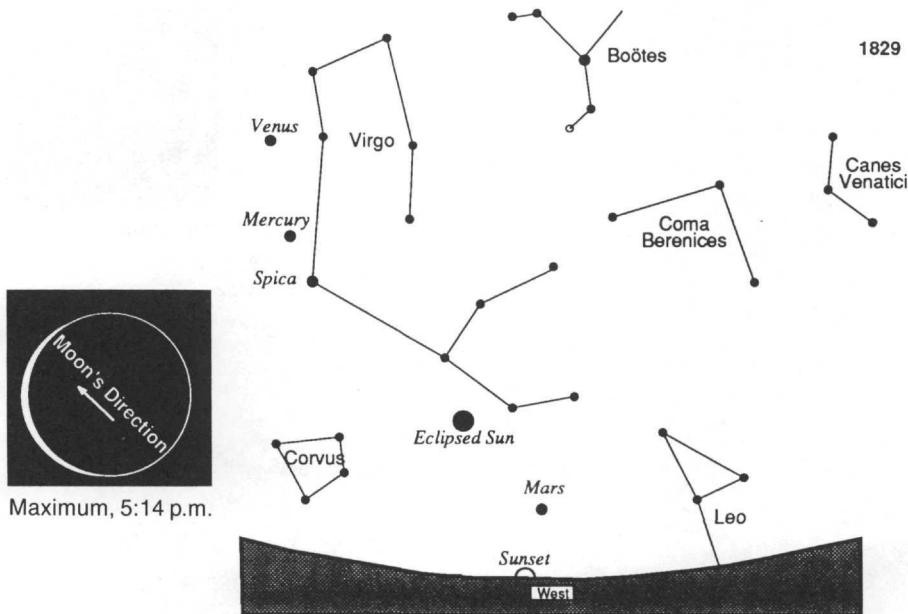
touched the earth a thousand miles west of Hawai‘i, swept eastward across the Pacific and Central America, touched the tip of Florida, and ended in the Atlantic. The sun was in Scorpius, making a low path across the southern sky, for this was two weeks before winter solstice.

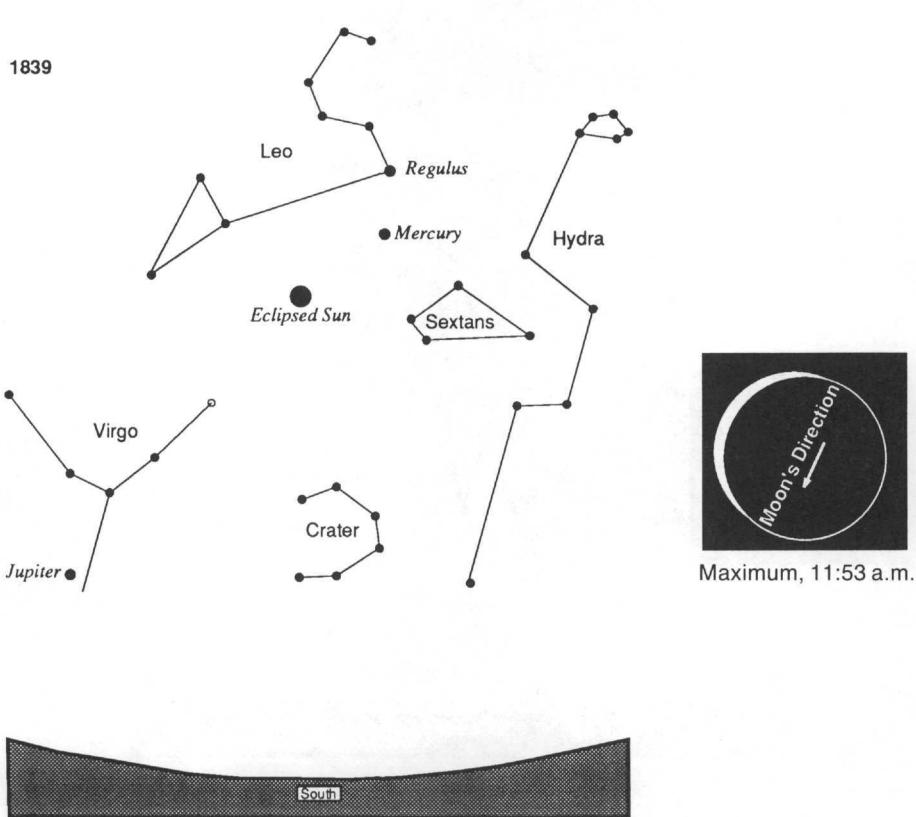
September 27, 1829

The sun was just past the equator on an equinoctial afternoon and nearing the horizon. The sky darkened, and all but 3 per cent of the sun disappeared, the thinnest of thin crescents. The path of centrality of this annular eclipse was 50 miles north of the island of Kaua‘i. Mercury and Venus were two bright objects in the evening twilight.

Stephen Reynolds paid little attention to this eclipse although it was a more interesting one than that which he had calculated in 1824. He explains:

Cloudy—Fresh trades. An Eclipse of the Sun in afternoon So cloudy could not observe it. Brig Neo arrived from Tahaite—cargo timber & cocoa nut oil.⁸





September 7, 1839

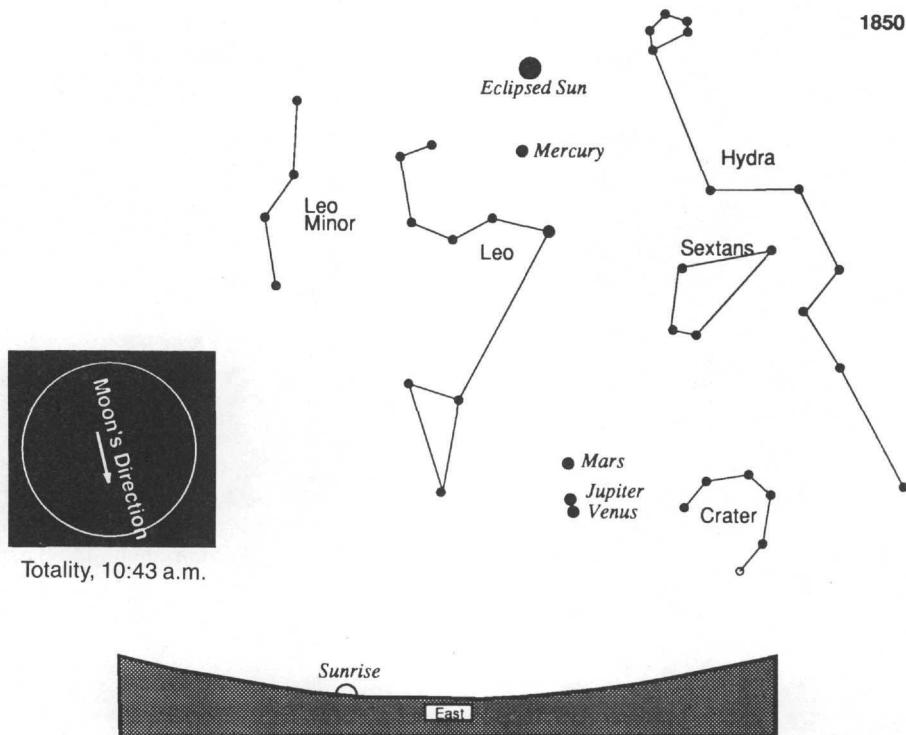
Near-darkness at noon with the sun almost directly overhead and only 3 per cent of it visible. But even in the path of totality, 50 miles south of the island of Hawai'i, the moon was too far from the earth to totally cover the sun.

August 7, 1850

Darkness, total darkness of the sun near noontime, a rare event. The sun was in the direction of Cancer. Mars, Jupiter, and Venus formed a beautiful trio between Crater and Leo. The separation of Venus and Jupiter was only 1.1° , a spectacular sight during totality as well as in the evening sky after sunset.

The first newspaper account of an eclipse appeared in *The*

1850



Friend and shows the exactitude that astronomical observation had attained at that time:

LOOK OUT FOR THE ECLIPSE.—M. Adams, agent of the French authorities at Tahiti, sent hither to make observations upon the eclipse of August 7th, has addressed a communication to H.H.M.'s Minister of Foreign Relations, from which we make the following quotations:—

'On the 7th of August next, a total Eclipse of the Sun, will be visible, at Honolulu, and the Hawaiian Islands, in general, of which the principal phases, at Honolulu will be:

	Hours	Minutes	Seconds
Commencing at	8	54	19
Total Eclipse	10	13	8.5
End of Total Eclipse at	10	19	15.5
End of the Eclipse	11	45	52

'From the commencement, till the total eclipse, the light of the Sun will diminish gradually. At 10 hours, 13 minutes, 8 1-2 seconds when the last portion of the Solar Disk, will have disappeared, the darkness will become very deep, and will continue for 6 minutes and 7 seconds, after which the Sun's Disk will reappear, and the light will return by degrees, until the end of the Eclipse.

'It is difficult to predict what will be the degree of darkness, but every thing conduces to the belief that the darkness will be greater than in a night of full moon. Most probably all the bright stars, will be seen. The planets Venus, Mars, and Jupiter, happening to be very close together, during the Eclipse, will be seen to the East of the Sun, towards the horizon.

'The total eclipse, spoken of, is one of the strongest of the present age. Generally, in the same place, one is not seen oftener than in a century; and sometimes, even several centuries pass over, before a total eclipse is reproduced.'⁹

"Perplexing uncertainty" attended the viewing of that eclipse —will clouds cover the sun and "the cup of enjoyment" be dashed? An extensive report appeared in *The Polynesian*:

Wednesday morning opened with a dense bank of clouds lying along the mountain range to the eastward of the town, and a drizzling, rainy, mist threatened to spoil the expected observations, which it certainly would, had the eclipse happened before eight o'clock. But towards nine, the sun rose above it, and the fleecy clouds began to fly off before his approach, occasionally obscuring his glory, and thrusting themselves before him, with peculiar obtrusiveness.

Anxieties and doubts were felt and expressed in regard to the critical moments when, only the grand phenomenon could be witnessed; and when the morning breeze set in, it began to be a matter of perplexing uncertainty whether, after all, the cup of enjoyment was not to be dashed, just as it was raised to the eager lips. But soon all doubts were removed, and the sun rose triumphantly and unobscured above the clouds, and at the expected moment the eclipse commenced, and a most splendid sight it was. Gliding up noiselessly, but with an unerring motion, the sun passed behind the moon, and in 79 minutes was totally eclipsed. As the obscurity increased, the light became dim, and a feeling of awe seemed to

pervade the minds of all. Objects near and at a distance, stood out with a marvelous distinctness, and when the last ray was obstructed, a shout rose from the multitude of spectators which made the welkin ring.

For 16 minutes before and after the eclipse was total, Venus became visible; and for seven minutes Jupiter glimmered in the twilight, close by her side. During the total obscuration, ten stars, in different parts of the heavens, shone out distinctly, but were all quickly lost, when the rays of the sun were again released. The light was greater at the darkest period, than the brightest moonlight, and the outline of the Waianae mountains, 25 miles distant, could be distinctly seen.¹⁰

A personal description of human activity centering about an eclipse is given by Dwight David Baldwin. Although he is uncertain of the date, the only total eclipse that it could have been was this one:

The old time Hawaiians viewed eclipses of the sun and moon with astonishment and great fear, believing them to be a token of the displeasure of their gods; and hence presaging the death of a high chief or some other public calamity.

During all the years of my father's residence at Lahaina it was his practice to calculate the exact Lahaina time of the beginning, end, and duration of every eclipse of the sun and moon visible there; and to make public announcement of the same a few weeks previous to their occurrence. He did this partly from a love of natural science, but especially, I think, to counteract the superstitious notions of Hawaiians regarding eclipses, by showing that they were the result of established laws of nature.

I have a vivid recollection of what occurred at the time of one of these eclipses which took place sometime, I think, during the period 1841 to 1843, when I was a lad of 10 or 12 years. It was a total eclipse of the sun; and, as usual, father had calculated the time of its occurrence and made public announcement of the same. The day arrived. The eclipse was to commence near the noon hour; but in the early morning the people began to collect in and about our Lahaina premises; and long before noon our own spacious yards and all the surrounding roads and yards were filled with men, women & children. The whole population of Lahaina had assem-

bled there to view the eclipse. It was however reported at the time, that two or three old time "kahunas", who professed to have an astrological knowledge of the heavens had said that, "the 'haole' [Caucasian] was wrong; there would be no eclipse"; and they staid at home.

The predicted moment of commencement arrived; and sure enough, the dark body of the invisible moon was beginning to eat off the edge of the sun. All saw it; some through smoked glasses, but very many were looking at the sun with the naked eye. There was no applause or cheering. The matter of eclipses was too weird for the Hawaiians of that time to welcome. All through the crowd were heard subdued expressions of awe and wonder. "Kupanaha"!—wonderful—"How did he know it?" "He mana akua"—A power divine.

As the period of total obscuration approached a gloom seemed to pervade the dense crowd; and when the sun was wholly lost to sight and a few stars appeared they exhibited evident signs of fear and agitation.

The eclipse lasted two or three hours; and when it was over, the people still lingered about our premises, apparently afraid to leave them. It was night-fall before they had entirely dispersed.

In later years, after my father had accurately predicted many eclipses, he was well aware that many of the more ignorant and superstitious Hawaiians credited him with having superhuman powers; a belief which he of course firmly discountenanced.¹¹

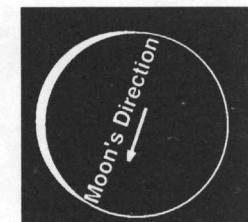
For such a fine eclipse the inveterate eclipse reporter, Stephen Reynolds, seems surprisingly terse:

Wednesday 7. Fine morn. About 9 o'clock the Eclipse began, all eyes were turned to the sun. When total darkness began the stars appeared. Duration of total darkness 6 minutes, 7 seconds.¹²

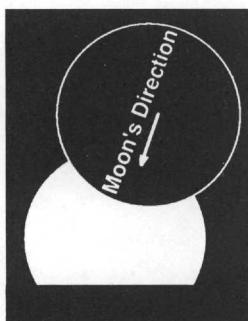
November 30, 1853

The sun rose partially eclipsed, and 42 minutes later only 2 per cent of it was visible. A hundred miles south of South Point the eclipse was total.

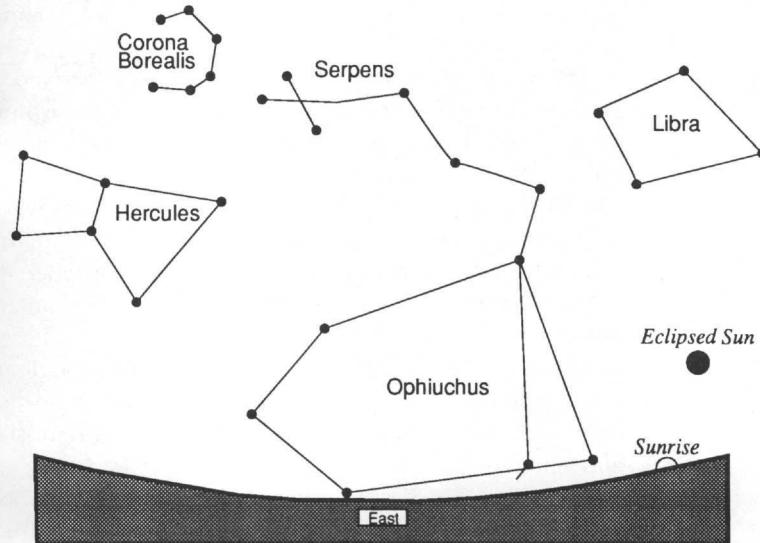
The tone of the report in *The Polynesian*, somewhat condescend-



Maximum, 7:39 a.m.



Sunrise, 6:57 a.m.



ing, unfortunately does not specify how "some natives" were able to calculate eclipses with precision:

As announced the eclipse of the sun occurred on the morning of the 30th. Its commencement could not be observed from Honolulu, on account of the high hills on the eastern side of the town; but when the sun rose above them it was found nearly obscured, and the further progress of the eclipse could be observed with distinctness. The frequent recurrence of eclipses of the sun have had the effect of diminishing the superstitious awe with which the natives of the islands were wont to regard them. They are understood as natural phenomena, subject to fixed laws, and there are some natives so far enlightened, as to calculate them with precision.¹³

March 25, 1876

The sun was in the direction of Pisces and close to the place where the previous eclipse had occurred. Venus and Mars, both in

Aries, trailed the sun and made a bright pair in the evening sky. The path of centrality passed 250 miles north of the Islands. About 95 per cent of the sun was hidden at maximum as viewed from O'ahu.

A writer for *The Hawaiian Gazette* viewed it with humor:

ECLIPSE OF THE SUN.—On Saturday next there will occur a nearly total eclipse of the sun, commencing at half past seven in the morning, and lasting till five minutes past ten o'clock. The period of greatest darkness will be about a quarter before nine. A number of interesting phenomena will be observed in connection with this eclipse, among which we would mention a universal throwing back of the head simultaneously with a raising of glasses to a close proximity with the face. This will be seen even among the staidest temperance people. The chickens will also generally sneak back to their roosts with a flagrante delicto air.¹⁴

The *Gazette* reported the eclipse the following week in a similar flippant style. Apparently eclipses by now were nothing to fear:

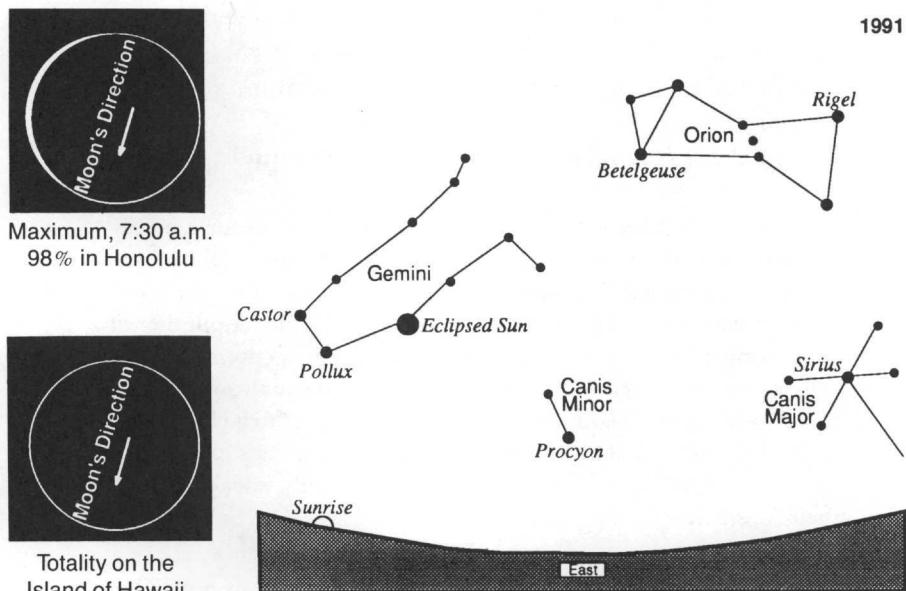
THE ECLIPSE came off on Saturday according to appointment, proving itself the very pink of promptness, being not a second too early or too late. Unfortunately the morning was cloudy, and the beginning and end of the eclipse could not be observed with as much definiteness as was desirable.¹⁵

THE 20TH CENTURY

The 20th century had one total eclipse but fewer partial eclipses than the two earlier centuries. However, it did enjoy two returns of Comet Halley.

July 11, 1991

The moon's shadow touched the Pacific a thousand miles southwest of Hawai'i and moved eastward over the greatest collection of big telescopes on earth. The sun was about 20° above the horizon when the moon moved in front of it for a period of four minutes and nine seconds. The shadow raced across the Pacific, and it



was noontime in Baja California and Mexico City when darkness lasted almost seven minutes. The shadow continued through Central America and ended in Brazil at sunset. An excellent description of the family history of this eclipse is given in *Totality: Eclipses of the Sun*.¹⁶

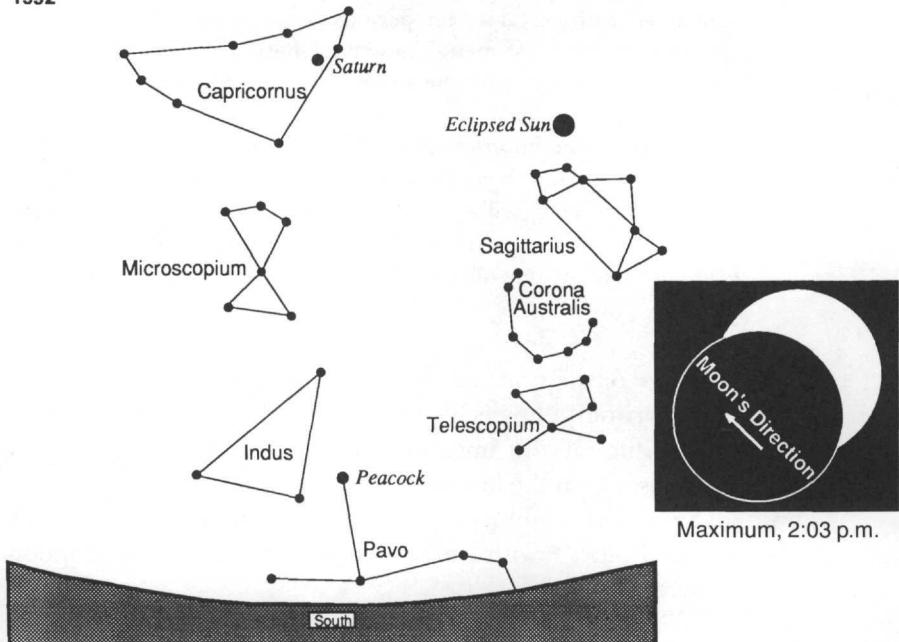
January 4, 1992

The last eclipse of the 20th century will occur in the early afternoon of a January day. The sun, then in Sagittarius, will be making a low arc across the southern heavens. Only slightly more than half the solar disk will be covered at maximum, for the path of centrality will be 900 miles to the south. Saturn will be following the sun and shining brightly in the evening sky above the setting sun.

THE 21ST CENTURY

The next eclipse will be in 2001; the next total in 2106.

1992



CONCLUSION

We've looked at solar eclipses that have occurred in Hawai'i over the past three centuries and at descriptions that early historians have given. Written accounts of Hawaiian reaction to eclipses is condescending, even the well-written account of the eclipse of 1850 in which the writer of the article hopes to change the minds of "doubting natives" and "elevate their ideas:"

We conclude by alluding to the superstition of the nation on the subject of eclipses. From time immemorial they have associated an eclipse, of either the sun or the moon, with the death of their chiefs, and readily allude to them as having happened in conjunction. In regard to the one above noticed [the 1850 eclipse], they are not entirely free from their old opinions; though the better informed freely admit that they have no connection in reality. We are happy to know that considerable extra influence has been

employed to explain the reason of eclipses, and that they could be calculated with certainty for periods in the future, exceeding the life-time of the oldest men. These explanations have had a beneficial effect in eradicating the superstition of many, but others are still faithless. . . .

We hope this demonstration of the precision of science in calculating eclipses, and the perfection with which the works of the Creator are conducted, will tend to establish in the minds of the doubting natives the character of that God whose attributes are, on occasions like the one noticed above, so clearly revealed to the universe.¹⁷

Knowledge of the universe has changed remarkably since that article was written. Now eclipses are viewed more with awe than fear. And what of the ancients? With the 1,500 eclipses that Polynesia has had in the last 3,000 years, is it not plausible to suppose that ancients might have regarded them in like manner? Or, like the Tahitians,¹⁸ with humor at the sight of sun and moon making love?

NOTES

- ¹ S. M. Kamakau, *Ruling Chiefs of Hawaii* (Honolulu: Kamehameha Schools P, 1961) 266.
- ² J. B. Zirker, *Total Eclipses of the Sun* (New York: Van Nostrand Reinhold, 1984) 52.
- ³ Theodor von Oppolzer, *Canon of Eclipses*, trans. Owen Gingrich (New York: Dover, 1962).
- ⁴ Jean Meeus, *Canon of Solar Eclipses*, (Oxford: Pergamon Press, 1966).
- ⁵ *VoyagerII*, computer software, Carina Software, 1989.
- ⁶ Stephen Reynolds, *Journal of Stephen Reynolds*, vol. 1: 1823-1829, ed. Pauline N. King (Honolulu: Ku Pa'a Inc.; Salem: Peabody Museum of Salem, 1989) 30.
- ⁷ Hiram Bingham, *Residence of Twenty-one Years in the Sandwich Islands*. (Hartford: Hezekiah Huntington, 1847) 229. Kaumuali'i, the King of Kaua'i, had just died, and the chiefs were threatening war.
- ⁸ Reynolds, *Journal* 279.
- ⁹ *F*, 1 Aug. 1850.
- ¹⁰ *P*, 7 Aug. 1850.
- ¹¹ Dwight D. Baldwin, "A Reminiscence of Rev. Dwight Baldwin," ms. Children of the Mission, 1830-1900. HMCS.
- ¹² Stephen Reynolds, Journal. 7 Aug. 1850, ts. HHS.
- ¹³ *P*, 3 Dec. 1853.

¹⁴ HG, 22 Mar. 1876.

¹⁵ HG, 27 Mar. 1876.

¹⁶ Mark Littman and Ken Willcox, *Totality: Eclipses of the Sun* (Honolulu: U of Hawaii P, 1991)

¹⁷ P, 10 Aug. 1850.

¹⁸ Littman, *Totality* 42.

