Origins of Astronomy in Hawai'i

Walter Steiger
Professor Emeritus, University of Hawai'i

1 Astronomy to the Early Hawaiians

Interest in the heavens goes back far into the ancient fabric of Polynesian culture. Many of the early Polynesian gods and demi-gods derived from or dwelt in the heavens, and many of the legendary exploits took place among the heavenly bodies. The demi-god Maui, especially, was known for such astronomical deeds as snaring the Sun to slow its passage across the sky[1], or of fashioning a magical fishhook (recognized in Western astronomy as the stinger in Scorpio) to fish up the Hawaiian Islands out of the deep ocean.

In a more practical vein, the early Polynesians were highly skilled sailors and navigators who sailed thousands of miles over open ocean between the Society Islands, the Marquesas, and Easter Island to the east, the Hawaiian Islands to the north, and New Zealand to the southwest. Navigation was accomplished primarily, we believe, by a thorough knowledge of the stars, their rising and setting points along the horizon and their meridian passage as a function of latitude. Of course, there were other indicators in nature that helped guide them: the winds, the waves, the ocean swells, cloud formations, and birds and fish[2,3].

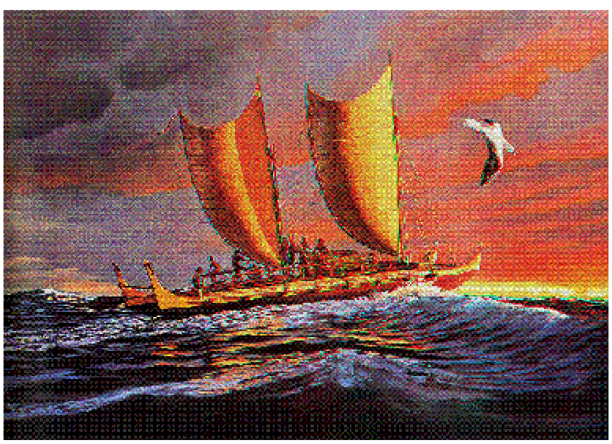


Figure 1: Image from the Polynesian Voyaging Society.

No instruments or charts of any kind were used to assist these early navigators. But with the arrival of Captain Cook in 1778, and subsequent arrivals of foreign ships, the Hawaiians were introduced to spyglasses, sextants, compasses, clocks, and charts, and easily adapted to Western technology. The foreign ideas and techniques soon crowded out the ancient and extensive knowledge of the sky and, sadly, most of this ancient lore has been lost and forgotten. To a large extent our current lack of knowledge of Hawaiian astronomy can be attributed to the early immigrants, mostly missionaries, who transcribed the unwritten language of the Hawaiians. The Hawaiians had names for hundreds of stars and other astronomical objects and concepts. Many of the words were recorded, but not their English equivalents, which were unknown to the transcribers[4].

2 Post-Captain Cook

The first record of scientific astronomical observations being made from Hawai'i appears to be that of a British expedition on 8 December 1874. Captain G. L. Tupman of the HBM Scout observed a transit of Venus from a site on Punchbowl Street[5]. Observations of this transit were also made from Waimea, Kaua'i.

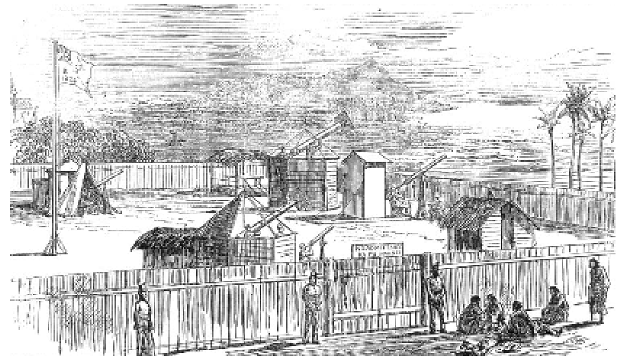
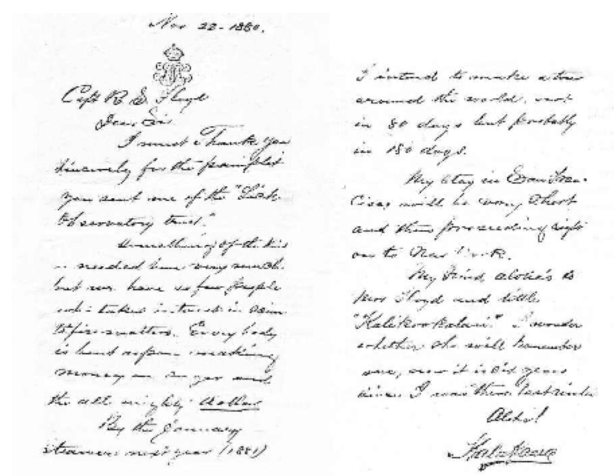


Figure 2: The transit of Venus of 1874. The British expedition waiting for contact on Punchbowl Street in Honolulu with Diamond Head in the background.

David Kalakaua reigned over the Kingdom of Hawai'i from 1874 to 189l. King Kalakaua was a worldly and progressive monarch, especially considering how recently his people had been exposed to the society and culture of the "civilized" Western world. It was his ambition, as King of Hawai'i, to travel far and wide to learn the ways of the outside world. Even before his voyage, which took place in 1881[6], Kalakaua had shown an interest in astronomy, and in a letter to Captain R. S. Floyd on November 22, 1880, had expressed a desire to see an observatory established in Hawai'i. His voyage began with a visit to San Francisco, where he visited Lick Observatory in nearby San Jose. Mr. French of Lick Observatory evidently was the King's guide at the observatory. In his journal Mr. French noted how interested and enthusiastic the King had been and how he had expressed a desire to bring such a telescope to Hawai'i.



Nov 22-1880.

Capt R. S. Floyd
Dear Sir
I must thank you sincerely for the pamphlet you sent me of the "Lick Observatory trust."
Something of this is needed here very much, but we have so few people who takes interest in such matters. Every body is hard up for making money — anyway and the all mighty dollar.
By the January steamer next year (1881) I intend to make a tour around the world, not in 80 days but probably in 150 days.
My stay in San Francisco will be very short and then proceeding right on to New York.
My friend, aloha's to Mrs Floyd and little "Kalikookalani." I wonder whether she will remember me, now it is six years since I saw them last.
Aloha!
Kalakaua

Bishop Museum, used with permission

Figure 3: Letter from King Kalakaua. Bishop Museum, used with permission

It was not long after this that King Kalakaua expressed

his interest in having an observatory in Hawaiʻi. Perhaps as a result of the King's interest a telescope was purchased from England in 1883 for Punahou School, a private school established by early missionaries to Hawaiʻi. In 1884 the five-inch refractor was installed in a dome constructed above Pauahi Hall on the school's campus. Unfortunately, it was not a stable, solid mounting, and the telescope was not useable. Nevertheless, it was the first permanent telescope in Hawaiʻi and did prove itself useful later on, as we shall see. In 1956 this telescope was installed in Punahou's newly completed MacNeil Observatory and Science Center. Sometime since then it was replaced and has disappeared, sad to relate.

3 Halley's Comet

Soon after the turn of the century an astronomical event of major scientific as well as popular interest stirred the citizens of Honolulu: the predicted appearance of Halley's Comet in 1910. By public subscription an observatory was built on Ocean View Drive in Kaimuki, which was then a suburb of Honolulu in the vicinity of Diamond Head.

Figure 4: The University of Hawai'i Observatory, Kaimuki, 1910 to 1958, as seen in 1917 by E. H. Bryan, Jr. Bishop Museum, used by permission.

A civic group known as the Kaimuki Improvement Association donated the site, which offered an excellent view of the sky. A six-inch refractor manufactured by Queen and Company of Philadelphia was placed in the observatory along with a very fine Seth Thomas sidereal clock and a three-inch meridian passage telescope. The observatory was operated by the fledgling College of Hawaiʻi, later to become the University of Hawaiʻi. The public purpose of the Kaimuki Observatory was served and Halley's Comet was observed. But, unfortunately, the optics of the telescope were not good enough for serious scientific work.

Because of Hawaiʻi's longitude (157° W) and low latitude (21° N), it was well situated for observing Halley's Comet. The Comet Committee of the Astronomical and Astrophysical Society of America determined to sponsor an expedition to Hawaiʻi to observe and measure the comet. Professor Ferdinand Ellerman of the Mt. Wilson Observatory made up the one-man expedition. With assistance from the U.S. Weather Bureau, the College of Hawaiʻi, and the U.S. Coast Guard, he set up a temporary observing shelter on the seaward slope of Diamond Head, not far from the

Figure 5: Beauty and the Beast. Physics student Barbara Jay in 1958 with the Kaimuki Observatory telescope.

Coast Guard's Diamond Head Light House, and obtained an excellent series of observations.

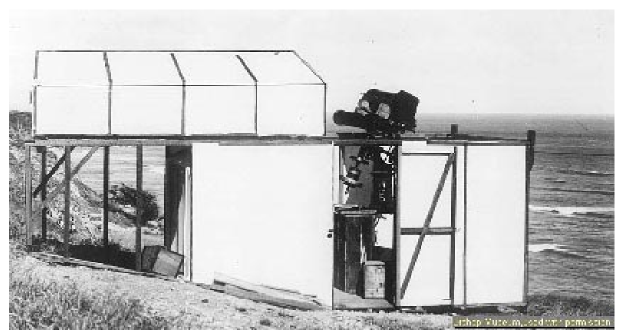


Figure 6: The Astronomical and Astrophysical Society's Comet Halley Observatory by Diamond Head in 1910. Bishop Museum, Used by permission.

In 1916 Professor Arnold Romberg of the youthful physics department of the College of Hawaiʻi joined forces with Frank E. Midkiff, science instructor at Punahou School, to make observations of Mars at its close opposition. They moved the superior Punahou telescope to the Kaimuki Observatory, and there it stayed for the next forty years. It was used periodically by persons from the College of Hawaiʻi, and others as well. During 1917 to 1918 the telescope was used rather regularly by R.W. French, a sergeant in the U.S. Army Medical Corps, and E.H. Bryan, Jr., of the Bishop Museum, both charter members of the American Association of Variable Star Observers, to observe variable stars. During the following decades, the Kaimuki Observatory with the Punahou telescope was used mainly for educational purposes and public viewing of the skies. John S. Donaghho, professor of mathematics and astronomy at the University of Hawaiʻi, and Mr. Bryan took the leading role in attending to the observatory.

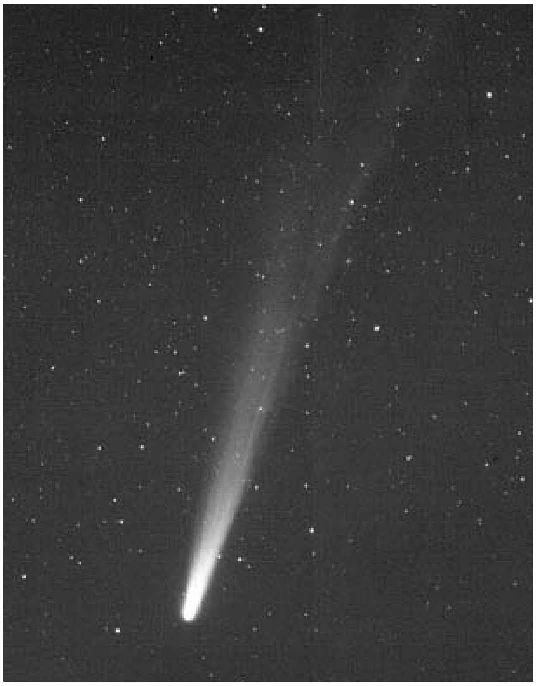


Figure 7: Comet Halley as photographed by Prof. Ellerman near Diamond Head in 1910. Bishop Museum, with permission.

Alas, the ravages of time and termites eventually took their toll, and in 1958 the badly deteriorated structure of the Kaimuki Observatory was demolished.

Figure 8: The Seth Thomas sidereal clock, now located in the UH Institute for Astronomy library. The large hand reads minutes, upper and small hand, hours, and the lower small hand, seconds, of sidereal time, or time by the stars, as opposed to solar time. On the right is seen one of the two weights that drive the clock. They must be wound to the top once a week.

4 Radio Astronomy

Hawai‘i played a minor role in the early days of radio astronomy. After the discovery of cosmic radio emissions by Carl Jansky in 1931, one of the first to take up the scientific investigation of these emissions was Grote Reber with a radio telescope in his backyard in Wheaton, Illinois. Around 1940 Reber came to Hawai‘i to take advantage of a unique geophysical condition. By placing his antenna atop 10,000-foot Haleakala on the island of Maui, he hoped to use the ocean as a reflector so that the antenna received both the direct signal from a cosmic radio source and the signal reflected from the ocean, forming a “Lloyd’s Mirror” type of interferometer. His antenna was built on a circular track so that it could be rotated in any direction.

Students at the Maui Technical School (later Maui Community College) constructed the welded steel and wood truss support system. Reber was disappointed with his results. Apparently, the unevenness of the ocean surface did not provide a sufficiently specular reflection. He was still on Maui in 1955 when I first investigated Haleakala as a possible solar observatory site. Soon thereafter Reber left for Tasmania, where he continued his researches. In 1957 the antenna structure collapsed under the weight of heavy ice deposited by a storm, a not-unusual condition on Haleakala where supercooled clouds may pass over the mountain and cover exposed structures and wires with several inches of ice.

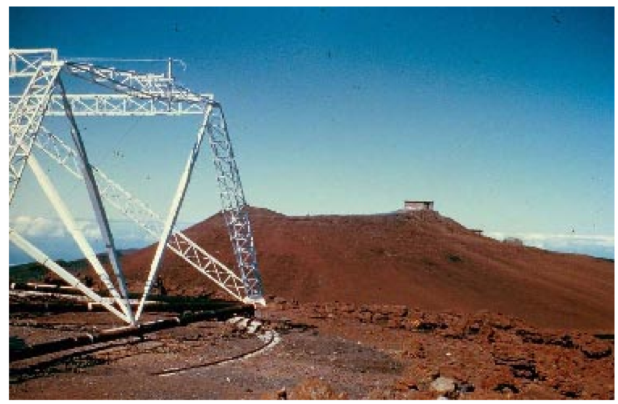


Figure 9: A portion of Grote Reber’s anetnna structure showing the circular track upon which it rotates. In the background is Red Hill, the summit of Haleakala, and some remaining WW2 structures. 1955.

5 Amateur Astronomers

During the 1930s and 1940s a growing number of amateur astronomers felt the need for some form of organization and the availability of astronomical information tailored to Hawai‘i. E. H. Bryan, Jr., responded to this latter need by preparing a booklet entitled Stars Over Hawai‘i in 1955[7]. It contained a star chart for each month for the latitude of Hawai‘i. It also contained, in addition to basic astronomical information, some material on Polynesian astronomy, and an interesting discussion of the path of the Sun at this latitude. There are times in Hawai‘i when the Sun passes directly overhead, which occurs nowhere else in the United States. This book received wide circulation and certainly must have had a significant impact on astronomical literacy in Hawai‘i. Bryan also initiated the monthly publication in a local newspaper of the current star chart and a description of astronomical phenomena for the month, a tradition that was continued uninterrupted by the Bishop Museum Planetarium Director George Bunton and all subsequent directors to the present day. Bryan also authored numerous popular articles on astronomy in Hawai‘i. Recalling also his frequent hosting of star-gazing at the Kaimuki Observatory, it is my opinion that E. H. Bryan, Jr., more than any other individual, served to inform and stimulate public interest in

astronomy during the early decades of the 20th century.

The idea of an Astronomical Society began in 1948. Meetings began in 1953 at McKinley High School. In June 1954 the public was invited to view Mars through amateurs' telescopes in Kapiolani Park in Waikiki. Public response was very enthusiastic. The close approach of Mars in 1956 prompted a second open house and, again, the telescopes were literally mobbed. But the society needed dynamic leadership, which serendipitously appeared in late 1956. Dr. Earl G. Linsley, retired director of the Chabot Observatory of Mills College had come to spend Christmas with his nephew, Dr. Linsley Gressit of the Bishop Museum. Under Dr. Linsley's guidance the society flourished. Numerous distinguished scientists gave talks to the society, and he himself was a frequent and popular contributor.

Dr. Linsley's enthusiastic promotion of a planetarium and observatory at the Bishop Museum for the entertainment, enlightenment, and education of the public was successful in raising the necessary financial support from the community. Construction of a beautiful facility was completed in 1962, with a Spitz A3P planetarium projector in a 30-foot dome, and a 12.5-inch telescope in a separate astronomical dome.

From 1962 until his retirement in 1980, George W. Bunton directed the Kilolani Planetarium. During these exciting years of the dawning of the space age, Honolulu was fortunate to have a person with the knowledge, skills, creativity, enthusiasm, and ability to communicate that Bunton had as the voice of astronomy. Many hundreds of thousands of schoolchildren, local citizens, and visitors from all over the world have had their horizons extended by this facility.

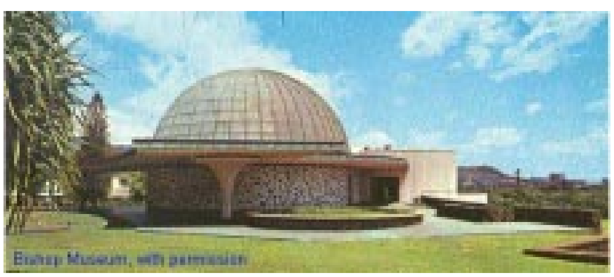


Figure 10: The Bishop Museum Planetarium soon after construction in 1962. Bishop Museum, with permission.

6 The IGY Period

Soon after joining the faculty of the University of Hawai'i Department of Physics in 1953, I began to think about the unique potential of Hawai'i's high mountains for observations of the Sun, and it became my goal to establish a solar observatory on the top of one of the mountains. There were three possible sites: Mauna Loa (13,680 ft.), and Mauna Kea (13,784 ft.), both on the island of Hawai'i, and Haleakala (10,025 ft.) on the island of Maui. Mauna Loa was an active volcano with very difficult access and was deemed unsuitable. Mauna Kea, though volcanic in origin, as is all of Hawai'i, was considered dormant or extinct. But like Mauna Loa, it was very remote and without vehicular access or electric power. Haleakala, though significantly lower than Mauna Kea, was still quite high as compared with other solar observatories around the world. Only the High Altitude Observatory at Climax, Colorado, at 11,000 feet was slightly higher. The great advantage of Haleakala was its ease of access via a paved road and commercial power to the summit. Site testing was begun in 1955 with the assistance of graduate student John Little.

Figure 11: Graduate student John Little using the sky-brightness photometer on Haleakala, 1955.

The crucial parameter for solar coronal studies is the brightness of the sky immediately adjacent to the solar disk. The results of a year's measurements with an Evans-type sky brightness photometer showed that Haleakala was indeed an outstanding site, not only in terms of sky transparency but also in the number of clear days per year[8]. But funds for planning and constructing an observatory were not readily available.

In the meantime, the forthcoming International Geophysical Year 1957-58 placed Hawai'i in a crucial position, both in terms of latitude and longitude, for a number of geophysical observations in a worldwide network. Thus, the IGY provided the impetus and some modest funds to begin various projects. A solar observatory in Hawai'i was crucial to the work of the IGY but there was neither time nor funds to develop one on Haleakala. If coronal studies were forgone, a sea-level site could be suitable, and thus a site on the Island of Oahu at Makapu'u Point, about 300 feet above sea level, was found and developed. Fortunately, a small concrete building abandoned by the telephone company was available, and several experiments were installed and operating by the official beginning of the IGY, July 1, 1957.

A solar flare patrol telescope was set up on an optical bench inside the building with a heliostat outside the building directing a solar beam into the telescope through a hole

Figure 12: [a] The University of Hawai'i Solar Observatory at Makapu'u Point, Oahu, 1967. The solar radio noise 10-ft dish is at the left. The heliostat mirror is at the left end of the building. On the roof, covered by a tarp, is the old Kaimuki Observatory telescope. [b] The solar telescope mounted on a rigid optical bench inside the building. On the left is a prism directing the solar beam from outside down the optical bench. Near the center is the shutter, and to the far right is the 35-mm camera, directly in front of which is the 0.5Å H-α filter.

in the wall. The telescope employed a Halle 0.5ÅH-α filter and routinely took photographs of the Sun every two minutes on 35-mm film. These films were processed daily at the university campus and scanned in a microfilm viewer. Flares and prominences were measured and the data reported every evening via a military communications link to the World Data Center in Boulder, Colorado.

An indirect flare detector (IFD) provided very useful data to complement the optical data or provide indications of flare activity when the telescope was clouded out. The IFD was an experiment of the High Altitude Observatory in Boulder, Colorado, designed and built by Robert Lee of that institution. It consisted of two radio receivers, one tuned to 18 kHz with a long wire antenna, and the other tuned to 18 MHz with a very directional antenna pointed towards the zenith. The low frequency receiver picked up natural radio noise generated in the Earth's atmosphere by lightning and propagated great distances by reflections from the base of the ionosphere. During the onset of a flare on the Sun the increase in ultra-violet and x-radiation reaching the Earth's atmosphere causes an increase in the degree of ionization in the ionosphere and hence an increase in its ability to reflect the atmospheric radio noise, resulting in an enhancement of the atmospheric radio noise received. The high frequency receiver detected radio noise from outside the Earth's atmosphere, referred to as cosmic radio noise[9]. In the event of a solar flare, the enhanced ionization in the ionosphere resulted in a greater absorption of the cosmic radio noise arriving at the antenna.

The Sun is itself a generator of radio noise and a study of this radio energy is a useful tool for understanding soar activity. Professor Iwao Miyake of the University of Hawai'i

Figure 13: The heliostat mirror, which tracks the Sun and directs the solar beam into the hole in the side of the building, and into the telescope.

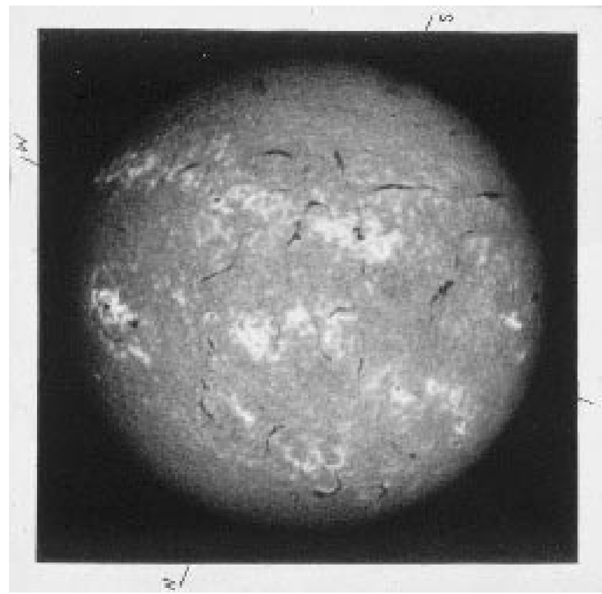


Figure 14: Image of the Sun taken at the Makapu'u Point Solar Observatory on 29 February 1958, at 2110 UT, in hydrogen light (H-α).

Department of Physics built and operated for the IGY a 200 MHz radio receiver adjacent to the Makapu'u Point Solar Observatory. Starting with a surplus Navy radar dish about 10 feet in diameter, he mounted it in an equatorial drive system so that it could be made to track the Sun. Bursts of radio noise in the frequency range used here are generated by the rapid expulsion of material from the surface of the Sun up through the Sun's highly ionized atmosphere, and thus are an indication of violent disturbances on the surface of the Sun.

In cooperation with Dr. Robert Brode and Dr. Edward Chupp of the Department of Physics, University of California at Berkeley, the Makapu'u Point Solar Observatory also operated cosmic ray neutron and mu-meson monitors. These were telescopes in a sense because their sensitivity was directional and they were designed to detect changes in the particle flux associated with solar activity. Only in the case of the neutron flux was any change ever noted – a so-called Forbush decrease – related to solar activity. Since these changes are related to the Earth's magnetic field, it is the low latitude of Hawai'i that made it very unlikely to find

such decreases.

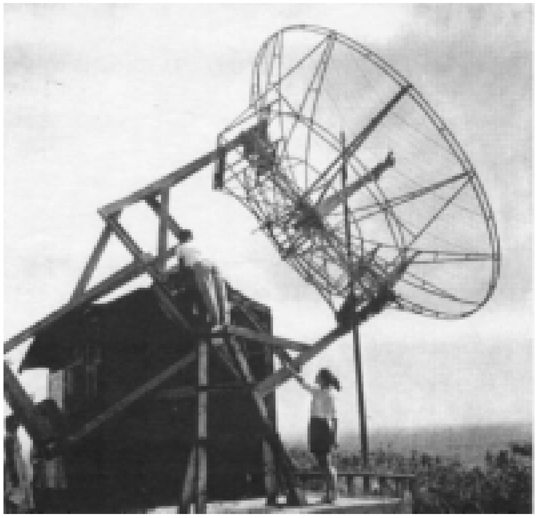


Figure 15: The solar radio noise receiver. The equatorially mounted dish tracks the Sun and receives radio noise at 200 MHz generated by storms on the Sun.

The IGY elicited a great deal of public interest which, to a large extent, was due to the planned launching for the first time in human history of an artificial Earth satellite. The planners of the IGY were very concerned about their ability to locate and track the satellite once it was launched. To accomplish the acquisition of the satellite, a volunteer citizen corps was established called operation MOONWATCH. For the precise tracking of the satellite, a worldwide network of twelve Super-Schmidt tracking cameras was envisioned. In both of these operations Hawai'i was in a position to fill a crucial gap in the vast Pacific.

In early 1957 I organized a MOONWATCH team made up of interested volunteers from the community. The base of operation was made at the Makapuu Point Observatory because of its relative remoteness from city lights and access to electric power and telephone and other conveniences of the observatory. MOONWATCH telescopes were fabricated in the Physics shop and the MOONWATCH volunteers set up a row of sturdy pedestals on which to mount them. After numerous training sessions and many delays of satellite launchings, a satellite did finally appear in our skies, albeit, designated as a "sputnik"! And so the volunteers were finally rewarded. It is quite likely that the greatest payoff of the operation was the opportunity for citizens to participate in an active role in this exciting new era, rather than be passive bystanders.

7 The Haleakala Period

With regard to the telescopic tracking network: in 1956 Dr. Fred Whipple of the Smithsonian Astrophysical Observatory (SAO) Cambridge, Massachusetts, wrote a letter to Dr. C. E. Kenneth Mees in Hawai'i. Dr Mees was the retired vice president for research of the Eastman Kodak Company and the developer of the color film Kodachrome. He was especially well known among astronomers because of his interest in developing special photographic emulsions suitable for astrophotography, and his insistence that the company provide these materials to the astronomers at cost. Dr. Whipple asked his old friend if he knew of some way a satellite tracking station could be established in Hawai'i. Dr. Mees in turn contacted me at the University of Hawai'i and he made an offer: if I would undertake the project he would donate some of his Kodak stock to underwrite the cost. I accepted the offer not only because it was an important project, but because I could see that Haleakala was the right place for such a tracking station, and this was an opportunity for the University to acquire land and establish a base of operations on Haleakala in preparation for the solar observatory.

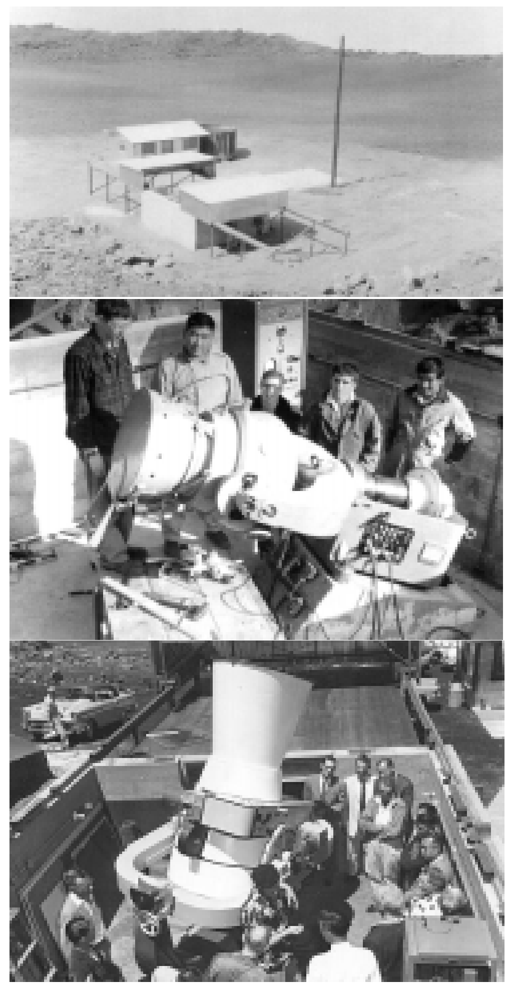


Figure 16: [a] The satellite tracking facility completed in early 1957 consisted of a camera building with sliding roof and a small office building. [b] The meteor tracking camera served initially as the satellite tracking camera. Dr. Richard McCrosky of the Harvard-Smithsonian Observatory is on the left. [c] The Baker-Nunn satellite Tracking Camera was dedicated on August 2, 1958.

The University sold the Kodak stock and with the $15,000 proceeds we managed to build on Haleakala a small cinder-block building with a sliding roof to house the anticipated Baker-Nunn Super-Schmidt tracking camera, and a small wood-frame building for living accommodations for the observers. The informality of the project would be unheard of today–no environmental impact statements and no building permits. It was just a matter of finding a contractor willing

to do a job at a very remote site on top of the mountain, 50 miles from the base yard, in the bitter cold, on a shoestring budget. Contractor Ed Ige of Kahului, Maui, was such a one. Of course, the university did take all the proper legal steps to obtain a use permit from the State of Hawai‘i and, in due course, 18 acres were set aside for the university as a science preserve.

The satellite tracking facility was ready for the camera on July 1. 1957, but the camera was not ready. Because of the importance of the Hawai‘i station, SAO decided to send one of its meteor-tracking Schmidt cameras, and with it came Dr. Richard McCrosky and a crew to install and operate the camera. It was this team, then, that initiated satellite tracking from Haleakala. Some six months later, the Baker-Nunn camera arrived and was installed. Walter Lang became the first full-time observer atop Haleakala. In subsequent years the SAO invested a great deal more money in the facility. It enlarged and improved the original structures and built a spacious, comfortable dormitory.

As tracking technology gradually improved over the years, the usefulness of the Baker-Nunn cameras gradually declined, and the tracking assignments and staff at Haleakala gradually decreased until 1976, when the facility was shut down.

Figure 17: Dedication of the Mauna Loa Observatory of the U.S. Weather Bureau – National Bureau of Standards on June 28, 1956. Mauna Kea is in the background.

Also associated with the IGY and having long-term implications was the establishment in 1956 of the U.S. Weather Bureau/National Bureau of Standards Mauna Loa Observatory[10].This facility, intended primarily for long-term atmospheric studies, such as ozone and CO_2 content and distribution, was built on the northern slope of Mauna Loa at an elevation of 11,134 feet, in an area that was believed to be relatively safe in terms of future volcanic activity. Among the first users of the facility were NBS researchers C. C. Kiess and C. H. Corliss who, at the time of the dedication on June 28, 1956, were making high-resolution spectroscopic observations of Mars on its close approach to Earth.

Some years later, in 1965, the High Altitude Observatory of the National Center for Atmospheric Research, built a small solar observatory near the MLO facility in which to place a coronal patrol instrument. Richard Hansen and Charles Garcia established the program. Garcia continued to operate the facility until his retirement in 1991.

In 1962, Dr. Franklin E. Roach of the National Bureau of Standards in Boulder, Colorado, who for many years had conducted photometric studies of auroras, airglow, zodiacal light, and the diffuse galactic light, became intrigued by the possibility of studying these phenomena at a low latitude

Figure 18: The night sky photometry program was housed in this remodeled WW2 blockhouse, formerly occupied by Grote Reber's radio astronomy program.

site. Haleakala appeared to be an ideal site for such studies because of the atmospheric transparency established earlier, the dark skies uncontaminated by artificial light, the large number of clear nights, and the low latitude (20°N). As with the argument for a solar observatory, the ease of access and availability of commercial power were simply icing on the cake!

I collaborated with Roach in establishing the airglow photometry program on Haleakala. We decided to use the old blockhouse in which Grote Reber had once housed his equipment. Scanning and fixed photometers were placed on the roof of the blockhouse with the electronics and recorders in the room below. The photometers scanned the sky through narrowband interference filters centered on important emission lines of the night airglow. Absolute photometric calibration was accomplished with the use of a standard radioactive phosphor periodically placed in front of the photometer. The program was initiated with the assistance of Mack Mann, borrowed from the Boulder laboratory. Mack did everything from enlarging the building and facing lit with lava rock to installing the equipment, getting it working, and taking the data.

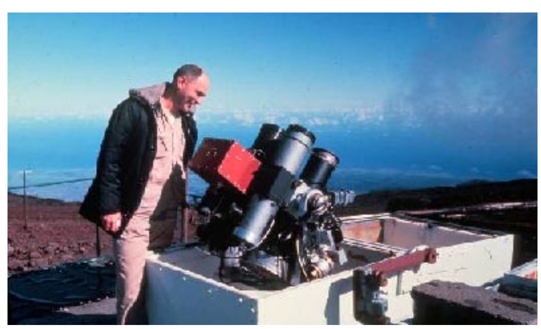


Figure 19: The airglow and zodiacal light photometers on the roof of the blockhouse. The cluster of telescopes rotates in azimuth while scanning the sky at various altitudes. Checking the instruments is Site Manager Alex Kowalski (1962).

Once the program was established, we looked for local talent to operate and maintain the station. The first University of Hawai‘i employee to be stationed full-time on Haleakala was Alexander Kowalski, recruited from a civilian electronics job with the U.S. Army on Oahu. Like Mack

Mann, Alex was a jack-of-all-trades and, as site manager, proved to be the perfect man for the developments ahead on Haleakala.

Over the years a number of dedicated individuals worked as observers at the airglow observatory: Barry Cartmell, Leon Offenhauser, Henry Heeseman, Roy Graham, Ronald Furukawa, and Tomeo Kametani.

Prior to the start of the airglow program, a graduate student at the University of Colorado was interested in doing his thesis research on the zodiacal light, which is sunlight scattered by dust particles concentrated in the plane of Earth's orbit. Since Franklin Roach was on his thesis committee, there was no question that Jerry Weinberg would have to come to Halea-kala to make his observations. He came with great enthusiasm and drive, and with a photometer that not only recorded the brightness of the zodiacal light but also its polarization, a parameter that is crucial to understanding the nature of the particles that scatter the sunlight. After completing his observations, Weinberg returned to Boulder to analyze his data and to complete the writing of his thesis. He was awarded the Ph.D. degree for this work in 1963 from the University of Colorado. After completing the work for the doctorate, Weinberg returned to the University of Hawaii as a postdoctoral researcher and continued his studies of the zodiacal light[11].

During the same period a graduate student from the University of Tokyo, Hiroyoshi Tanabe, spent a year with the program on work that contributed to his doctorate from his university.

The night-sky photometry program reached a high point in 1963/4, when Roach spent the full year with us and we were joined by airglow scientists Dr. Masaaki Huruhata, from the Tokyo Astronomical Observatory, and Dr. P. V. Kulkarni, from the Physical Research Laboratory in Ahmedabad, India. Huruhata was supported here as an East-West Center scholar. It was a very stimulating and productive year[12].

Figure 20: Visiting researchers in the airglow and zodiacal light program, 1963. L to R: Prof Masaaki Huruhata, Dr. P. V. Kulkarni, Dr. Huruhata's daughter, Kuniko, W. Steiger, and Dr. Franklin Roach.

In 1964 a graduate student in physics at the University of Hawaiʻi, Walter Brown, chose to do his thesis research on the relationship between the airglow and the dynamical behavior of the ionosphere. Total electron content data was obtained from an analysis of radio waves propagated from a geostationary satellite (ATS-1) through a program conducted by the Radio Science Group of the University of Hawaiʻi Department of Electrical Engineering. Brown set up an airglow photometer at Haleakala to look at that portion of the ionosphere through which the radio waves were propagated. Brown completed his thesis and was awarded the Ph.D. degree in January 1969[13].

8 Finally, A Solar Observatory

In the mean time, the search for support for a solar observatory on Haleakala continued. The IGY program provided a great impetus to geophysics in Hawaiʻi, to the point that the University felt the need for establishing an Institute of Geophysics. It was decided to combine the two projects and include in the proposal for the Hawaiʻi Institute of Geophysics (HIG) the construction of a solar observatory on Haleakala. In 1961 the National Science Foundation approved the proposal and provided funds for the construction of the observatory. Plans were prepared, a construction contract awarded, and groundbreaking took place on February 10, 1962. Fortunately, weather conditions were very favorable during the following months and the basic construction was completed in November 1962. In addition to the 30-foot dome, the observatory housed dormitory space, a day room with kitchen facilities, a well-equipped machine shop, offices and laboratories.

Figure 21: [a] Haleakala solar observatory groundbreaking, February 10,1962. l. to r.: Robert Hughes, Board of Regents of the Univ. of Hawaiʻi; Greg Sinclair, President Emeritus of UH; Laurence Snyder, President of UH; Lt. Governor James Kealoha; Maui County Mayor Eddie Tam; and Robert Hiatt, Vice President and Director of Research. [b] UH Haleakala solar observatory upon initial completion, Nov. 1962.

During the following year, the furnishings, machinery, and the Boller and Chivens 10-foot, equatorially mounted, octagonal spar gradually arrived and were installed. The

octagonal spar provided the new observatory with a great deal of flexibility, for it was, in effect an eight-sided optical bench that would automatically and continuously track the Sun with great precision. On it could be mounted a variety of optical telescopes. Initially, the flare patrol telescope from the Makapuʻu Point Solar Observatory was moved to the new observatory. This was soon followed by a k-coronameter from the High Altitude Observatory in Colorado. Along with the k-coronameter came Richard Hansen and Charles Garcia, who later moved the instrument to Mauna Loa, as alluded to earlier.

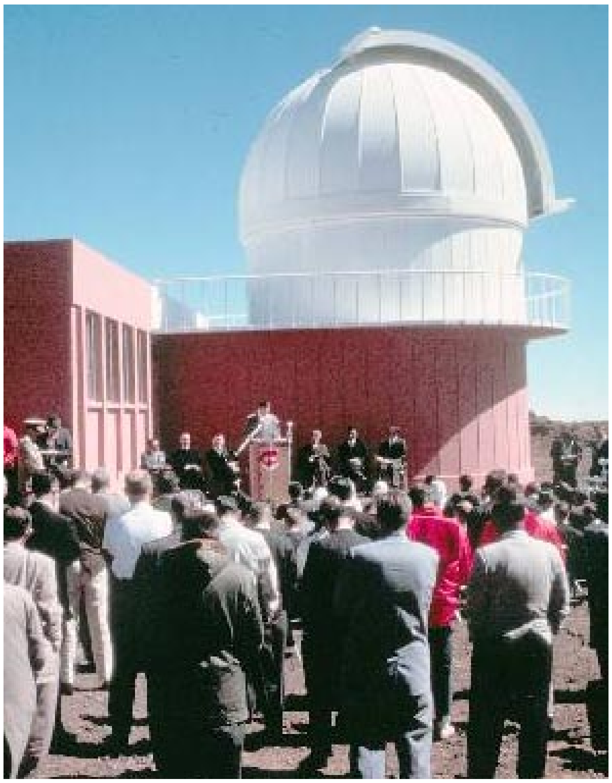


Figure 22: Dedication ceremony of the Haleaka solar observatory naming it the Mees Solar Laboratory, in recognition of the contributions to astronomical photography by Dr. C. E. Kenneth Mees, January 1964.

Dedication ceremonies of the new observatory took place took place on a cold but sunny winter day in January 1964. The facility was named the C.E. Kenneth Mees Solar Laboratory in honor of the now deceased photographic scientist who did so much for astronomy in general and helped us get started on Haleakala. As part of the Hawaiʻi Institute of Geophysics, the facility was informally called the HIG Haleakala Observatory, or HIGHO, a rather neat acronym for a high altitude observatory, I thought!

An observatory without astronomers is but a pile of brick and cement. But before there was an observatory no astronomer was willing to come to Hawaii. Now, at last, we had something to offer and were successful in recruiting, for a new program in solar astronomy, the eminent astronomers John Jefferies, Frank Orrall, and Jack Zirker. Marie McCabe soon joined them under their research grants. At this point I bowed out of leadership of the program and invited John Jefferies to provide the leadership and direction of the future solar physics program. It was, then, under his able

Figure 23: Recognition of the HIGHO staff by W. Steiger: L to R: Richard Hansen, Chester Dilley, Roy Graham, Alex Kowalski, Jerry Weinberg, Charles Garcia, and Ronald Furukawa.

direction that later the Institute for Astronomy was formed, separate from the Hawaii Institute of Geophysics, and that the spectacular developments on Mauna Kea began – developments that in the 1950s I would not have dreamed of.

9 Epilog

Shortly after the dedication of the Haleakala solar observatory, a distinguished visitor appeared and asked permission to make some studies of the quality of the astronomical seeing at this site. His name was Gerard Kuiper, world-renowned astronomer and director of the Lunar and Planetary Laboratory based in Tucson, Arizona. He was interested in finding a superior site for a new telescope for his laboratory. With his assistant, Alika Herring and Alika's superb 12-inch telescope, they found the seeing on Haleakala to be quite extraordinary. But on some nights there was a tendency for fog to climb over the summit and spoil observing. This is because Haleakala at 10,000 feet is not sufficiently higher than the normal inversion layer at around 8,000 feet to be always above the clouds. Looking across the channel to the Big Island (Hawaiʻi), Kuiper could see the summit of Mauna Kea high above the clouds and wondered if that peak might not be a better site.

Having also received an invitation from the Hawaii Chamber of Commerce to consider Mauna Kea for an observatory site, Dr. Kuiper visited the Big Island and expressed

a desire to conduct a site evaluation, as he had done at Haleakala. Very soon the Governor of Hawaii, John Burns, released funds for the bulldozing of an access road to the summit of Mauna Kea. A small dome to house Alika's telescope was set up on Pu‘u Poliahu and the site study began. When completed, the study, to Dr. Kuiper's delight, showed that Mauna Kea was a truly superb site, the finest he had ever seen. With this established, he submitted a proposal to NASA for a new telescope to be placed on Mauna Kea.

At this point, NASA decided to open the competition to other proposals and invited both the University of Hawaii and Harvard University to do so. The University of Hawaii had no astronomers experienced in telescope development, only the new team of solar astronomers. To Dr. John Jefferies, now in charge of the solar program, fell the responsibility of organizing an observatory development plan and submitting a proposal to NASA. The plan called for an 88-inch telescope. It was a well-conceived plan that ultimately won NASA's approval for support! This outcome was, understandably, a terrible blow to Dr. Kuiper, who felt "his mountain" was "stolen" from him. Regardless of the outcome, Dr. Gerard Kuiper must be acknowledged as the discoverer of Mauna Kea as a superb astronomical site.

So, Mauna Kea's incredible astronomical story begins with the construction of the University of Hawai‘i's 88-inch (2.2 meter) telescope. It is a story that has been told in various forms and places[14,15].

References

[1] Varez, Dietrich, Maui, the Mischief Maker, Bishop Museum Press, Honolulu, 1991.

[2] Lewis, David, We the Navigators, the Ancient Art of Landfinding in the Pacific, University of Hawai?i Press, Honolulu, 1972.

[3] Chauvin, Michael, "Useful and Conceptual Astronomy in Ancient Hawai‘i", in Astronomy Across Cultures, H. Selin, ed., Kluwer Academic Publishers.

[4] Johnson, Rubellite Kawena, and John Kaipo Mahelona, Na Inoa Hoku - a Catalog of Hawai?i and Pacific Star Names, Topgallant Publishing Company, Honolulu, 1975.

[5] Chauvin, Michael E., Astronomy in the Sandwich Islands: The 1874 Transit of Venus, The Hawaiian Journal of History, Volume 27, 1993.

[6] Armstrong, William M., Around the World with a King, Frederick A. Stokes Company, New York, 1903.

[7] Bryan, E. H., Jr., Stars Over Hawai‘i, Books About Hawai?i, Honolulu, 1955. Revised edition by Petroglyph Press, Hilo, Hawaii, 1977.

[8] Steiger, Walter R. and John W. Little, "On the Feasibility of a Solar Observatory in the Hawaiian Islands", Publications of the Astronomical Society of the Pacific, Volume 70, No. 417, December, 1958.

[9] Steiger, Walter R., and Warwick, James W., "Observations of Cosmic Radio Noise at 18 Mc/s in Hawai‘i," Journal of Geophysical Research, Volume 66, No. 1, 1961.

[10] Miller, John, ed, Mauna Loa Observatory - a 20th Anniversary Report, U.S. Department of Commerce, September 1978.

[11] Weinberg, J. L., and Mann, H. M., "A Program of Ground Based Studies of the Zodiacal Light", in NASA SP-150, Proceedings of a Symposium on the Zodiacal Light and the Interplanetary Medium, held at the East-West Center, University of Hawai‘i, 1967.

[12] Steiger, Walter R., Low Latitude Observations of the Airglow, in Aurora and Airglow, Proceedings of the NATO Advanced Study Institute, B. M. McCormick, ed, held at the University of Keele, Stratfordshire, England, 1966, Reinhold Publishing Corporation, 1967.

[13] Brown, Walter E., "The Dynamical Behavior of the Nighttime F-Layer at Hawai‘i," Ph.D. dissertation, University of Hawai‘i, 1969. University Microfilms 69-16,649.

[14] Krisciunas, Kevin, Astronomical Centers of the World, pp. 222-231, Cambridge University Press, Cambridge, 1988.

[15] Parker, Barry, Stairway to the Stars, Plenum Press, New York and London, 1994.