

THE Polynesians of old conceived of the sky as a dome or inverted bowl resting upon the rim of the hemispherical earth. One legend compares the universe with a calabash, the cover of which formed the sky, while the bowl was earth, land, and sea, the juice became rain, and the seeds were metamorphosed into sun, moon, and stars. Several writers divide into three zones the space between the earth—paa ilalo, the “solid below”—and the heavens—paa iluna, the “solid above.” Kepelino’s<sup>2</sup> work contains several allusions to the triple heavens, lani kaukolu, as in the chant:

In the space above, heaven is held fast;  
In the space below, held fast is muddy earth.  
From the space of heaven to the space of earth, there is still space.

The Hawaiian text from Kepelino reads:

O ka lewa iluna ua paaia he lani.  
O ka lewa ilalo, ua paaia Honua-kele.  
Mai ka lewa lani a i ka Honua-lewa, he lewa e!

The triple heaven thus consisted of three hemispherical zones, the highest being purely celestial, the lowest terrestrial, and between them was ka lewa “the air or space” (fig. 1).

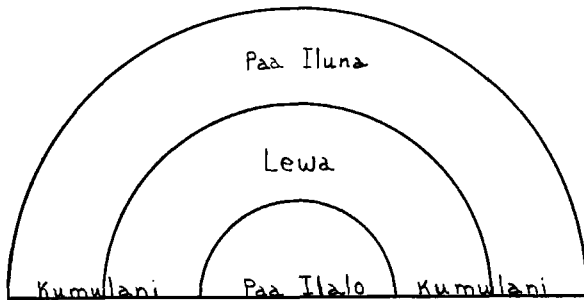


FIG. 1. The triple heaven of the Hawaiians.

<sup>1</sup> In the summer of 1935, I collected data on ancient Polynesian astronomy at the Bernice P. Bishop Museum, in Honolulu. The present paper is the first of a series on this subject. I am greatly indebted to Vassar College for a grant which made the research into original sources possible, to Dr H. E. Gregory, formerly Director of the Museum, who placed the facilities of that institution at my service, to Professor Martha W. Beckwith of Vassar for invaluable advice, to E. H. Bryan, Jr, Curator, K. P. Emory, Ernest Beaglehole, J. F. G. Stokes, and other members of the staff of the Museum, past and present, without whose aid the work would not have been possible.

<sup>2</sup> Martha Warren Beckwith (ed.), *Kepelino's Traditions of Hawaii* (Bulletin, Bernice P. Bishop Museum, No. 95, 1932), p. 28.

Malo<sup>3</sup> states explicitly:

*Ka lani paa* is that region in the heavens which seems so remote when one looks up into the sky. The ancients imagined that in it was situated the track along which the sun traveled until it set beneath the ocean, then turning back in its course below till it climbed up again in the east. The orbits of the moon and stars were also thought to be in the same region with that of the sun, but the earth was supposed to be solid and motionless.

In Malo's work each of the three principal zones is subdivided into three strata. We should consider all except the ninth as terrestrial. The lowest, *luna ae*, is the region immediately above a man's head when he stands upright; the sixth, *luna a ke ao*, is the "high place of the clouds." The last three zones are (1) *ke ao, ulu*, "the black clouds;" (2) *ka lani uli*, "the blue sky;" and (3) the highest or *ka lani paa*, "the fixed or solid heavens."

Neither Kepelino nor Malo mentions a rotating heaven. In their cosmogony the celestial bodies are constrained to move on tracks across the sky. Kamakau,<sup>4</sup> however, writes that at the extreme boundary or *kukulu-o-ka-lani* ("border of heaven") are found the fixed heaven, the rolling heaven, and the triple heaven. It is probable that Kamakau's version was somewhat influenced by his study of contemporary science.

In the Hawaiian cosmology, it was possible to journey to heaven by ascent of a tall tree or the rainbow. One could come within reach of the sun or moon by sailing out to the edge of the horizon and lying in wait at the point where they rose, to catch them unawares. Thus the sun was snared by Maui with cords or a rope of hair. In another legend the sun was caught and shut up in a cavern for two months, bringing terrible suffering on earth until his release. An interesting and very old legend found in various parts of Polynesia records that in the early days, the sky was so close to the earth that human beings were forced to crawl about like animals, being unable to stand erect. The method by which the sky was finally pushed up out of the way varies in different islands.

The general cosmological concept of a hemispherical heaven resting upon the rim of a hemispherical earth is reflected in the ancient names for the horizon and the cardinal points. The word *kukulu*, appearing in many phrases, originally signified a vertical erection of some kind. In the names of the cardinal points, *kukulu* evidently refers to the four great pillars, supporting the dome of heaven at these points. *Kukulu* also appears to have

<sup>3</sup> David Malo, *Hawaiian Antiquities* (Special Publications, Bernice P. Bishop Museum, No. 2, 1903), pp. 28-30.

<sup>4</sup> S. M. Kamakau, *Ke Au Okoa*, Nov. 4, 1869 (Ms. translation in Bernice P. Bishop Museum).

the derived meaning of circle, as in the phrase for horizon, probably coming from the idea of a circular wall surrounding the earth and holding in the ocean.

Specific Hawaiian terms for the astronomical circles and reference points are the following:

1. *The horizon.* We speak of the celestial horizon and of the terrestrial horizon. So, too, the Polynesians, with their usual love of antithesis have two terms for the horizon:

(a) Ke kukulu o ka lani, "the circle of the heavens." Malo further specifies it to be "the walls of heaven; the border of the sky where it meets the ocean," while Kamakau adds, "the place above the dark clouds encircling the earth."

(b) Ke kukulu o ka honua, "the circle of the earth." Malo, "the compass of the earth;" Kamakau, "the edge of the ocean close to the sky where it circles the borders of the earth."

2. *The zenith.* Malo expresses direction upward in the vertical direction as mai kela paa a keia paa, "from this solid to that solid."

Ka ho'okui, "the juncture" (between the terrestrial and celestial zones) undoubtedly refers to the zenith according to both Malo and Kamakau.

Ka halawai, "the place of meeting," a synonymous term is believed by Emerson, Malo's commentator,<sup>3</sup> to signify the line where heaven and earth meet, i.e., the horizon. Kamakau,<sup>4</sup> however, also couples ho'o ka halawai with ka ho'okui and interprets them as names of the point upward in a vertical direction, equidistant from heaven and earth.

A line in an ancient chant, "Kau ka la i ka lolo," has been translated "Hangs the sun in the zenith," and Andrews' dictionary<sup>5</sup> gives lolopua, "rise up high," as the modern word for zenith. However, since the sun is near the zenith only in midsummer and may be as much as 40° south of the zenith at noon in the latitude of the Hawaiian Islands, i ka lolo is more correctly "at its highest point," and is then synonymous with the Maori phrase, poutu maro.<sup>6</sup>

Curiously enough, Tregear<sup>6</sup> gives Puanga, the name of the star Rigel in the constellation of Orion, as a synonym for zenith. Since New Zealand is 35° or more south of the earth's equator, and Rigel is only 8° south of the

<sup>3</sup> Lorrin Andrews, *A Dictionary of the Hawaiian Language* (Special Publication, Bernice P. Bishop Museum, No. 8, 1922): lolopua, p. 381; awakea, p. 75.

<sup>6</sup> Edward Tregear, *Maori-Polynesian Comparative Dictionary* (Wellington, N. Z., 1891), pp. 361, 365.

celestial equator, such usage must go back to a time when the Maori inhabited a land in 8° south latitude. Precession of the equinoxes would have placed Rigel in the zenith of North Island 10,000 years ago.

3. *The meridian.* The celestial meridian is defined as the circle passing through the poles, the zenith, and the north and south points of the horizon.

In his *Instructions in Ancient Astronomy as Taught by Kaneakahoowaha*, Kamakau<sup>7</sup> refers to a line drawn on the sky from the North Star through the center (zenith ?) to the southernmost star of Newe. If Newe is the Southern Cross, as is usually accepted, such a line would correspond roughly to the twelfth hour circle, that is, a circle through the poles and the autumnal equinox. In the early evening of May and June it would coincide with the meridian. That Kamakau had the meridian or a fixed circle through the zenith in mind is evident from his subsequent explanation that the line divides the sky into halves. The eastern half of the sky he terms *ke alaula a Kane*, "the dawning or bright road of Kane," i.e., the half of the sky in which the stars are still rising. The western half is *ke alanui maawe ula a Kanaloa*, "the much-traveled highway of Kanaloa." Alanui is a highway; *maawe*, traveled; *ula*, red; hence, a path traveled so much that the red earth appears. The first phrase may be interpreted as signifying that the stars are entering the realm of the god of the upper regions; the second that they are descending to the region ruled by the god of ocean depths.

The Gilbert Island aborigines, who either had retained more of the earlier astronomical knowledge or had advanced beyond their fellow tribes in science, called the meridian *te taubuki*, "the ridge-pole of the sky-roof."<sup>8</sup>

4. *The cardinal points.* The four directions on the horizon were associated with the four *kukulu*, or supporting pillars of heaven, with the diurnal motion of the sun, and with the motion of the trade-winds.

*North*: *kukulu akau*, "right-hand pillar." The observer was thus thought to be facing west, possibly because the southwestern or leeward side of the Hawaiian Islands was considered the "front," or because tradition referred to a far western land as the original home of the Polynesian race.

Other names for north are *luna* or *iluna*, "up," and *ko'olau*, one of the names of the North Star. "After this star," Kepelino<sup>9</sup> writes, "Hawaii-nui [reputed discoverer of the islands] called the direction on the earth *ko'olau*

<sup>7</sup> S. M. Kamakau, *Instructions in Ancient Astronomy as Taught by Kaneakahoowaha, One of the Counselors of Kamehameha I* (Thrum's Hawaiian Annual, 1891 [tr. by W. D. Alexander from the Nupepa Kuokoa, August 5, 1865]), pp. 142-43.

<sup>8</sup> Arthur Grimble, *Gilbertese Astronomy and Astronomical Observations* (Journal, Polynesian Society, Vol. 40, pp. 197-224, 1931).

<sup>9</sup> Beckwith, *Kepelino's Traditions*, p. 78.

or north, not *akau* or right, which is an introduced word." The Tongan word for north is identical, i.e., *tokolau*, according to Collocott.<sup>10</sup>

Kamakau gives the following synonyms for north: *uliuli*, *ulunui*, *melemele* and *hakalauai*. Since Malo lists *Uliuli*, *Melemele*, and *Hanakalauai* as geographical names found in ancient prayers, they are probably names of islands situated north of some land occupied by the ancestors of the Hawaiians in ancient times, thus giving their names to the direction. *Uliuli*, "dark blue of ocean depths," is also the name of a star which Kamohoula places in the southern sky. *Hakalauai* and *Hanakalauai* are also star-names, probably identical. *Melemele*, "beautiful," is a star-name throughout Polynesia. The connection between islands and stars follows as a matter of course, since stars guided navigators to the various islands and to each island corresponded the star-name which was its sailing direction.

*South*: *kukulu hema*, "left-hand pillar;" *lalo* or *ilalo*, "down;" *kona*, "the direction of the cross of stars, *na hoku kea*," according to Kepelino. Compare the Tongan word for south "tonga," which is the same word as *kona*.

*Lipo*, "darkness," and *lewa*, "space," were other synonyms for south. Kamakau names a point just above the southern horizon *kuanalipo* "standing in the dark." The words *lipo* and *kuanalipo* have as their opposites *lio*, "bright," and *kuanalio*, "standing in the light," which are applied to stars remaining continually above the northern horizon, perpetually encircling the pole.

*East*: *kukulu hikina* (from *hiki*, "rise," and the present participle ending). Other synonyms are *ka la hiki*, "sunrise;" *ka la hiki ola*, "life-giving day," and similar phrases on the same theme.

The Tuamotuan *hiti* and Maori *whiti*, "east," are identical with *hiki*.

*West*: *kukulu komohana*, "sunset pillar." Other words are *ka la kau*, "the sun lodged;" *kaulana* or *napoo*, "sunset," and so on.

Malo also gives local terms for the cardinal points referring to geographical features such as the uplands or the ocean and depending on the observer's location.

5. *The equator and ecliptic on the sky.* A people as advanced in the science of astronomy as the Hawaiians would be expected to have phrases describing the annual motion of the sun on the ecliptic. Kamakau, however, seems to be the only modern historian of the islands who offers any information on the subject. He gives two synonymous terms which have been interpreted as the celestial equator: *ke alanui o ke ku'uku'u*, "the highway

<sup>10</sup> E. V. Collocott, *Tongan Astronomy and Calendar* (Occasional Papers, Bernice P. Bishop Museum, Vol. 8, No. 4, 1922), p. 160.

of the spider," and ke alanui i ka piko a Wakea, "the way to the navel of Wakea" (the sky-parent).

The same phrase in Maori, te pito a Rangi, "the navel of the sky-parent," is said by Smith<sup>11</sup> to signify the ecliptic, and aramatua, "parent path," is given as a synonym. One of the Tuamotuan appellations for a planet, given to Emory by Fariua, also contains the word for spider, and is the only other such reference that I have found in Polynesian literature. It is Takurua a te tuku haga pō. I am inclined to the opinion that the path of the spider refers to the spiraling motion of the sun northward and southward during the year, i. e., to the ecliptic, and that the way to the navel of the sky-parent is the celestial equator as Kamakau states.

6. *Tropics*. A line parallel to the celestial equator and marking the northernmost limit of the sun in declination—corresponding to the Tropic of Cancer on the earth—Kamakau names ke alanui polohiwa a Kane, "the black-shining road of Kane." A similar parallel in declination  $23\frac{1}{2}^{\circ}$  south and corresponding to the Tropic of Capricorn, he terms ke alanui polohiwa a Kanaloa, "the black-shining road of Kanaloa."

Within this zone, he states, are found the "fixed stars ruling the various lands," na hoku ai-aina or na hoku (stars) o ke aina (lands). Outside the zone are the foreign stars, na hoku o ka lewa, "the stars of space," and the highways of the navigation stars, ke alanui o na hoku ho'okele. Reference to a distinct class of "stars ruling lands" is found in several Hawaiian authors. The skilled Polynesian navigators knew which stars passed through the zenith of a certain island. Hence if they sailed north or south, as the case may be, with the tradewinds, until such stars passed through their zenith during the night, they knew they were in the right latitude and would then lay their course east or west to their destination. This method of navigation was probably more useful on protracted voyages than the other method of lining up the canoe between a bow and stern star, thus laying a great circle course directly to the island. Which method would have the advantage depends on the direction of the wind.

Although the zone on the sky thus defined by Kamakau and corresponding to the Torrid Zone on the earth is not the Zodiac of the Chaldeans, it does contain within it the paths of the sun and planets, and the moon can only exceed it by a small amount. To critics who aver that Kamakau was influenced by a study of modern astronomy, it should be remarked that the Gilbertese Polynesians had a similar division of the sky into zones and the practice was probably much more widespread among the Polynesian astron-

<sup>11</sup> S. Percy Smith, *Lore of the Whare Wananga* (Memoirs, Polynesian Society, Vol. 3, 1913), pp. 167-68.

omer-priests than would be thought from a study of the few fragments of science that have come down to us.

In spite of the fact that scarcely twenty of the 30,000 natives of the Gilbert Islands had any knowledge of astronomy and these were most unwilling to impart it, navigation secrets being still prized the most jealously, Grimble<sup>8</sup> succeeded in obtaining a very illuminating account of the ancient method of keeping the calendar, based on the annual motion of sun and stars.

In Gilbertese astronomy, the sky or "roof of voyaging," *uma ni borau*, was bisected by the ridge-pole (meridian), *te taubuki*, and supported by imaginary rafters, *oka*, three on the east and three on the west, vertical to

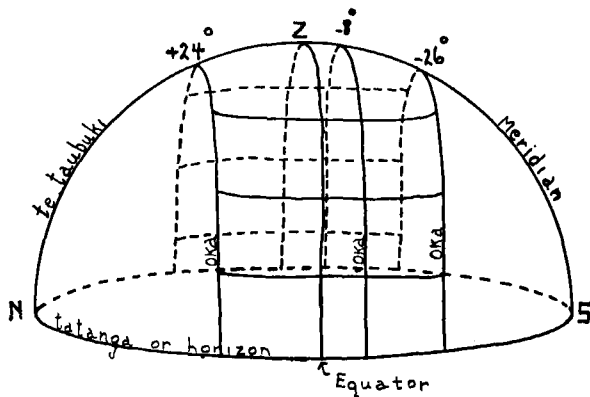


FIG. 2. The Gilbert Islanders' concept of the heavens.

the horizon. The northern pair met where the Pleiades cross the meridian,  $24^{\circ}$  north of the celestial equator; the southern pair had their apex where Antares transits, or  $26^{\circ}$  south of the equator.

From the horizon, *tatanga*, to the meridian were three crossbeams or purlins parallel to the horizon, forming four zones which were used in estimating the altitude of heavenly bodies (fig. 2).

The two outer "rafters" thus passed very near the solstices and were useful in keeping track of the progress of the sun in its annual motion in declination along the ecliptic. The central rafters were said to meet not in the zenith as one would expect, but at the point where Rigel crosses the meridian, i.e.,  $8^{\circ}$  south of the celestial equator. Thus the central rafter did not coincide with the celestial equator, which is curious when it is remembered that the equator passes close to the zenith in the latitude of these islands. There is an obvious connection here with the usage of the star name for Rigel as synonym for zenith, found in the Maori, and noted above.

The Gilbertese astronomers noted the point of rising of the sun every ten days and further checked its annual motion by observing the eastern constellations just before dawn. Hence they must have formed a concept of the constellations of the zodiac through which the sun passes on its annual journey. When the Pleiades were on the first purlin in the east (altitude about  $22\frac{1}{2}^{\circ}$ ) an hour before sunrise, they knew the sun was at its northern limit, or the summer solstice, which they called *toki*. The point where the sun rose due east in the fall was called *kaitara*, "face to face," and was the autumnal equinox. The winter solstice, where the sun starts north again in December, they called *bike ni kanenei-ang*, "islet of moving north." The word *bike*, "island or sandy beach," probably came to be applied to a sun-station as the result of the Polynesian habit of fixing a direction or bearing with reference to neighboring islands. Arrival of the sun back at the vernal equinox in March was verified by the position of Antares, *Rimwimata*, which is  $180^{\circ}$  away from the Pleiades, *Nei Auti*.

Grimble quotes Ke, a celebrated astronomer of Butaritari, as follows: "When you see *Rimwimata* in the middle, between the ridgepole and the first purlin to westward, you know that the sun is on his *bike ni kaitara* (islet of making face-to-face)." That is, Antares is about  $10^{\circ}$  west of the meridian at 5 A.M., when the sun is at the vernal equinox.

The Hawaiians, too, observed the annual motion of the sun for the purpose of the calendar, and in each locality the astronomers had doubtless worked out the azimuths of sunrise and sunset throughout the year, establishing them by means of fixed landmarks. The following fragment may be quoted from Kamakau as typical:

When the sun crossed the equator, it stood directly over the islet of Kaula [which evidently obtained its name from the astronomical event: *la*, "sun," *kau*, "set"], and set at Kawaihoa. And because it set over Kawaihoa, the *Makalii* season was called *Kau*. And also for the resting-place, *Kaulana*, of Kane it was called *Kau*. When it set at Kaula and turned south, the *Kau* (season) was called *Hooilo*. And in the same way the people of Oahu reckoned from the setting of the sun at Puu-o-kapolei, until it set in the hollow of Mahinaona, it was called *Kau*. And from Puu-o-kapolei, the sun moved south.

While this paragraph corroborates the statement that the Hawaiians fixed the annual motion of the sun by landmarks, it also illustrates the difficulty to be overcome by the modern commentator who would interpret statements recorded and translated by people who did not understand them. If, for example, the sun "stood directly over," that is, passed through the zenith of Kaula, it was not at the equator, but at the summer solstice. This is corroborated by the statement that it then turned south. The second



sentence should then read "The *Kau* (season) was called *Makalii*" for that reason, i.e., because the sun would then have attained the same distance north of the equator as the Pleiades, which were called *Makalii* in Hawaii. This is consistent with the Gilbertese practice of connecting the summer solstice with the Pleiades.

There is a tradition in Puna district, Hawaii, as told to Professor Martha W. Beckwith by Kalawe, a justice of Kapoho on May 23, 1914, that a great temple once stood on Haehae, a hill on the east coast of the island. A large, flat altar rock had a line or groove running diagonally across it. When "the star" (probably the sun in its annual motion north or south) rose from the sea horizon at a point directly in line with this groove, a man was sacrificed. The heiau, which stood on the extreme eastern point of the island group, was so situated with respect to two high crags, that the astronomer-priest could sight from the observation platform of the temple by the northern rock to the point where the sun rose at the summer solstice, and by the southern rock to the point where the sun rose in December, when it was at the winter solstice. Kalawe added that between full and new moon one could still hear the beating of the drum.

According to Smith,<sup>11</sup> the entire structure of Maori philosophy was built on astronomy, and the prevalence of the number twelve is the result of the division of the zodiac, *te ara matua*, "the parent path," into twelve signs of constellations. Stowell gives the names of twelve stars which rule the months in turn. Of the seven identified, four lie at some distance from the ecliptic (Rigel, for example, more than 30°) but all are within 32° of the equator. If Stowell and Best's identification of the stars is correct (and there is reason to believe that it is) then the Maori "zodiac," like those of the Hawaiians and Gilbertese, must be a belt with limits parallel to the equator passing through or near the solstices, and enclosing the ecliptic, the sun, moon, and planets.

We come finally to the Hawaiian system of circles or zones on the sky, which must have constituted an important part of the astronomical teachings since they are described in detail by both Malo and Kamakau (fig. 3).

1. *Kahiki moe*, "the circle or zone of the earth's surface, whether sea or land, which the eye traverses in looking to the horizon" (Malo); "place from the land and from the ocean as far as the eye can see; also the lands of that circle" (Kamakau).

2. *Kahiki ku* (*ku*, "erect," as opposed to *moe*, "prone"), "the circle of the sky which bends upward from the horizon" (Malo); "edge of dark clouds which rises up and lies away at its back, to the base of the sky; also the lands of that circle" (Kamakau). Kamakau also gives *kukulu o kahiki* as

“all the lands far away from the Hawaiian group, at the back of the circle of kahiki moe and kahiki ku; also called kukulu o ka lani, “circle of the heavens,” paia ku a lani, “standing-wall of heaven,” and kumulani, “base of heaven.” Fornander<sup>12</sup> interprets kahiki ku and kahiki moe as continents or large islands lying to the east and west respectively of a former habitat of the Polynesians. Kahiki means foreign land, literally “the border.”

3. Kahiki ke papa nu’u, “zone above *kahiki ku*” (Malo). Apapa nu’u, “in the places where there are innumerable islands” (Kamakau).

4. Kahiki ke papa lani, “zone above *kahiki ke papa nu’u*” (Malo). Apapa lani: “same explanation as for *apapa nu’u*” (Kamakau).

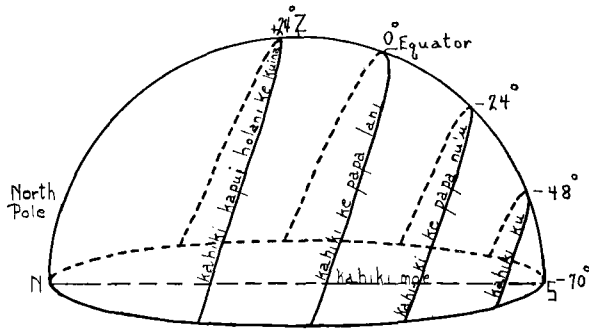


FIG. 3. The Hawaiian system of circles or zones on the sky.

5. Kahiki kapui holani ke kuina, “zone above *kahiki ke papa lani* and directly overhead” (Malo). There is no equivalent in Kamakau. Kuina, “a uniting,” is also found in a Tongan star or constellation name, Tuinga-ika, translated by Collocott,<sup>10</sup> “a string of fish,” and thought to be Orion’s Belt, which is situated on the celestial equator. Malo gives Holani as a geographical name found in ancient chants. Emerson<sup>3</sup> notes that it is suggested (apparently by S. Percy Smith) that the Hawaiian Holani is the Herangi of the Maori, the name of a place formerly known to the Polynesians, believed to be in Malaysia. Kepelino,<sup>13</sup> it should be noted, calls *apapa-nu’u*, *apapa-lani*, *kahiki-ku*, and *kahiki-moe*, “the high places of the four corners of the earth.”

Since the zones described by Malo and Kamakau are obviously on the celestial sphere, an attempt should be made to interpret them in modern

<sup>12</sup> Fornander *Collection of Hawaiian Antiquities and Folk-lore: Third Series* (Memoirs, Bernice P. Bishop Museum, Vol. 6, No. 2, 1919), p. 241.

<sup>13</sup> Beckwith, *Kepelino's Traditions*, p. 54.

astronomical terms. Since they "bend upward from the horizon," their identification as parallels of declination does not seem far-fetched, since they would then coincide with or lie parallel to the diurnal paths traced by the heavenly bodies from east to west, as the sky appears to revolve on an axis through the poles. The diurnal paths are directly observable. They are what Kamakau calls *na alanui o na hoku ho'okele*, "the great highways of the navigation stars." It is well known that the Polynesians were acquainted with the bearings of stars at rising and setting and with those stars which followed along the same path, i. e., lay on the same parallel of declination, which were said to rise from the same *rua* or *pit*. If they therefore wished to divide the night sky into zones, the most natural divisions would be by circles parallel to the celestial equator.

Furthermore, for the purposes of navigation, the Hawaiians were chiefly interested in that hemisphere which extended south from the zenith, since the inhabited lands with which they were acquainted lay to the southward.

If these assumptions may be accepted, Malo's circles, being four in number from horizon to zenith, divided the southern half of the sky in four zones each 22–24° wide, if equally spaced. Since it is obviously impossible to fix these circles with great exactness, we note that within a few degrees, as seen from any part of the Hawaiian Islands, *kahiki ke papa nu'u* corresponds to the parallel through the winter solstice which we have met before in Grimble's account of Gilbertese astronomy and in Kamakau's *Instructions in Ancient Astronomy*. Likewise, *kahiki ke papa lani* coincides with the celestial equator and *kahiki kapui holani ke kuina* with a parallel through the summer solstice. The similarity between these zones and those of the Gilbertese is very striking.

*Kahiki ku*, accordingly, incloses a segment of sky between the extreme southern horizon and a parallel of declination –48° approximately. Conspicuous stars within it are Alpha and Beta Centauri, the Southern Cross, Achernar, and Canopus, the last named lying close to the circle.

*Kahiki ke papa nu'u*, corresponding with the parallel through the winter solstice, forms the upper boundary of the second zone, which lies between declinations –48° and –24° approximately, and contains such constellations as Grus, Scorpio, Sagittarius, Phoenix, Corona Australis, and part of Centaurus. Antares lies on the circle and Fomalhaut not far below it.

The third zone has *kahiki ke papa lani*, corresponding roughly to the celestial equator, as its upper boundary, and contains Sirius, Mira, Rigel and the lower half of Orion, Alpheratz, Spica, and Deneb Kaitos as conspicuous objects.

The fourth zone extends from the celestial equator to the circle passing

through the summer solstice which is close to the zenith in the mean latitude of Hawaii.<sup>14</sup> Arcturus and the Pleiades lie practically on the circle of kahiki kapui holani kuina, and other conspicuous stars are Betelgeuse and Bellatrix in Orion, Aldebaran, Altair, Denebola, Regulus, and Procyon.

6. *Astronomical observations.* To the ancient Polynesian navigator, the sky, particularly the night sky, was compass, chart, and chronometer. Point out a star to him and he would tell you the islands to which that star would lead you, if you steered your canoe toward the point where it rose or set at the horizon. He could also point out the other stars which followed it along the same diurnal path across the sky, and which could be used as bow star after it had set. He could likewise tell you what stars stood in the zenith over a given island, so that if you sailed directly south until those stars passed nightly across your zenith, you would know that you had reached the same latitude as that of your destination. Kepelino<sup>15</sup> says, "The stars which act as guides to land are those which hang in turn over each land, as *Hoku-lea* [Arcturus ?] over the Hawaiian Islands and *Hoku-kea* [Southern Cross] over Tahiti."

The motions of the heavenly bodies across the sky informed the ancient Polynesians of the time of day or night. Na Hiku, "the seven" (Big Dipper), served as convenient hour-hand on the great dial of the sky, to mark off the watches of the night. We are also told that the change in the orientation of the Milky Way through the night was used for time determination. The phrases, *huli ke kau*, "the Milky Way has turned," and *ua huli ka i'a*, "the fish [Milky Way] has turned," denoted that the hour of midnight had arrived.

Awakea, "noon," was named for the god who opened the gates of the sun, according to Andrews' dictionary. In Maori, the same word is found in the phrase, *kura hau awatea*, signifying a solar halo (*kura*, "red") according to Best.<sup>16</sup> The Mangaian called the sun the "right eye of Awatea," the moon was the "left eye."

The kahuna, whose duty it was to keep account of the progress of the months and seasons by means of astronomical observations, held one of the most important offices in the Polynesian economy. If life was to be preserved, it was essential to recognize in advance the proper time for planting the various crops, when the winds might be depended upon for long voyages, when the common noddy flew farther from the island than usual and

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<sup>14</sup> Compare *kuina* with *ka ho'okui*, "zenith," given above.

<sup>15</sup> Beckwith, *Kepelino's Traditions*, p. 82.

<sup>16</sup> Elsdon Best, *Maori Navigation and Star-lore* (Monograph, Dominion Museum, Nos. 1-7, Wellington, N. Z., 1922-24).

so might be relied upon to lead venturesome fishermen homeward, and the seasons of storm when it was safer to stay at home. There was Kaelo, the month when plover are plump; Kaulua, when mullet spawn; Nana, the month when the flying fish swarm; and Kaaona, the month favorable for opelu fishing. Finally there was Welehu, month of the great New Year festivities, for which extensive advance preparation must be made.

The importance of the stars to agriculture is emphasized in the following quotations from the Maori:<sup>17</sup>

Rigel is looked upon as one of the "food-bringers," and also gives notice of approaching dawn. "The sun itself is pushing it up from behind," as an old native expressed it. The stars that are guides to the seasons are eternal, and are ever flashing in the heavens. Our forebears consulted these sign-giving stars in connection with the planting of the *kumara* crop. The principal stars so relied on were Rigel, the Pleiades, Orion's Belt or *Tautoru* ["the three"], and *Whakaāhu* [Castor, star of August; "spring growth"]. According to the manner of their rising, the crops would be planted early or late. I have spoken of these stars as a token of regard for the beings who directed our ancestors and elders, now lost to this world.

The first appearance of the Pleiades after sunset in the east marked the beginning of the New Year throughout the greater part of Polynesia. The Gilbertese word for year, *ririki* may shed light on the etymology of the word for Pleiades: *Matariki* in the south, *Makalii* in Hawaii. The Gilbertese name for this star cluster was *Nei Auti*; *Auti* being a woman's name and *Nei* her title (*Grimble*).<sup>8</sup>

A valuable hint as to how the bearings of sun and planets may have been fixed is supplied by *Beattie*,<sup>18</sup> who was told by a native informant that he recalled seeing an astronomer observe *Wero-i-te-ni-nihi* by putting sticks in the ground. This celestial body, whose name (*wero*, "tail") suggests a comet, was certainly a member of the solar system since it moved with respect to the stars, and its progress across the sky was considered important for astrological predictions: "If the observed 'star' moved south, the season would be bad; if north, the season would be dry and good."

The Gilbertese, *Grimble* records, made their astronomical observations from the top of a stone platform facing east. These platforms or *buatarawa*, prototypes of the great modern observatories, were three or four feet square at the base and rose to a height of from two to twelve feet, tapering gradually. Flat and smooth on top, they faced the unbroken sea-horizon to eastward, enabling the observer to note the points of rising of sun, planets,

<sup>17</sup> Best, *op. cit.*, No. 3, p. 39.

<sup>18</sup> H. Beattie, *Traditions and Legends Collected from the Natives of Murihiku (Southland, New Zealand): Part VIII* (Journal, Polynesian Society, Vol. 27, pp. 137-61, 1918), p. 145.

and stars. Posts or pylons may have been set up in the line of sight to the object as permanent markings for comparison in future observations. It is possible that the Gilbertese Polynesians were advanced beyond other tribes in the development of astronomical knowledge and scientific methods of observation, since they appear to be the only Polynesians, Grimble states, who had gone beyond the lunar calendar, differing in this respect even from their close neighbors of the Caroline Islands. He found that the nights of the moon which formed an essential part of the usual island calendars were much more vague in the Gilbertese than the stations of the sun. In fact he was unable to find any names for the nights of the moon beyond the twentieth.

The extreme accuracy with which the Polynesians were able to reckon time is illustrated by the fact that from remote times until the 14th century A.D., representatives of tribes forming the Friendly Alliance met periodically at Opoa, in the Society Islands, to do honor to the god Oro. Delegates came from distant islands, even far-away New Zealand. To quote from *Ancient Tahiti*:<sup>19</sup>

These allied island kingdoms formed a convention for their priests, scholars and warriors to meet periodically at Opoa for great religious observances and international deliberation. The appointed time was exactly reckoned by numbering the year and naming the season, the lunar month and day of the month.

The great double canoes carried deep-toned drums and conch-shell trumpets named "trumpet-sounding-over-the-sea-from-horizon-to-horizon," with which the canoes signaled each other, as they converged from all directions toward Opoa, on the given date.

Upon approaching the sacred passage of Te-ava-moa, just at daybreak of the appointed day, the canoes united in procession, and out from the horizon, as if by magic, they came in double file, each representing a separate kingdom.

From all the above considerations, we can hardly escape the conclusion that far more of the jealously guarded knowledge of Polynesian astronomy has been lost than has been preserved for posterity.

VASSAR COLLEGE  
POUGHKEEPSIE, NEW YORK

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<sup>19</sup> Teuira Henry, *Ancient Tahiti* (Bulletin, Bernice P. Bishop Museum, No. 48, 1928), p. 123.