The University of Arizona's

LUNAR AND PLANETARY LABORATORY

Its Founding and Early Years

Ewen A. Whitaker

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FOREWORD

The Centennial Year of this University also marks the 25th anniversary of the founding of the Lunar and Planetary Laboratory, the oldest and largest establishment of its kind in this or, indeed, any country. To document its complete history and achievements over that period would involve much research, and such a production would be beyond the scope and intent of this article in any case. What I will attempt to do here, therefore, is to trace the events and circumstances that led to the founding of LPL in Tucson, to pick out some of the highlights and other memorabilia of those earlier years, and to intersperse this material with personal anecdotes and reminiscences.

At this point, all the reader needs to know is that the LPL was founded in 1960 by Dr. Gerard P. Kuiper, an outstanding and dynamic Dutch-born astronomer who, after making many noteworthy contributions to stellar astronomy, turned to the then largely disdained area of the study of the planets and satellites of our Solar System.

My only qualifications for preparing this account are that my association with Dr. Kuiper dates back to 1955 when we first met at an international astronomical convention, and that my full-time collaboration with him started in 1958, predating by three years any other current member of LPL. I cannot claim to be either a historian or a writer; although I will draw upon various letters, documents and other sources for data, opinions, reminiscences, etc., the narrative will undoubtedly be biased by my own experiences from these thirty years. The full story awaits a dedicated biographer or historian who has the time available to go through the voluminous correspondence and related documents and items of the Kuiper Archive.

Ewen A. Whitaker
Associate Research Scientist in the
Lunar and Planetary Laboratory
Member of the Kuiper Archive Committee

THE PRE-TUCSON ERA

Historical Background

Just three years before the founding of this University, a comparatively insignificant event occurred in South Africa that, within a period of a decade or two, changed the entire emphasis in astronomical research. Exactly seventy-five years later, another rather more significant event was destined to reverse this change, thereby largely restoring the earlier priorities. As we shall see, these two disparate and apparently unconnected events provided the ideal astronomical climate to give an unexpected boost to a modest astronomical project that had just been initiated in southern Wisconsin. They also contributed significantly to the success, stature and rapid growth of this project following its transfer to Tucson in 1960, exactly seventy-five years after the founding of the University.

Before expanding a little on these perhaps somewhat cryptic statements, we need to be aware of the general thrust of astronomical research up to the 1870's. At that time, photography had not attained the stage of perfection or convenience where it constituted a valuable technique in telescopic observation. This was still the era of visual observation, and not unnaturally, those objects which presented the most detail, or changes of appearance, or which showed motion of rotation or revolution, came under the greater scrutiny. The Sun, Moon, planets and satellites, and comets fall into one or more of these categories. The stars and nebulae, on the other hand, respectively never appear as anything more than points or faint smudges of light, and are, by comparison, quite static. Thus the Solar System objects received the lion's share of attention simply because they provided much more observable and measurable data. This imbalance is reflected in the astronomical literature of the period.

In 1882, a bright comet made its appearance in the southern skies. Sir David Gill, Her Majesty's Astronomer at the Cape of Good Hope Observatory, borrowed a portrait camera from a local photographer, strapped it to the side of one of the telescopes in order to follow the motion of the sky, and made several time exposures of the comet and surrounding sky. He was astonished not only at how well the faintest parts of the comet were portrayed, but even more at the very large number of star images that appeared on the plates. The reason for this success was that he used photographic plates coated with the newly-introduced gelatin-based emulsions rather than the older collodion emulsions which were less sensitive by a factor of 100 or more.

This incident initiated the greatest surge of data-gathering in astronomy since the invention of the telescope—the application of these latest photographic products to the study of the stars, star clusters, nebulae, the Milky Way and space in general. A universe of undreamed-of magnitude and complexity was opened up in the process; every direct photograph revealed new objects, every spectrogram displayed unusual features that prompted further research. Photographs could be examined and measured at leisure, intercompared to detect changes in the positions, brightnesses or appearances of objects, and retained as permanent archival records.

By comparison, the advantages gained by the application of these improved photographic products to the study of Solar System bodies were much more modest. Indeed, direct photographs of the Moon and planets still failed to record all the detail that could be detected visually with the same telescopes. It is thus little wonder that research in stellar, galactic and extra-galactic astronomy progressed by leaps and bounds while Solar System studies languished. In fact, the stage was reached where the importance accorded the study of the heavenly bodies was, not counting the Sun, roughly in direct proportion to their distances from the Earth. Our nearest neighbor in space, the Moon, was virtually treated with contempt, and many astronomers roundly cursed its existence (and still do to this day!) because its scattered light hampered the long exposures needed to record faint objects!

Enter Gerard P. Kuiper

Such was the general climate in astronomy in September 1924, when two freshmen students in particular presented themselves at Leiden University in the Netherlands. One was the late Gerard P. Kuiper, the other the late Bart J. Bok. Bart Bok recalled that as on that first morning there was little to do, they not unnaturally gravitated towards the reference library, and in particular to the card catalogue of astronomy books. Bok continued, "After introduction formalities were over, Gerard asked me what was my special field of interest in astronomy. I promptly replied that I was most interested in the Milky Way and the Cepheid variable stars. He responded, 'That is not an uninteresting field. But I expect to study a more fundamental area, the problem of three bodies and related questions about the nature and origin of the Solar System.' It was evident right at the start that Gerard was determined to make major research contributions to astronomy and astrophysics. Gerard knew that the Solar System was to be his to explore, the physics of the planets as well as their motions and origins."

Bart Bok stayed with his choice and became a foremost authority on the subject of the Milky Way. His and Gerard's paths parted following their graduation from Leiden University, and it is an unusual quirk of fate that they eventually came together again in Tucson as Directors of the two astronomical institutions of the University of Arizona. Gerard Kuiper's professional career commenced with positions at Lick Observatory and Harvard University, but in 1936 he transferred to Yerkes Observatory in southern Wisconsin, which houses the Astronomy Department of the University of Chicago, and remained there until his move to this University in 1960. Virtually all of Kuiper's earlier researches were directed towards a better understanding of the characteristics and evolution of double stars. This research resulted not only in many notable advances in our knowledge of double-star systems, but also added materially to our comprehension of many fundamental aspects of single stars. But all this work was largely the means to an end, namely to see if there might be some observable or deducible connection or sequence between double-star systems and the Solar System.

Towards the end of 1943, Kuiper started to observe Solar System objects. Using infra-red-sensitive plates in conjunction with the recently installed 82-inch reflecting telescope of the McDonald Observatory, which is located in the Davis Mountains of southwest Texas, he discovered that Titan, Saturn's largest satellite, possessed an atmosphere of methane gas. Previously, it was believed that all the satellites were atmosphereless. Following an absence for War Service, he turned his full attention to planetary observation and research, using the newly-available Cashman infra-red detectors to obtain improved I-R spectra. This and other lines of investigation led to a whole string of new discoveries and interpretations ranging from the detection of carbon dioxide on Mars, the discovery of a new satellite to each of the planets Uranus and Neptune, and improved measures of the diameters of Neptune and Pluto, to papers on the origin of the asteroids, of the Solar System, of planetary atmospheres, and various other topics.

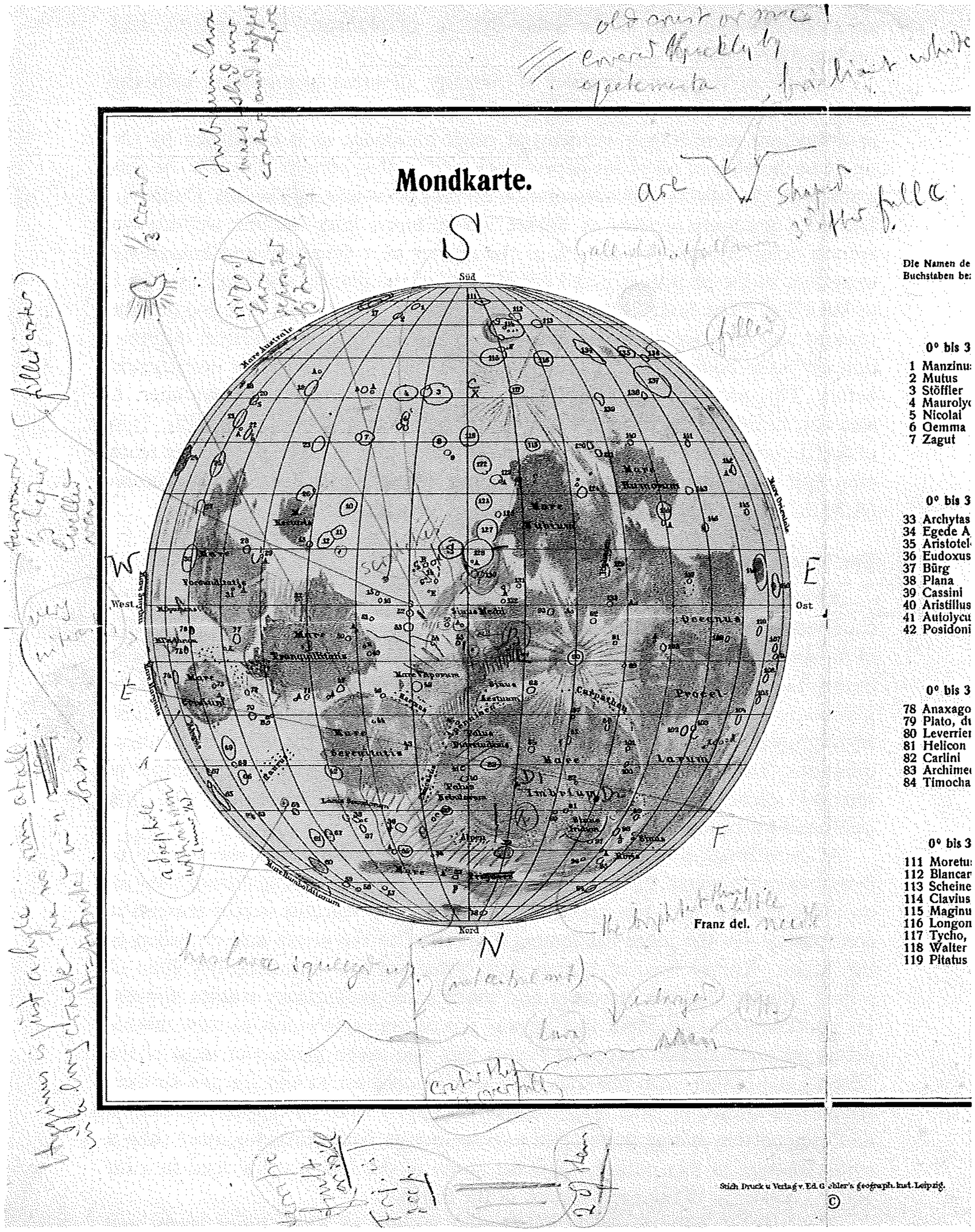
Because of the preoccupation of virtually all other astronomers with the unlimited possibilities of stellar, galactic and extra-galactic research, Kuiper's investigations were largely carried out single-handedly, as is confirmed by the single authorship of all of his papers dating from that period. However, he was assisted at the McDonald telescope on several occasions by the late Daniel L. Harris, a graduate student at Yerkes whose name later became well-known among Solar System researchers as the author of a definitive and exhaustive treatment of the photometry and colorimetry of the planets and satellites (Ch.8 in Vol.III of "The Solar System," ed. G.P. Kuiper, 1961). His first cooperative venture was an asteroid survey designed to provide reliable statistical information on these bodies down to much smaller sizes than had been investigated before. This program was initiated in 1949 and completed nine years later. It was not, however, the program that led to the eventual founding of LPL. Two of the six collaborators on this particular project later rejoined the Kuiper team after the establishment of the Lunar and Planetary Laboratory in Tucson (A.M.J. "Tom" Gehrels and the late Georges Van Biesbroeck).

The Moon enters the picture

Although active research into the origin and evolution of the Moon had been shunned by astronomers for at least half a century, some excellent photographs of its surface had been secured at Yerkes, Mt. Wilson and Lick Observatories during this period. A few individuals with expertise in the fields of geophysics, geochemistry and related disciplines had studied a small selection of these photographs, and had put forward their own ideas of the answers to these questions. The most recent of these was the late Dr. Harold C. Urey, winner of the 1933 Nobel Prize in chemistry for his isolation of Deuterium, who first published his conclusions on the subject in 1951.

A disturbing aspect of all these and earlier papers was the degree of disagreement between them; this general lack of consensus ranged from theories on the origin of the lunar craters—the century-old volcanic versus meteoritic controversy—to the more fundamental question of the origin and evolution of the Moon. Kuiper was, of course, fully aware of this unsatisfactory state of affairs, having read the literature and made some preliminary studies himself. He also knew that the lunar surface was presenting us, in comparatively minute detail, an unblemished record of events that had taken place over most of the Moon's 4½-billion year lifetime. This was in contrast to the Earth's surface, which was known to have been changed so utterly both by crustal movements and erosion that it was impossible to trace events backwards for more than a small fraction of this period. Thus the study of the Moon could lead to a far better knowledge of the early history of the Earth.

This double incentive certainly caused Kuiper to place lunar study and observation at or near the top of his list of priorities at that time (1952-1953). He first of all had a binocular eyepiece made, to be used on the McDonald 82-inch telescope. This would be the first time that such a large telescope, the third largest in the world at the time, would be used for serious visual observation of the Moon. It also would be the cause of some consternation among the hard-core astrophysically-oriented astronomers, who considered it sacrilege to squander valuable telescope time on mere Solar System objects, especially that dead lump of rock, the Moon!



Small lunar map with Kuiper's annotations; about 1953

In order to coordinate his visual observations, Kuiper needed a fairly large selection of top-quality lunar photographs and a good map. Here he met some problems. Although many good-quality negatives had been secured at several observatories, as already noted, only a very limited selection of these had been used to make prints; those prints that were available were mostly at a scale far too small for detailed scientific study or for use at the telescope while observing. The situation with maps was even worse; not a single available map was either sufficiently detailed or accurate to be adequate for the job. Despite these setbacks, he began a series of visual observations in the second half of 1953 and continued them through the first half of 1954, using the binocular eyepiece on the 82-inch telescope. He annotated those photographs and maps that he had at hand with remarks and short descriptions of unusual or interesting features; he also made drawings of some of these features, and recorded comments on a Dictaphone while he observed.

As a result of this fairly short but quite intensive piece of research, Kuiper reached some conclusions concerning the Moon which he published towards the end of 1954 in a paper titled: "On the Origin of the Lunar Surface Features." It is clear, however, that he considered this to be only a beginning because in it, he refers to several unsolved problems concerning the Moon. He was also hampered by the scarcity of adequate maps and photographs as a basis for further research.

A call for suggestions

At the Ninth Congress of the International Astronomical Union held in Dublin, Eire in Aug-Sept 1955, Kuiper distributed two memoranda on lunar matters to members of Commission 16 ("Physical Observations of Planets and Satellites"), of which he was President at that time. One of these memos dealt with some current lunar nomenclature problems, but the other, "Considerations on a New Photographic Lunar Map," emphasized the pressing need for a lunar atlas made up of large-scale, high-resolution photographs of the lunar surface in order to provide a solid basis for further research. It also included some preliminary suggestions regarding a suitable scale, possible format and other related matters. Kuiper verbally solicited comments, criticisms, alternate suggestions or any other advice at the meeting of Commission—I learned some time later that I was the only person to reply to his solicitation.

This underwhelming response resulted in a lively and stimulating exchange of correspondence between us on this particular subject. However, before proceeding with this and other contemporary events that had a strong bearing on Kuiper's ordering of priorities, and on the general course of prosecution of his Solar System studies, I must digress a little and briefly describe my own background and the circumstances that led to this unplanned meeting. I do this with some reluctance, and only because it throws some light on Kuiper's criteria for selecting collaborators, which is all part of the LPL story.

At the time of the 9th Congress of the I.A.U., I had been a professional astronomer at the Royal Observatory, Greenwich, England for six years, engaged in astrophysical and astrometric programs. My interest in the Moon started early in 1951 and resulted from a desire to join one of the observing sections of the British Astronomical Association, a long-established organization of amateur astronomers. The Lunar Section appeared to offer a greater variety of interesting programs; after making various observations of lunar surface features and taking photographs of the Moon with the Observatory's instruments, I became quite hooked on the subject and made it a prime avocation. Kuiper and I must have been operating on the same wavelength because in 1952 we independently reached the same conclusions about the inadequacy of existing lunar maps and the dearth of good-quality photographs as accessories for scientific study.

The British Astronomical Association had a small fund available to finance a few members to attend the 9th I.A.U. Congress; among those selected were myself and an experienced amateur observer, Alan Lenham, who was also an instructor at the Military College of Science in England. I naturally traveled the least expensive way which, I discovered, entailed trying to sleep on a coil of hard, smelly rope on the deck of a small steamer that took all night to cross the Irish Sea! Both Lenham and I knew of Kuiper's recent discoveries and other work, and were happy to find out that he was also attending the Congress. Lenham was introduced to Kuiper by a mutual friend, and Lenham later introduced me to Kuiper during a break between Commission sessions. The Congress was held at University College, and I recall that Kuiper took us downstairs to the refectory and bought cups of coffee for us and himself. We eagerly discussed matters of mutual interest; Kuiper had recently observed the planet Saturn with the 200-inch telescope at Mt. Palomar, and I remember very well his contagious enthusiasm as he drew a graph of the brightness variation across the planet's rings. On the strength of this quite brief meeting between us, he asked me to act as one of the two secretaries to record the proceedings of the upcoming Commission 16 session; this aspect of Kuiper's character is brought out very well by David Arthur later in this account.

As a result of these short meetings with Lenham, Kuiper offered him a position at Yerkes for an unspecified period, which in practice was limited to three years because of his professional obligations in England. He worked primarily on astrophysical programs such as stellar parallaxes (i.e., distances), double star studies, and proper motions in galactic star clusters, but devoted part of his time to lunar and planetary observation and study. He observed and photographed both Mars and Jupiter from 1956-58, the former throughout the very favorable opposition of 1956; the results were published in the Journal of the British Astronomical Association, a publication for which Kuiper had a high regard. Lenham was thus Kuiper's first collaborator in the field of planetary surface studies.

The Harold Urey affair

I mentioned earlier that Urey's paper regarding the Moon was the most recent to appear before Kuiper's. Urey was, at the time, a fellow member of the faculty of the University of Chicago, specifically in the Institute for Nuclear Studies. He and Kuiper had discussed items of mutual interest in lunar and related matters during their occasional encounters, and had been in correspondence for five or so years. They were clearly in agreement over some but not all details regarding lunar origin and evolution, as is normal in science when theories and ideas are taken beyond the limits of available data.

However, things changed quite dramatically after Urey had read Kuiper's 1954 paper, which contained new ideas based on the observations with the 82-inch telescope. He wrote a quite intemperate criticism of just about every point raised in the paper; it was published in July 1955, a month prior to the I.A.U. Congress. Kuiper immediately wrote a reply to Urey's criticisms, clarifying matters in very moderate terms which contrast noticeably with Urey's rather abrupt and tart remarks. We later found that Kuiper did not normally waste valuable time and effort by getting into verbal exchanges to try to prove a point; rather, he would initiate an investigation or some new research to try to resolve the matter. In this instance, the blast from Urey undoubtedly strengthened Kuiper's resolve to regard further lunar research as a high priority item, and to pursue his still somewhat tentative plans to produce an atlas of lunar photographs as a necessary first step for these studies.

In any event, this affair caused a long-lasting rift between the two men, although we will see later that an unexpected turn of events necessitated their peaceful collaboration on several occasions through the 1960's. The papers which caused all this furore can be found in the Proceedings of the National Academy of Sciences, Kuiper's appearing in Vol. 40, no. 12, and Urey's in Vol. 41, no. 7. Kuiper's reply is in Vol. 41, no. 11. Subsequent research has shown that although both authors reach incorrect conclusions on various points, one of them comes much closer to reality than the other does. I will leave the reader in suspense regarding which of the antagonists proved to be the more correct until later in this story.

Preliminaries for the lunar atlas

As I noted earlier, Kuiper's solicitation for comments and suggestions regarding his proposals for a lunar atlas elicited one single reply—mine. I agreed with some but not all of his ideas, and proposed some alternatives, with reasons for doing so. One of these suggestions was to draw the complete lunar coordinate grid - a fixed system equivalent to the grid system used on some terrestrial maps - on representative photographs that collectively included the entire visible face of the Moon. As we will see, this later turned out to be a much more important and serendipitous suggestion than could possibly have been imagined at that time.

Kuiper was clearly delighted to find someone who had a strong mutual interest in his proposals, and we maintained a regular exchange of letters from then on. He informed me of any progress, new ideas, changes, etc., some of which he had reached as a result of discussions with Lenham, while I replied with my comments on these. Meanwhile, he had the problem of collecting the basic materials for the atlas—large-scale prints made from original negatives. For the few good negatives at Yerkes Observatory, there was no problem since the Observatory's photographer, the late Joe Tapscott, could make the necessary enlargements. For the 130 or so negatives at Lick Observatory and the more than 500 at Mt. Wilson Observatory, he would need to select the best and make his own enlargements. In addition, there were over 300 new negatives that he and Lenham had taken with the 82-inch telescope during 1956 that required selection and enlargement, and about 30 more that would be loaned by the Pic-du-Midi Observatory in the near future. Since each negative contained up to about six atlas fields, and enlargements would be made on 14x17-inch paper, the whole project was obviously becoming a major operation with attendant funding and staffing problems.

1957 - A dream begins to take shape

In the early Spring of 1957, Kuiper applied for a grant from the National Science Foundation to finance what he called the "Lunar Atlas Investigations Research Project." On the strength of the probability that he would obtain these funds without problem, he wrote to ask me whether I could spend two or three months at Yerkes to select and enlarge the best McDonald lunar negatives, and participate in the editorial work of the atlas. I should perhaps add here that I would not be approaching this job "cold." I already had a good grounding in the theory and practice of black-and-white photography, plus considerable experience in darkroom work, including the rather specialized art of producing aesthetically pleasing enlargements from lunar negatives - all of which, of course, Kuiper was fully aware of.

Naturally, I was very excited at this prospect, and readily agreed in principle to accept the invitation. Neither of us was prepared for the roadblock thrown up by my chief, the Astronomer Royal (R. van de R. Woolley), who had no liking for either the Moon or Kuiper, or for the administrative problems and SNAFUs that occurred in trying to arrange for my visit. Kuiper spent much valuable time in sending a barrage of letters and phone calls to the University Comptroller's office in Chicago dealing with such mundane chores as visas, work permits, prepaid air tickets, income tax rebate, social security number, etc., to say nothing of trying to persuade Woolley to grant me a sabbatical-type leave. I mention these minor points only to illustrate the personal trouble to which Kuiper would go in order to return loyalty to those who offered the same to him.

The sought-after funding was indeed approved in April 1957. The following month he traveled to Caltech in Pasadena, California, to select the best Mt. Wilson negatives, and took them (very carefully - they were glass plates, many being the most detailed photographs ever taken of the Moon) to Lick Observatory, which is located on Mt. Hamilton, southeast of San Jose. Here, with the assistance of Mr. R. Watson, the Lick photographer, he made some 600 enlargements from both these and a few of the best Lick negatives. This task occupied a full two months; enlargements from the remaining Lick negatives were made by Watson. My visit to Yerkes was finally arranged for the month of October 1957, but it was made possible only by giving up my entire annual leave. By putting in long hours and six-day weeks, I completed the preparation of enlargements from the McDonald series of negatives. Together with those made by Kuiper himself and the few from the Yerkes negatives made by Tapscott, this made a very substantial collection of almost one thousand prints.

There is no doubt whatever that Kuiper considered the preparation of this lunar atlas as the first step towards more comprehensive projects. In a letter dated Jan. 30, 1958 to David Arthur (concerning whom, more later), Kuiper writes: "I have hoped for years to be able to start what may be called a planetary institute, and I have now received the necessary support for it." The support referred to here is the NSF grant received the previous April together with a new and more substantial contract entered into with the Air Force Cambridge Research Directorate.

The shot that was heard (and seen) around the world

For my visit to Yerkes I actually left London airport on the evening of Saturday 5th October, just as the evening newspapers were splashing the banner headlines: "Sputnik I orbits the Earth," or words to that effect. I picked up a copy, little realizing that this event was heralding the dawn of the Space Age, an era that would land men on the Moon within a dozen years, give us thousands of close-up views of Jupiter and Saturn and their satellites, and provide us with a far better appreciation and understanding of our own planet Earth.

I was met at Chicago's O'Hare Field (it was hardly more than a group of converted Air Force buildings then) by Kuiper, who was accompanied by a French astronomer (Audouin Dollfus) and a Yerkes student (Clayton Smith). I handed him the newspaper; he was surprised and impressed by the news of Sputnik, and amused by the personal courier method of learning about it. He certainly had no inkling at that moment that this event would, albeit indirectly, bring his dream for a planetary institute to fruition much sooner than he could possibly have expected.

Other irons in the fire

Before proceeding further with this story, I first want to dispel any impression I may have given that this Lunar Atlas Project was Kuiper's sole interest and activity at this time. He had been appointed Director of the joint Yerkes and McDonald Observatories as of 1 September 1957, with concomitant chairmanship of the Department of Astronomy of the University of Chicago, and he was still President of Commission 16 of the I.A.U. He was editor of and a contributor to an encyclopedic series of four major volumes titled "The Solar System," and general editor of another series titled "Stars and Stellar Systems." His sixteen publications for the years 1956-57 alone included such major papers as "On the Origin of the Satellites and the Trojans," "The Formation of the Planets," "The Origin of the Earth and Planets," "Visual Observations of Mars," "Origin, Age, and Possible Ultimate Fate of the Earth," and "The Atmosphere and the Cloud Layer of Venus." He was also winding up and preparing for the publication of his cooperative Asteroid Survey project. He was indeed an ever-busy man.

Secondly, I must now bring into the picture David Arthur, who played a leading role in our lunar programs for about nine years (after which he transferred to the U.S. Geological Survey's Branch of Astrogeology in Flagstaff). While Kuiper, Lenham and I were discussing lunar matters during our brief meeting in Dublin in 1955, I mentioned that another member of the Lunar Section of the B.A.A., David ("Dai," pron. "dye") Arthur, had a great deal of expertise and experience in the field of lunar cartography. This stemmed from his profession as a photogrammetrist in the Ordnance Survey, the Government mapping agency for Great Britain, plus an interest in astronomy in general and the Moon in particular. Lenham corroborated my remarks.

In March 1957, both Arthur and I were surprised to receive letters from Kuiper asking us to contribute a chapter on selenography to Vol. 4 of his "Solar System" series of books. We agreed to do this; Arthur completed his part in timely fashion, but my part was never completed because as of early 1956, I had taken over the Directorship of the B.A.A. Lunar Section on the resignation of H.P. Wilkins, a position that involved many hours per week in answering correspondence. I should add that Kuiper asked Arthur to write his part of this chapter merely on hearsay from Lenham and myself; he had never met nor corresponded with Arthur prior to this time.

Kuiper seeks full-time help for the Lunar Project

At the end of January 1958, Kuiper sent letters to both Arthur and me inviting us to participate in his lunar atlas project. The letter he sent me is reproduced herewith. The prospect of working on a project in which I was truly interested, plus the dangling carrot of being allocated observing time on the 82-inch telescope, were strong incentives to consider this offer very seriously. The salary of $6500 per annum was, at the prevailing rate of exchange of $2.80 to the pound sterling, more than double my salary at the Royal Observatory. However, the cost of living was quite a bit higher in the U.S. than in England; moreover, at that time the Royal Observatory had completed its move (apart from its historical buildings and instruments, of course) from Greenwich to Herstmonceux Castle in SE England, near the site of the 1066 Battle of Hastings, and my

THE UNIVERSITY OF CHICAGO

YERKES OBSERVATORY
WILLIAMS BAY, WIS.

January 31, 1958

Confidential

Mr. E. A. Whitaker
Royal Greenwich Observatory
Herstmonceux Castle
Hailsham, Sussex, England

Dear Mr. Whitaker:

We are now setting up a fairly large lunar and planetary project in which one of the first items of business will be the completion of the Lunar Atlas, including the proposed nomenclature and descriptive text. I should like to inquire whether you would be interested to participate in this work by accepting a position as Research Associate at the Yerkes and McDonald Observatories at the salary of $6,500 per year.*) The appointment will be on an annual basis, but is expected to continue. I can practically assure you now a three-year appointment and it will almost certainly extend beyond.

This letter is not a formal offer but an inquiry. I expect that the formal offer will be made after you have indicated to me your interest. I hope very much that you are interested. In that case, I recommend that you try to get a Quota-Immigration Visa, which will give you the same status as citizens. I do not know how long it will take to get such a visa; a letter from the University of Chicago might expedite this. I would suggest that the appointment begin about July 1, 1958 or as soon thereafter as you can get the visa.

Please keep this letter confidential until the matter is somewhat further along. I am writing a similar letter to Mr. Arthur, inviting him also. I shall be looking forward to hearing from you.

With best regards,

Yours sincerely,

Gerard P. Kuiper

Gerard P. Kuiper
Director

GPK:las

*) I would foresee annual increases. Observing in Texas is of course included in the plan.

Letter from Kuiper to the writer, inviting participation in his Lunar Project; January 1958

family and I were living comfortably on less than $2800 per annum in idyllic surroundings just a few miles from the seaside. Arthur and I discussed the matter carefully, each of us weighing the pros and cons in the light of our own personal situations. For each of us it would mean giving up secure Civil Service jobs with their handsome retirement pensions. For Arthur, who was a bachelor, the prospect of pulling up roots and resettling in another country involved much less trauma than for myself, a married man with three young children and a houseful of personal effects.

We both decided that the promise of interesting and challenging work outweighed the secure but mostly routine positions we were holding in the Civil Service. The paperwork and red tape involved on both sides of the Atlantic was incredible. My family and I were all fingerprinted, and among the documents I had to sign was one asserting that I was not taking my wife to the U.S. for immoral purposes! Arthur arrived at Yerkes early in September 1958, and my family and I at the end of October. As another indication of Kuiper's personal concern, he and his wife Sarah had prepared the house for our arrival - beds made, a cot for our youngest, toys for the children, extra furniture, food, milk and drink in the 'fridge, and the heating turned on; plus, a day or two later, a loan of $500.

Work on the atlas had come to a standstill following my busy session of enlargement preparation the previous October. However, for the summer months of 1958, two visiting students undertook some preliminary organizational work for compiling necessary data for the atlas sheets, assessing the extent of the photographic coverage of the Moon, etc. These were Alan Binder and Dale Cruikshank, both of whom later rejoined the Kuiper team in Tucson. Two offices had been prepared and furnished for Arthur and me in the NE turret at Yerkes, and work started in earnest as soon as we had settled in.

1959 - the Lunar Project gathers momentum

Arthur's chief concern was to set up two new projects proposed by Kuiper. The first of these was a program to improve and extend the fundamental coordinates of selected lunar features, something that had not been done for half a century, and to obtain, if possible, the figure of the Moon. The second was to construct a projection system using positive transparencies of lunar phases with a matte white hemisphere as a screen, so that specific lunar regions or the whole globe could be viewed or rephotographed from any desired direction. My own main area of responsibility was the prosecution of the lunar atlas project. In addition we were able to make visual observations fairly frequently with the 40-inch refracting telescope, the world's largest of its type.

Arthur's selenodetic program required the use of the 40-inch to obtain negatives of near-full phases of the Moon. For image stability and to ensure the inclusion of the whole lunar disk, 8x10-inch glass plates were used; star trails were added to a selection of plates to provide exact image orientation. It was decided from the start (November 1958) to include photography at all lunar phases since the atlas, despite the 1000 or so prints already made, still had some notable deficiencies. The photography program was taken on by a full-time student, Elliott Moore. I say "taken on" because it involved a great deal of dedication and effort on his part, what with duty periods getting later by 50 minutes per night during each lunation, temperatures in the dome frequently dropping to below zero degrees Fahrenheit in the winter, and sometimes being obliged to balance precariously at the very top of a ten-foot and not too steady stepladder. Arthur and I assisted Moore on many occasions during the first year, but we chickened out when duty periods started after midnight! Three students (Cruikshank, Binder and Huzzen) also assisted on occasion, as did Kuiper himself, but it was Moore who did all the less palatable chores and who deserves recognition for his indispensable contribution to this program.

The photographic part of this program was terminated in November 1962 after Moore had made several trips back to Yerkes from Tucson to obtain more plates at near-full phases of the Moon; over 1800 plates were obtained during the three-year program.

The projection apparatus for 8x10-inch transparencies of the Moon was completed during this year, but the 3-ft. diameter wooden hemispherical shell was found to be somewhat unsatisfactory because of humidity changes. It was replaced by a cast aluminum hemisphere of the same size, which proved to be excellent for the job. Various lunar areas, particularly the maria (i.e., the large dark spots), were rephotographed from points directly above their centers, thus restoring their true shapes and aiding in their study and interpretation.

More enlargements for the lunar atlas were prepared from the recently borrowed Pic-du-Midi Observatory negatives and also from the new plates obtained with the 40-inch telescope. A few two-week runs on the McDonald 82-inch telescope by Kuiper, Arthur and myself provided yet more useful negatives and visual observations. The large task of selecting, from the collection of more than 1200 prints, some 200+ prints of the 44 fields into which the lunar disk had been divided was completed by Kuiper and myself during this year. This operation alone required far more space than we had available in the NE turret, so Kuiper had the Yerkes "battleship" (i.e., the east attic, which had porthole-like windows) converted into a suite of sizable offices. At one point, the operation expanded into the cavernous basement of the 40-inch dome; numerous portable tables were set up and were quickly covered with piles of 14x17-inch prints. A preliminary selection of perhaps 300 prints was made, which were dry-mounted on heavy cardboard and protected with attached brown paper flaps. They were then provided with identification data and crop marks. Touching out dust marks and other imperfections was another time-consuming operation, performed by Tapscott and an expert hired from Chicago, F. Manning. Kuiper and I examined numerous pairs of prints with a large mirror stereoscope to detect missed image flaws. Moore collected all the plate data and computed various physical parameters, while Arthur and I dealt with overlays for feature identification, together with nomenclature clarifications, data tabulations, etc., for the explanatory booklet that would accompany the atlas. Tapscott would later have the quite onerous and responsible job of acting as liaison between Yerkes and the printers in Chicago (85 miles away), of maintaining quality control, and ensuring correct sequencing of the four prints on each sheet. I mention these details to show that the production of the atlas was indeed a major cooperative venture.

A new factor in the Lunar Project - LPL story

At this point, the close of 1959, let us turn from the flourishing Kuiper Lunar Project to some of the events that followed the successful orbiting of Sputnik I in October 1957. This event had a major effect in the U.S.—it shattered confidence in American technological supremacy. This had an electrifying effect on those in a position to rise to the challenge—the Government, the Department of Defense, the Armed Services and the top scientific organizations of the country. The story of the scramble and rivalry between the Army, Navy and Air Force to lead in the development of rocketry for extraterrestrial purposes, and of the formation of ARPA (Advance Research Projects Agency) and NACA (National Advisory Committee for Aeronautics), is a long one and need not concern us here. Suffice it to say that prior to the formation of NASA (National Aeronautics and Space Administration) in mid-1958, and in fact very shortly after Sputnik I, William H. Pickering, Director of the Jet Propulsion Laboratory in Pasadena, California, wanted to meet the Russian space challenge by sending a spacecraft to the Moon. By June 1958 he had ready a proposal (Project Red Socks) to send a series of nine rocket flights to the Moon. Definite official interest was shown in the general concept of the proposal, and the Pioneer series of missions in late 1958 and early 1959 were all targeted for the Moon or cis-lunar space. Various problems prevented any of these, or some subsequent Atlas-Able flights, from reaching the lunar surface, but several of the missions made important discoveries concerning magnetic fields and the particle streams (Van Allen belts) surrounding the Earth.

The failure of these missions to reach their prime objective, however, did little to bolster confidence in American technological leadership. In fact, confidence fell to new lows as concurrent Russian missions to or near the Moon were basically successful. Luna I, launched January 1959, passed within two diameters of the lunar surface, measuring the magnetic field and radioactivity. Luna 2 was launched 12 September 1959, and was the first spacecraft to impact the Moon. It crashed near the crater Archimedes, deployed a Russian flag, and detected no measurable magnetic field. Luna 3 was launched less than one month later; it photographed part of the previously unseen far side of the Moon and relayed the photographic images back to Earth by radio.

While the Moon missions managed by ARPA were going through their failures, NASA was building itself up. Homer Newell, Assistant Director of Space Sciences at that time, appointed Robert Jastrow to head up his newly-created Theoretical Division. In November 1958 Jastrow visited Urey, who was by that time at the La Jolla campus of the University of California, to learn what he could for his new assignment. Urey quickly apprised Jastrow of the importance of understanding the Moon, since this was the key to learning more about the Earth and the other planets. The two of them convinced Newell of the importance of lunar exploration by spacecraft; thus was born a new concept in lunar missions - the Ranger Project. We will see later that this project was destined to play a major role in boosting the reputation and aiding the expansion of LPL in the mid-1960's.

The Air Force enters the lunar cartography business

A separate consequence of the choice of the Moon as a prime objective for the first U.S. space shots was that the Air Force foresaw the need for the acquisition of improved technical data on the lunar surface and its features. The substantial funding granted to Kuiper at the close of 1957 to pursue and complete his lunar atlas project was the first implementation of this foresight. In the summer or early fall of 1959, the Air Force decided that since available maps (as distinct from photographs or atlases) were totally inadequate as support documents for the planned and future unmanned Moon shots and, looking ahead much further (as it was then thought), for any possible manned missions to that body, they should embark on a program of producing accurate and detailed maps of the Moon. The task of actually producing the maps was delegated to the Air Force Chart and Information Center (ACIC) at St. Louis.

Mapping the Moon involves the use of unfamiliar data sets and of criteria for surface feature portrayal that are different from those used in normal terrestrial cartography. The group at ACIC responsible for this mapping program discovered this pretty quickly, and it wasn't long before the Chief of the group (Bob Carder) plus a few colleagues visited us at Yerkes for help and advice, we being the only people in the country who had had several years' experience of lunar coordinate systems and of topography interpretation. We gladly assisted in all ways possible, of course, especially in those early days when all their drawn craters resembled flatbottomed cake or tart tins. This liaison flourished and remained cordial to the end. In return, ACIC assisted us materially in many ways, thereby notably enhancing the stature of LPL in its earlier days.

I should mention here that the Army Map Service (AMS) got into the Moon-mapping business at about the same time that the Air Force did, although their goals were slightly different. They hoped to produce lunar maps having contour lines at 1000-meter or even 500-meter intervals. To do this they required transparencies of lunar images in which the viewing angles differed as much as possible, permitting (they hoped) photogrammetric analysis. We gladly accommodated them at Yerkes by allowing them to copy any or all of the negatives we had obtained with the 40-inch refractor, but this in actuality was quite a small number, our program having been started up only a few months earlier. They were thus obliged to look elsewhere for a comprehensive series of plates, and ended up with eight stereo pairs selected from several thousand plates taken at the Paris Observatory during the period 1896 - 1909. These old negatives were quite grainy compared with modern emulsions and did not have sufficient resolution to accomplish the task. Nevertheless, the first maps prepared from this program appeared in 1962, but were greatly inferior to the maps drawn up by ACIC. We will see later how a review of these maps by Arthur produced a distinct souring of relations between AMS and LPL, a situation that persisted for about 15 years.

The Lunar Atlas published at last

Kuiper's participation in the preparation of the materials for the lunar atlas meant that less time was available for his other commitments and activities, despite long hours assigned to their prosecution. He therefore searched for an editorial assistant for the two series of books for which he was editor, and finally chose yet a third Britisher, Barbara Middlehurst (the fourth, if we count Lenham who had returned to England by then). The rest of the Yerkes personnel were probably wondering whether Paul Revere's ride might have all been for naught!

At the same time, preparations for the lunar atlas had reached the stage where most of the mounted photographs were ready for the printer, signaling the start of a major chore for Tapscott, who had to shuttle back and forth between Yerkes and Chicago during the miserable winter weather. Kuiper always had an eye for publicity when it would aid science, and prepublication news of the forthcoming atlas must have traveled far and wide, since shortly after Luna 3 had photographed the far side of the Moon, some of the then big names in the Russian space program (Blagonravov, Sedov and others), visited the Observatory to see our operations.

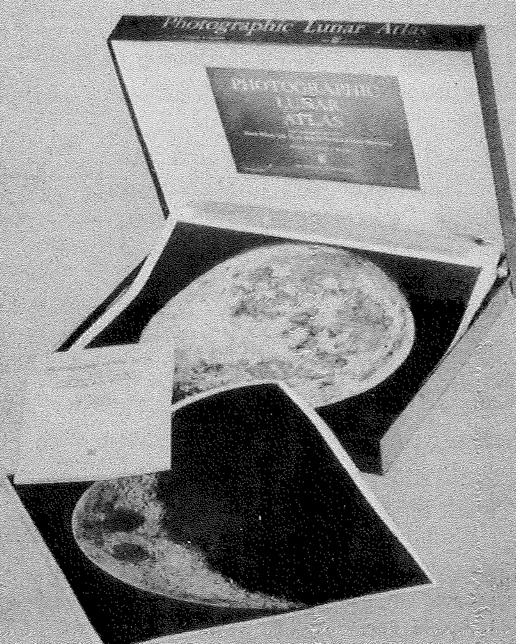
The lunar atlas finally appeared in April 1960. It was published in two versions; the one by the University of Chicago Press was loose-leaf in a box, and was intended for the general public, while the other was a postbound hardcover version for the use of the Air Force and other government agencies. Despite its awkward size (18"x22") and weight (22 lbs), the "Photographic Lunar Atlas," as it was finally titled, received very favorable reviews. It was widely distributed,

PHOTOGRAPHIC LUNAR ATLAS

based on photographs taken at the

Mount Wilson, Lick, Pic du Midi, McDonald and Yerkes Observatories

Edited by G. P. Kuiper with the collaboration of D. W. G. Arthur, E. Moore, J. W. Tapscott, and E. A. Whitaker



Five supplements to the PHOTOGRAPHIC LUNAR ATLAS are planned or are in preparation:

1. Giving the standard rectangular orthographic map grid with coordinate lines shown at intervals of 0.01 radius which will permit interpolation to 0.001 radius.

2. "Rectified" photographs of the limb areas, i.e., with the foreshortening removed by projection of the selected photographs on a large white sphere and the photography of the sphere normal to its surface.

3. Photographs of high quality of selected surface markings on double the scale of the present ATLAS.

4. Additional material and replacement of lesser quality sheets in this ATLAS.

5. More detailed nomenclature based on interpretative visual studies now being carried out at the McDonald and Yerkes Observatories.

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Advertisement and order form for the Photographic Lunar Atlas; 1960

and sold for $30 per copy. As a point of interest, I have in front of me a 1977 catalogue of antique and second-hand books, etc., from a bookseller in Liechtenstein. It offers a used copy of "this monumental lunar atlas - very rare" for 1500 Swiss francs, or $780! That amounts to an appreciation rate of over 20% per annum!

Directly following this, Kuiper asked Arthur and me to set up production of what he visualized as Supplement 1 to the Atlas. This was a direct follow-up of my earlier suggestion to provide each field of the Atlas with a coordinate grid. Arthur devised a relatively straightforward method for constructing the grid from those craters and other small features on the chosen Atlas sheets whose coordinates were already well known, using scale rulers and a flexible spline to draw the curving grid lines. This method could be used for much of the lunar disk, but the regions near the edge presented special problems, requiring Arthur to devise a method to calculate the size and shape of the grid from the computed orientation of the Moon and the scale of the printed image. At this point we hired a new assistant, Ruth Horvath, a resident of the local village (Williams Bay). I was responsible for gridding virtually all of the lunar disk out to about 0.8 of its radius, while Arthur and Horvath tackled the much more time-consuming outer edge.

Big problems with the Yerkes set-up

Backing up now to the closing months of 1959, it was becoming somewhat apparent (though certainly not obvious) that all was not well at Yerkes. Undercurrents of discontent were circulating among some of the nonlunar-oriented personnel. The trouble undoubtedly arose from the generally strong-arm tactics that Kuiper used in promoting and favoring the Lunar Project over the more traditional fields of stellar, galactic and extra-galactic astronomy. After all, in the space of just over a year he had made some fairly major structural changes within the observatory building, displacing staff, students, and sleeping accommodations from the "battleship." He had also imported three Brits, only one of whom had any kind of academic degree (Middlehurst, M.A.), and had given them almost V.I.P. status. This included several two-week runs on the 82-inch McDonald telescope, a versatile instrument for which there was never sufficient available observing time to satisfy all requests. Let me add at once that we were certainly never at any time treated as "foreigners"; we were all made very welcome by the Yerkes personnel and students.

At the same time, Kuiper was finding it increasingly difficult, even with the new editorial help, to divide his time efficiently between Lunar Project and general Solar System interests on the one hand, and the Directorship of the joint observatories and related commitments on the other. Even if he should resign from the Directorship, the prospects for being able to expand his lunar operations into something resembling his envisioned Planetary Institute were far from rosy.

First of all, Yerkes had no further available space, and the possibilities for installing any specialized equipment in the aging building, such as a long tube for obtaining the absorption spectra of gases and vapors, were virtually zero. Secondly, another major problem would be the telescope situation. While the 40-inch refractor at Yerkes was ideal for securing the necessary lunar photographs for Arthur's selenodetic program, it was generally quite unsuitable for other lines of lunar or planetary research. The average weather patterns of the location were hardly conducive to efficient operation anyway. The occasional two-week runs available on the 82-inch reflector at McDonald would certainly be inadequate for the observational needs of a separate, expanding Planetary Institute. As at that time, heavy or bulky equipment and supplies would have to be transported by car or other vehicle for the 1500 mile, 3 day journey - an expensive and time-consuming operation. Furthermore, the optics of the instrument were really not quite good enough for high-resolution lunar and planetary photography.

The whole situation clearly put Kuiper in quite a dilemma. On the one hand, the time was definitely ripe for setting up a Planetary Institute. The Lunar Project was becoming widely known for its pioneering work, both accomplished and planned, in selenography, selenodesy, and general photography and cartography of the Moon. Added to this, of course, was Kuiper's own worldwide reputation as a leading authority on Solar System astronomy. Moreover, "official" (i.e., NASA, U.S. Army, U.S. Air Force, U.S. Geological Survey) interest in the Moon was growing at an ever-increasing rate because of the "Space Race" between the U.S. and the U.S.S.R. in the field of rocketry and spacecraft. This would inevitably lead to a demand for new groundbased data on the Moon and planets and thus, presumably, to golden opportunities for receiving the necessary funding.

On the other hand, the problems at Yerkes of the burden of the Directorship, of the discontent among certain personnel, of the lack of space, and of not having a conveniently located, favorably sited precision telescope that was permanently available, clearly precluded any hopes of setting up such an institute there. Undoubtedly foremost in Kuiper's mind at this time was the question of whether or not it would be possible to transfer himself and the whole Lunar Project and editorial staff to a more favorable location. Where might such a location be found?

The southwestern U.S. begins to beckon

The overriding consideration in any tentative relocation plans was the availability of potentially favorable sites for establishing an observatory. "Favorable" refers to such criteria as accessibility at all seasons, minimal cloud cover, generally low wind velocities and atmospheric humidities, minimal occurrences of wind-borne dust, smoke and other contaminants, and also good "seeing." This last term relates to the crispness and steadiness of images formed in a telescope; poor seeing results from turbulent mixing of air currents of different temperature.

As long ago as 1730, Isaac Newton had suggested that mountaintops, with their "most serene and quiet air," would be ideal sites for astronomical observatories. While the "quiet and serene" description may be somewhat questionable, such peaks might well be expected to lie above much of the deleterious elements of the lower atmosphere. These ideas were first put to the test in 1856 when Charles Piazzi Smyth transported (with considerable difficulty!) a 7-inch refracting telescope plus mounting to an altitude of 9000 ft. on El Teide volcano, Tenerife, in the Canary Islands. His observations showed that such elevated sites could indeed be superior to those at the more normal lower altitudes. Further proof was forthcoming following the establishment of three major observatories (Lick, Mt. Wilson, Mt. Palomar) on mountains in the coastal area of southern California during the period from about 1890 to 1950, of Lowell Observatory on Mars Hill in Flagstaff, Arizona in 1896, and of McDonald Observatory in southwest Texas in 1939. Observing conditions and hours of clear skies were superior at all these sites to those at observatories located in the eastern U.S.

From these and other considerations, it was suspected that the area lying within a line bounded by these observatories and the Mexican border, i.e., basically the Desert Southwest, might yield some even better sites. Thus in the early 1950s, when the need for a major national observatory was being increasingly felt, this area was automatically selected for further study. Dr. Aden B. Meinel, a colleague of Kuiper's at Yerkes, was assigned the task of conducting this study, which commenced at the close of 1955. Of 150 possible sites chosen from a close study of aerial and rocket photographs of the whole area, five were finally selected for on-the-spot testing, four being in Arizona and one in California. This testing included making many optical and meteorological measurements at these five sites. Eventually, Kitt Peak was chosen as being the most favorable site, with the Observatory headquarters, after a temporary existence in Phoenix, being set up at the eastern edge of the University of Arizona campus in Tucson. Permission to use the site, located on the Papago Indian Reservation, still had to be obtained from the Tribal Council; this was granted (in March 1958) after the late Dr. Edwin F. Carpenter, then Director of Steward Observatory here, invited members of the Council to observe some of the heavenly bodies through the 36-inch reflecting telescope.

"There is a tide in the affairs of men, which taken at the flood, leads on to fortune; . . ." Brutus, in Shakespeare's 'Julius Caesar.'

Kuiper was, of course, fully informed on all these developments. In the late fall of 1959, the problems and restrictions at Yerkes must have finally reached the point where he felt that direct action was needed. He telephoned Meinel in Tucson. Meinel recalls the occasion and subsequent events thus:

> "While I was still Director at Kitt Peak I received a telephone call from Kuiper at Yerkes saying he wanted to discuss some ideas about planetary research. We had started a Space Division at Kitt Peak to look into planetary work and I thought he meant to propose something for Kitt Peak. We agreed to meet at the Quadrangle Club in Chicago on my next trip east. In the meantime I sounded out some opinions within the Board of AURA." (AURA stands for "Association of Universities for Research in Astronomy," a consortium charged with the management of Kitt Peak). "Some very strong negative positions were apparent. Some related the strain between Gerard and some younger members of the staff at Yerkes."
>
> "When I met Gerard he wasted no time coming to the point. He had in mind the University of Arizona. He knew that the AURA Board had some who were less than friendly, a problem that any person as dynamic as Gerard would face. Would the University of Arizona look favorably on the development of a Lunar and Planetary Laboratory? Gerard felt he would have strong support from NASA and knew of very talented persons to join the new staff. Would I be willing to approach the university administration about this thought?"
>
> "I replied that I thought Harvill and Patrick (then Coordinator of Research) would jump at the chance. I returned to Arizona the next day and immediately talked with Patrick, who did jump at the chance, and did go immediately to Harvill. Things flowed rapidly from then on."
>
> "I got quite a backlash from certain Board members who thought I should have first consulted their wishes. I also failed to consult Carpenter who I knew was not a fan of Gerard's. I was afraid that if I had done so it would have complicated what I viewed as an exceptional opportunity for the University. In view of increasing strain between me and the Board I was gratified when both Carpenter and Kuiper offered me a joint appointment so I too could join in the growing programs in astronomy at the University of Arizona, enabling me to leave Kitt Peak. The rapid growth of *both* Steward Observatory and the LPL justified my position that they were complementary and not competitive."

Kuiper and Meinel in fact met at the Dean's Luncheon, held at the Quadrangle Club on 15 Dec. 1959. As a result of Meinel's contacting both Patrick and Carpenter after his return to Tucson, an invitation was sent to Kuiper to visit Tucson during the period 14-19 Jan. 1960. A letter from Carpenter to Kuiper dated Jan. 8 reads thus:

> "Dear Gerard,
>
> The prospect of your joining our staff is at once so interesting and so unexpected that a note of some detail is in order, so that you may have a little time to formulate points which will require exploration during your visit next week."
>
> "I was of course quite astonished when Aden telephoned me promptly upon his return from Chicago. I passed the word at once to Dr. David Patrick, our Vice-President for Academic Affairs, who has been giving our search for personnel his close support and I am glad he was able to reach you by telephone." . . .

Exactly whom Kuiper conferred with during his visit to Tucson is not known, although there may possibly be some record among Kuiper's hand-written notes in the Archive. He certainly had meetings with President Richard A. Harvill, Vice-President Patrick, Ed Carpenter and also Dr. A. Richard Kassander Jr., Director of the Institute of Atmospheric Physics. Apparently Carpenter showed some reluctance to having Kuiper and his Lunar Project as a part of or an extension to Steward Observatory and the Department of Astronomy. After years of minimal recognition and of being cramped in the inadequate space of the original Observatory building, the Observatory/Dept. was at last getting a whole new building to itself, and there were plans to move the 36-inch reflecting telescope from the original building to a new site on Kitt Peak, with separate dormitory accommodations close by. No doubt Carpenter could envision his newly-found space and well-sited telescope being gobbled up by lunar insurgents before he had time to even savor them himself! The feeling was somewhat mutual in that Kuiper did not really wish to align himself with the Astronomy Department, which he considered to be a little out of touch with the current developments.

An amicable solution was soon found by affiliating the Kuiper group with the Institute of Atmospheric Physics rather than with the Astronomy Department. This Institute was also being relocated in new quarters, which were due for completion during the Summer of 1960. These would be that part of the fifth floor of the new Physics-Mathematics-Meteorology (PMM, now PAS) building that was situated east of the main staircase; there were insufficient funds (supposedly - but read on) to complete the part situated to the west of the staircase. Only the north wing of the building was being constructed at that time, at a cost of a little more than $1.3 million. Prior to the move to these new quarters, the Institute of Atmospheric Physics (IAP) personnel were occupying a group of five Quonset huts situated on the present site of the Science Library. The affiliation would be a natural one since the telescopic study of all the planets except Mercury was largely a study of their atmospheres (the surface of Mars could also be studied).

Kassander recalls the circumstances and events of the Kuiper visit thus:

> "It must have been around mid-January, 1960 when Dr. Harvill rather untypically cautiously approached me to explore whether the Institute of Atmospheric Physics might possibly be interested in providing an administrative home for Dr. Gerard P. Kuiper and a new planetary sciences oriented program, a possibility for which Dr. Harvill had been personally very much involved in order to attract Dr. Kuiper's interest in the University and he was eager to make appropriate arrangements. It seems that the Department of Astronomy and Steward Observatory felt that the science of planetology had not yet achieved a status of academic maturity which would have it appropri-

ately associated with those groups. Dr. Harvill was distressed and perplexed and turned to me, I suppose as a kind of last resort.

By a remarkable coincidence, not very long before that, the Atmospheric Physics faculty had studied its opportunities and goals and felt that a very high priority need was in the physics of the upper atmosphere and in the study of planetary atmospheres. We had approached some colleagues to join us, but had been unsuccessful. Dr. Kuiper would not have been dreamed of as a possible addition to our staff and Dr. Harvill must have felt overwhelmed at the enthusiasm with which we reacted to his cautious feeler.

Since space was terribly tight even then, we immediately turned to that practicality, it being assumed by both of us that Dr. Harvill would personally handle the budgetary details. We had only recently* moved into the Physics-Mathematics-Meteorology Building, now the Physics-Atmospheric Sciences Building. We had barely managed to squeeze into the construction budget the completion of the shell of the westernmost quarter of the fifth floor of the building. The Institute of Atmospheric Physics entertained dreams of that space but it was clearly hopeless for the foreseeable future with all of the other needs on campus. I proposed that it be finished for Dr. Kuiper. Judging from the speed of Dr. Harvill's favorable reaction, that must have been the hope that he entertained. I don't know what bargaining chip I gave up, but the generosity of University administration toward our new association proved to be such that it is hard to imagine what might have been asked for which was not provided when properly justified.

Dr. Kuiper was apparently in Tucson and waiting news of Dr. Harvill's talk with me. In a relatively few hours he and I were introduced, and soon thereafter he met the rest of our parallel faculty to his new Lunar and Planetary Laboratory of the Institute of Atmospheric Physics. Although I had been warned that I was taking on a large administrative headache, I must say that this first meeting heralded a most cordial and cooperative association which I remember vividly and will always cherish. Even those interactions we had to have which might be presumed to have been contentious were rather easily resolved in the good spirit Dr. Kuiper felt in our relationship. Perhaps the cordiality he felt after the unhappy months at Chicago immediately preceding his coming to Arizona influenced this, but if there was anything but real congeniality between the unusual mix he brought to be pushed into close association with the unusual mix we already had, I don't think he or I ever heard about it."

Here are President Harvill's recollections of that January visit:

"In the spring of 1960, Dr. David L. Patrick, who served as Dean of the Graduate College for several years and later as Director of Research, advised me that it would be well to invite Dr. Gerard Kuiper of the University of Chicago Astronomy Department to visit the University of Arizona and give a lecture or two pertaining to planetary astronomy, a field of his special study and competence. Dr. Patrick indicated the possibility of getting Dr. Kuiper to join the faculty and develop programs in the planetary sciences. Arrangements were made for two lectures.

Dr. Kuiper came by my office for a brief visit soon after his arrival, and returned again a couple of days later, on the afternoon prior to his leaving the next morning to return to Chicago. In the latter visit we had a very pleasant conversation, during which Dr. Kuiper expressed genuine pleasure in his visit. He indicated he had gained very favorable impressions of the University. He remarked: "I have thoroughly enjoyed the short time I was able to spend here, and I find the University to be a very interesting place with an atmosphere excellent for professional academic studies." I responded by saying: "Why don't you go look for a house, with a view to joining the faculty of the University of Arizona?" He replied: "Actually, I have looked at two houses, and one of them I like very much!" It was obvious that Dr. Kuiper was

*Kassander's memory is at fault here; the IAP did not move into its new quarters until mid-September 1960.

Planetary Astronomer Will Join UA Faculty

Dr. Gerard P. Kuiper, planetary astronomer, will join the University of Arizona faculty this summer or early fall as a professor of astronomy and atmospheric physics.

The announcement was made last night by Dr. Richard Harvill, UA president.

Dr. Harvill disclosed Dr. Kuiper as one of the world's greatest students of planetary astronomy. The 54-year-old scientist, now a member of the staff of the University of Chicago's Yerkes Observatory, has done considerable work on moon studies.

Dr. Kuiper, once director of Yerkes, situated at Williams Bay, Wis., and McDonald Observatory at Ft. Davis, Tex., was born in the Netherlands and became an American citizen in 1937.

He holds many honors for his accomplishments in astronomy, and has contributed to scientific journals. Dr. Kuiper also is editor of the book, "Atmospheres of the Earth and Planets."

He was a member of the operational analysis section of the Eighth Air Force in England in 1944 and the next year served on a special War Department mission to Europe.

Dr. Harvill said that Dr. Kuiper has expressed enthusiasm over the UA's geophysics program, which has been greatly expanded in recent years.

The Dutch-born astronomer holds memberships in several major science societies and is a fellow of the Royal Astronomy Society, London. He also has been decorated as a commander of the Order of Orange Nassau, a Dutch honor.

DR. GERARD P. KUIPER

UA Hires Famous Astronomer

One of the world's leading astronomers will join the faculty of the University of Arizona late this summer.

Dr. Gerard P. Kuiper, a former director of the University of Chicago's Yerkes Observatory, will bring his staff with him.

His staff currently is working at the Yerkes Observatory on a "map" of the moon. Kuiper will help launch the U. of A. into space with a study of the planets.

He will take a position both with the UA Steward Observatory and the Institute of Atmospheric Physics.

"The university is fortunate in the combination of circumstances which made it possible for us to attract a man of Dr. Kuiper's outstanding reputation — unquestionably that of one of the leading astronomers in the world," Dr. David L. Patrick, UA vice president said.

"The circumstances are the position of the Kitt Peak National Observatory here and our own research in atmospheric physics, geology, geophysics and geochemistry."

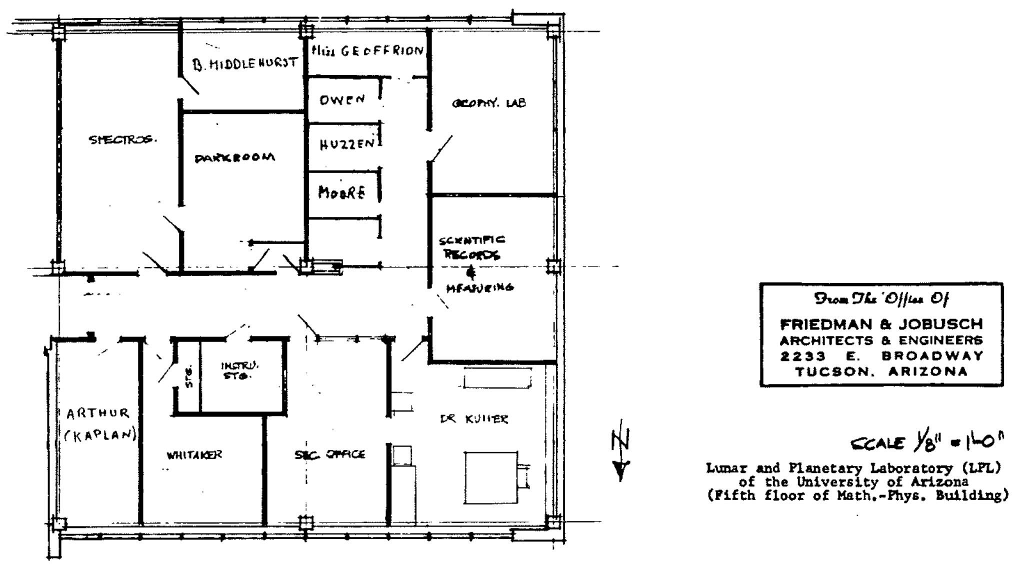
Kuiper, the author of a four-volume work on the solar system, soon will publish an atlas of the moon with pictures taken from the largest telescopes.

Kuiper, born 54 years ago in Holland, came to this country in 1933.

Newspaper cuttings announcing Kuiper's intended move to Tucson; 1960

> responding to efforts of Dr. Patrick and Dr. Weaver, and perhaps others, to interest him in joining the University of Arizona faculty.
>
> We were delighted, of course, to have him join the faculty, beginning with the first semester of the 1960-61 year. It was interesting that even before he received the formal appointment, but after arrangements had been made for him to join our faculty, I received a call one evening about ten o'clock from a reporter of the *Chicago Tribune*. He inquired: "What is all this news about Dr. Kuiper, distinguished scientist at the University of Chicago, joining the faculty of the University of Arizona?" I responded by saying that there had been no official action appointing Dr. Kuiper. He answered by saying that the morning newspaper would have the story, and the concern was that of why a man of his international distinction as a great astronomer would leave a highly distinguished institution to come to a "comparatively unknown university," as he put it. My response was simply that I could talk at great length about the interest of Dr. Kuiper in coming to the University of Arizona, as well as the interest of a great many outstanding scholars and teachers who had joined the University faculty in recent years, but that I would suggest that the best way for him to get an answer to his question would be to come to Tucson and the University of Arizona and see for himself the reasons for the interest being professed in the University of Arizona. I emphasized that this was what Dr. Kuiper had done."

While Harvill, Patrick and, to some extent, Carpenter would be involved more in the hiring procedures, Kassander had the task of setting up the physical arrangements to accommodate Kuiper and his Lunar Project staff, plus all the equipment, office files, photographic plates and other scientific records, books, etc., that would eventually be transferred from Yerkes. Once Kuiper and Kassander had been assured that funds were available to complete the 2500 sq. ft. of space at the west end of the fifth floor, they then and there divided up (on paper) the area into offices, student cubicles, spectrographic laboratory, darkroom, etc.; even tentative office allocations were made.



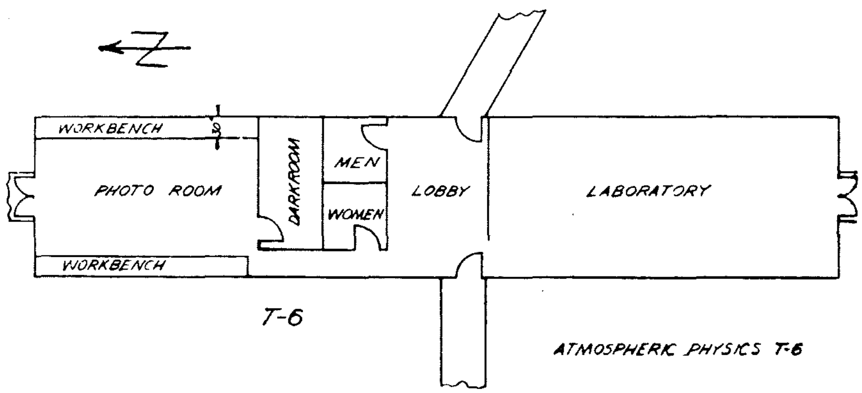
Preliminary division of floor space on 5th floor of PMM building; January 1960

In the meantime Kuiper had viewed two houses, as Harvill notes, and made a down payment of earnest money on one of them (721 N. Sawtelle Ave.). The die had been cast! Our days at Yerkes were numbered; our futures had been irrevocably changed by this, the first of a series of binding actions that would lead to our inevitable move to Tucson later that year.

Preparing for the move

Immediately on his return to Yerkes, Kuiper informed us of what had transpired in Tucson. I cannot recall either my own reactions or those of my colleagues on receiving this news. At that time we were all in the final hectic stages of preparing prints for the Lunar Atlas and seeing them through the printers, so that the impact was no doubt dulled by this activity. In any case, the need to prepare for the actual move to Tucson would not arise for another six months or so, since construction of the PMM building was not scheduled for completion before about July 1960.

At this end, Kassander immediately looked into such things as price estimates for office and laboratory equipment, and offered us one of the Quonset huts (T6) that IAP would vacate at the time of their transfer to PMM. This hut would provide an extra 2000 sq. ft., and was equipped with a small darkroom.

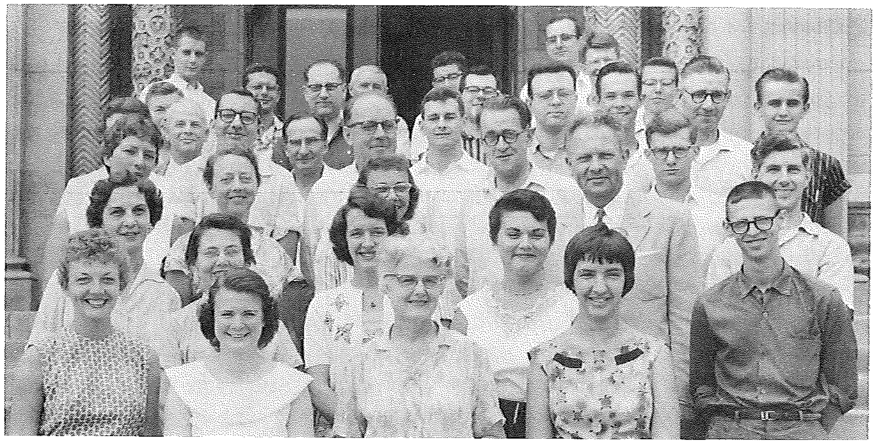


Plan of hut T-6 before renovation; 1960

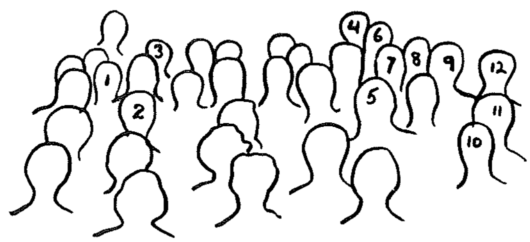
He also tentatively suggested the name "Planetary Studies Group of the Institute of Atmospheric Physics" for us. Kuiper came back at once with the alternative name "Planetary Physics Laboratory of the I.A.P.," but only four days later (1 Feb.) changed this to the "Lunar and Planetary Laboratory of the I.A.P." This was a smart move on Kuiper's part; as a "Group" we would always sound like a subset of some larger, more important department, whereas as a "Laboratory" we would convey the impression of being a separate, self-sustaining entity of some stature. This title seemed to be acceptable to all concerned. Later that month, an estimate of the moving costs was prepared: 5500 lbs. to be moved 1839 miles @ $13.70 per 100 lbs.

Kuiper tendered his resignation from the Directorship of the joint Yerkes and McDonald Observatories at about this time, the effective date being 31 March. The vacated position was taken by Dr. W.W. Morgan, a longtime member of the Yerkes faculty. As already noted, the various lunar programs continued unabated during the spring of 1960 following the publication of the Photographic Lunar Atlas. Other programs, such as the application to astronomy of a new and, for that time, extra-sensitive image-orthicon TV system (in fact, its purpose was to try to pick up faint, fast moving unfriendly satellites!), and investigations into the peculiar photometric properties of the Moon, were all run concurrently.

During this flurry of activity, another major factor in Kuiper's "tide of affairs" made its appearance. In a letter dated May 31, 1960, Hugh L. Dryden, who was Deputy Administrator of NASA at the time, invited Kuiper to serve as



1) W.W. Morgan
2) B.M. Middlehurst
3) C. Smith
4) E.P. Moore
5) G.P. Kuiper
6) C. Huzzen
7) P. Kuiper
8) W.B. Hubbard
9) D.W. Arthur
10) A.B. Binder
11) E.A. Whitaker
12) D.P. Cruikshank



Partial group of Yerkes personnel; about June 1960

a consultant on the newly-formed Planetary and Interplanetary Sciences Subcommittee, initially for a period of one year. The chairman was Homer E. Newell, Assistant Director of Space Sciences, who had already been primed by Urey and Jastrow on the great importance of lunar exploration. Kuiper accepted this invitation with pleasure, and the first meeting was held in Washington in November of that year. Although this was not Kuiper's first time of serving on a NASA committee - he had already in 1959 attended a meeting or meetings at NASA Ames on rocketry and spacecraft - it was the one that was destined to inaugurate a long and fruitful cooperation with NASA.

Various delays prevented our transfer to Tucson from starting in July, not least of which was the fact that our prospective new quarters in the PMM building were still unfinished. Finally at the beginning of August we began to pack all our equipment, supplies, books, papers, etc., into the inevitable cardboard cartons that we had managed to scrounge from local sources, mostly shops in the local village of Williams Bay. Strong wooden boxes were specially made for transporting the several hundred glass-plate negatives of the Moon, planets and satellites, and I can recall Kuiper fussing around like a concerned mother hen as we carefully loaded the precious plates into the boxes, and cushioned the gaps with corrugated cardboard. It was agreed that my family and I should be the first to leave Yerkes so that I could oversee the unloading of the first vanload of materials, and also inform Kuiper on the status of the PMM building from time to time. Personal belongings and furniture that could not be taken with us in the car (much of that would serve to keep the kids separated!) were also loaded into the van, which supposedly would be leaving directly after our departure. Separate weighings were made since we each had to pay our own moving expenses - in our case amounting to over $550 (about three weeks' salary).

THE TUCSON ERA

The Lunar Project makes the transfer

My family and I left Yerkes on 17 August 1960 complete with an overload of clothing, household goods, houseplants, etc., all crammed into our small Rambler American station wagon. Overstuffed suitcases were strapped on the roof rack. Plastic covering proved to be no match for Missouri rains, and we had to purchase a heavy tarpaulin to protect the cases and contents. We finally arrived in Tucson late on 20 August to find a dirty, uncooled house with no utilities available except water. We "slept" on car seats and the floor that first night. Betsy and the late Dr. James McDonald of the IAP kindly loaned us some essential furniture to tide us over until the van arrived (24 August).

Other members of the Lunar Project arrived at various times during September, some "camping out" in Kuiper's empty house until he and his family arrived at the very end of the month. We all became quite concerned when the second vanload of Project equipment and records, including all of the personal and household goods of the Kuiper family, failed to show up after several days. Enquiries elicited the fact that the van had broken down in Tucumcari, NM, and that it would have to remain there until the broken component could be replaced! The van finally arrived in Tucson on 6 October, and unloading started the following day. The first estimate of the total weight to be transported proved to be notably short of the actual weight, due at least in part to the inclusion of some 4000 lbs. of overrun sheets from the Photographic Atlas. We all became laborers for the day and transferred the several hundred cartons, packages, bundles, etc., partly to hut T6 and partly to our new quarters in the PMM building. Kassander recalls the following incident in connection with this operation:

> "Many, many amusing stories can be told about those days, and perhaps some one of us will coax one of the others to write the book, or perhaps there can be a tape-recorded storytelling memorial meeting instead of the usual distinguished scientific colloquium. I will burden this essay with only one such humorous episode. I don't recall how many boxes of books (hundreds) were sent by van from Yerkes. We had furnished a very nice large office for Dr. Kuiper, the most important feature of which was ample shelf space for the personal library of which he was very proud. The magic morning of the arrival of the van was at hand and, everyone was fluttering about (and I use that word advisedly) making ready for Dr. Kuiper's arrival that afternoon. Of course, that was the day the elevator broke down. It is hard to imagine the sheer panic which resulted. Too many were on the phone calling the elevator man. Fortunately I was not present, but did get a probably accurate blow-by-blow account from Dr. Battan, a person not given to upset in this sort of situation. He was finally approached and, as the director *pro tem*, against his better judgment he succumbed to the demand that he call the hitherto apparently unresponsive elevator repairman. Dr. Battan relates that he was greeted with language which I still cannot repeat, even with the permissiveness we have achieved in the ensuing twenty-five years, and was advised by the elevator man that every time he was about to leave for the job his phone rang with some new panic stricken person. Dr. Battan was given the choice of controlling the phones long enough for the man to leave or, given one more call, the repairman was going to close up shop for the day. Dr. Battan was easily up to that challenge.
>
> Of course, Dr. Kuiper arrived before the repair was completed and climbed the five flights to greet his trembling staff. Advised of the catastrophe of his not yet equipped library he announced that he knew most of what was in his books

—Citizen Photo

LUNAR LAB MOVING IN

The University of Arizona got the only lunar and planetary laboratory in the country today when 14,000 pounds of books, papers and instruments were unloaded on the campus. The director is the world famous astronomer Dr. Gerard P. Kuiper, who is moving here from the University of Chicago's Yerkes Observatory of which he is a former director. Kuiper (second from left) is shown here with his three English assistants who join him from Chicago (left to right) David Arthur, Miss Barbara Middlehurst, and Ewen Whitaker. Kuiper will work partly in the Institute of Atmospheric Physics and partly in the Steward Observatory.

Lunar Lab moving in; October 1960

anyway and would use the opportunity to find out what was in the UA Library! I am not sure whether at least one of his staff has recovered yet."

I cannot honestly recall this particular incident myself, and I am sure that none of us was "trembling," because even though we all had a very high regard for Kuiper's abilities and stature, we looked upon him as a colleague since he had always treated us as colleagues and never as underlings.

Final inspection of the fifth floor of the PMM building (Physics and Mathematics had already recently moved into their section) occurred on about 12 September 1960, and Kassander and the IAP transferred from the Quonset huts immediately afterwards.

The LPLIAP gears up for action

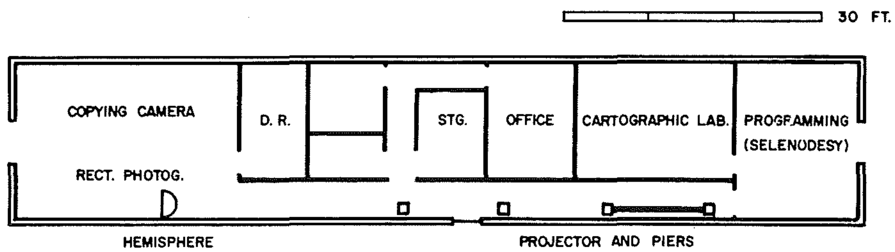
As I noted earlier, the full title of our newly-relocated unit was the Lunar and Planetary Laboratory of the Institute of Atmospheric Physics - quite a mouthful to say the least. We were all, of course, totally unconversant with the general procedures in the University, and our affiliation with IAP was absolutely crucial to our ability to get set up and to function as a separate unit. The very first LPL staff list is reproduced herewith. All but two of the listed people (graduate student assistants Geoffrion and Owen) had transferred from Yerkes; Gail Moore had not been a member of the Lunar Project there, although she had assisted her husband frequently while he was pursuing the Arthur program of lunar photography with the 40-inch refractor. Note that we had no telephones in our PMM offices at the time the list was prepared, a condition which persisted for some time. Note also that existing phones were only low 3-digit extension numbers of the main University number! Even the city had only three major telephone exchanges in 1960; EAst, MAin, and AXtel.

An interesting situation arose right at the outset. The State had a regulation that aliens could not be employed by the University, a regulation that was intended to prevent the hiring of illegally-entered Mexicans. Arthur, Middlehurst and I at least were legal aliens, so although we all received contracts, they were endorsed ". . . at zero salary." Mainly because of us, the regulation was rescinded in November 1961, and we were placed on the University payroll the following April, thereby finally severing our affiliation with the University of Chicago.

LUNAR AND PLANETARY LABORATORY PERSONNEL
FALL 1960

NAME	P.M.M.	ADDRESS	SPOUSE	PHONE	STEWARD	EXT.
ARTHUR, David W.G.	502A	3130 East Bray Road	—	—	—	—
GEOFFRION, Ann R.	502J	842 East Lester	—	—	124	249
HORVATH, Ruth		Maricopa Hall Campus	—	MA3-9477	—	—
HUZZEN, Carl	502H	1431 Benson Hwy Intermountain Motel	—	—	—	—
KUIPER, Gerard P. Research Professor	502E	721 North Sawtelle	Sarah	EA6-6998	208	288
MIDDLEHURST, Barbara M. Editorial Assistant	None	1202 East Drachman	—	None	122	448
MOORE, Elliott P.	502Q	1717 East Mitchell St.	Gail	None	101B	249
MOORE, Gail A. Secretary	502D	1717 East Mitchell St.	Elliott	None	—	—
OWEN, Toby	502K	816 East Drachman	Lynn	MA3-0679	101B	249
WHITAKER, Ewen A.	502B	5514 East 1st Street	Beryl	AX8-8977	—	—

First LPL personnel list; Fall 1960



Plan of hut T-6 after renovation

Some changes and renovations were made to hut T6 so that it would accommodate the 3-foot hemisphere and projection apparatus for the rectification of lunar images, and also to provide enough space for Arthur's current and planned lunar cartographic and cataloguing operations. Arthur selected a number of Dover paperback books, mostly on mathematical subjects that would be of general use, thereby forming the nucleus of what would gradually become the indispensable departmental reference library and document collection that it is today. At about the same time I ordered equipment and supplies to outfit the darkrooms in PMM and T6 adequately for their intended usage.

Because of NASA's increasing commitment towards the planning of various types of missions to the Moon, an early and urgent task was to publish those sheets of the Photographic Lunar Atlas on which we had drawn accurate grids of lunar coordinates. At that time (October 1960) this amounted to all but the very edge regions of the lunar disk, which were still being worked on by Arthur and Horvath. The gridded sheets plus the original negatives used in making the printing plates had, prior to our leaving Yerkes, been shipped to ACIC at St. Louis, who did a remarkable job in producing precision grids from our comparatively coarse-lined pencil-drawn grids. It was decided that the University of Arizona Press would publish the collection under the title, "Orthographic Atlas of the Moon, Part 1 (Central Area)," and that the printing would be carried out by a local printer of good reputation, Shandling Lithographing Co. of Tucson.

Because the correct placement of the grids on the photographs was of paramount importance, a close liaison was maintained with the printers throughout, which is just a nice way of saying that they probably uttered silent groans when we appeared on the scene to check up on their registration of the grid on every sheet. The printing was completed in December 1960, and copies of the atlas, which sold for a mere $9, were available the following month. Since positions of lunar features could be read off with an accuracy of one-half mile or better, whereas previous hand-drawn maps had misplacements of up to 50 or 100 times as great, this atlas at once became the standard. It was used extensively by ACIC and other agencies as a basis for producing accurate maps and charts of the Moon, as may be seen from the acknowledgments appended to each sheet of the "LAC," "LEM," and other series of maps. These maps were widely used by NASA and the U.S. Geological Survey for the planning and operational stages of various lunar missions, and for the geological mapping of the lunar surface respectively.

New programs and new faces

By the first quarter of 1961 we were feeling pretty much at home in our new surroundings, thanks to the very friendly and helpful attitudes of the IAP personnel in particular and just about everyone in general. The opportune

Aerial view of part of campus showing LPL locations; about early 1962

publication of the first half of the Orthographic Atlas had brought some favorable publicity, which Kuiper was quick to distribute to NASA brass. The program of projecting lunar transparencies onto the 3-ft. precision hemisphere was started up in earnest in hut T6; Arthur's selenodesy program got under way again, with Moore slated to take periodic trips to Yerkes to obtain further plates of full Moon with the 40-inch refractor; and occasional runs on the McDonald 82-inch reflector for high resolution lunar photography were scheduled. Arthur also initiated a program to revise, update and expand the only official catalogue and map of lunar nomenclature that was extant at that time - "Named Lunar Formations," published in 1935 by the I.A.U. - which was known to contain many errors. The editorial program had resumed in an office in the new Steward Observatory building, kindly put at our disposal by Carpenter.

Having been relieved of the burden of the Directorship of the Yerkes and McDonald Observatories, Kuiper was able to concentrate on expanding the Lunar Project into a full-fledged organization devoted to Solar System research. The basic aims of LPL, as enumerated by Kuiper himself, were:

Aims and Objectives of the Laboratory

The purpose of organizing the Lunar and Planetary Laboratory at the University of Arizona in the fall of 1960 was to create, in a favorable academic setting, a research and teaching unit concerned with the study of the Moon and the planets. Favorable has reference to (a) the presence of research scientists in supporting fields, such as meteorology, geology, geochemistry, physics, and electrical engineering; (b) clear skies, low humidity, accessibility to modern telescopes and electronic computers; (c) proximity to national laboratories and industrial facilities; (d) a well-developed or developing graduate school; (e) proximity to interesting geological terrain features for comparative studies of Moon and Earth.

The group was to be concerned with (1) research; (2) publication of major collections of scientific records; (3) graduate instruction and Ph.D. programs.

The need for such a university group had become increasingly apparent for some years. The recently accelerated national space programs with their scientific and personnel requirements made the execution of these plans timely.

By the summer of 1961 we had graduated to a fully self-sustaining entity, thanks to the excellent support provided by the IAP personnel, and we were able to dispense with the "of the Institute of Atmospheric Physics" portion of our title. Later that year, NASA's Space Science Steering Committee appointed Kuiper, together with Eugene M. Shoemaker of the U.S. Geological Survey and old sparring partner Harold Urey, as experimenters to analyze and interpret close-up television pictures that hopefully would be obtained from a series of impacting spacecraft that would be targeted for specific locations on the Moon's surface. This was the "Ranger" series of missions, a pioneering project which, after several disappointing failures, ended with three resounding successes and, as we shall see, with kudos for Kuiper and the LPL in general. Earlier that year, Kuiper had also been asked to serve on another lunar spacecraft project committee, in this case for the "Surveyor" project of soft-landing probes, but progress here was much slower than with the Ranger project due largely to problems in development of the Centaur rocket needed to boost the heavier Surveyor into orbit.

Kuiper also began to receive funding from NASA that year, permitting the hiring of extra personnel and the launching of the new projects and programs noted earlier. Another major project was the planning for a precision 60-inch reflecting telescope and other smaller instruments to carry out these programs. Kuiper had to face such major problems as finding the necessary funding for the telescopes, their buildings, and subsequent maintenance, to say nothing of finding suitable available sites for locating them. Such obstacles totally failed to daunt Kuiper, who had an enormous capacity for setting things in motion and seeing them through to completion. Our first telescope would be a 21-inch reflector, funded by a grant from the Naval Ordance Test Station, China Lake, CA., to act as a pilot instrument for testing new auxiliary equipment. The original plan was to set it up in the grounds of the university's Geochronology Laboratory, located half way up Tumamoc Hill just west of the city, but subsequent events permitted its siting high in the Santa Catalina Mountains.

By the close of 1961, research programs in the following categories were being pursued:

(a) Lunar Studies. Cartography and the production of atlases and position catalogues; selenodesy (the equivalent on the moon of geodesy); theory of the moon's rotation and librations; systematic lunar photography; tectonic surface studies—visual and photographic; polarization studies with broad wavelength coverage; associated laboratory and geomorphological studies; and nomenclature.

(b) Planetary Atmospheres. Planetary spectroscopy; IR spectrophotometry in the PbS region (1-3 μ), and beyond; associated laboratory studies of atmospheric gases; polarization studies, cloud phenomena; composition and photochemical studies. A number of recently discovered but as yet unidentified band systems are under study (Jupiter, Uranus, Neptune). Special emphasis will be placed upon laboratory studies of the greenhouse effect in the Venus atmosphere.

(c) Satellite Systems. Photography of the satellites of Mars, Jupiter, Saturn, Uranus, and Neptune; orbit determinations. Planetary dynamical oblateness;

satellite masses for Saturn and Uranus. Satellite diameters, densities, compositions. Surface properties (color, polarization variability with rotation, ice deposits on the outer satellites).

(d) Asteroids. Continued studies of asteroid light curves for determination of shapes, orientation of axes of rotation, and deviations from simple periodicity. Variability of polarization with rotation. Asteroid survey to 20th magnitude, for determination of numbers and space distribution of fainter asteroids. Collisional production of smaller asteroids and meteorites.

(e) Zodiacal Light. Polarization - wavelength dependence.

(f) Stellar Spectra, especially in the IR.

(g) Stellar Photometry and Polarization.

(h) Development of IR Instruments, in particular photometers and spectrophotometers, using commercially available photoelectric and photoconductive cells and, later, a germanium bolometer now under development at Texas Instruments Company, which is a detector of greatly increased sensitivity in the region of 1-1000 microns (but requiring a complex cooling technique at about 1° K).

(i) Development of Powerful IR Telescopes, with reduced tolerances appropriate for the IR.

(j) Development of a Spectroscopic Laboratory, for associated stellar studies: IR spectra of metallic oxides and hydrides (in an effort to identify a number of newly-discovered band systems in the cooler stars).

(k) The development of equipment for detection and analysis of extremely *tenuous planetary atmospheres* (Moon, Mercury).

(l) Development jointly with the Institute of Atmospheric Physics of *balloon-borne* planetary observations, for UV polarization studies and IR spectroscopy.

(m) The development of equipment to detect *very faint emissions* from planetary atmospheres (Venus, Mars).

(n) Mr. Kuiper and Mr. Gehrels have been appointed Experimenter by NASA on lunar and planetary projects, respectively.

Note that categories (f), (g) and (j) are not Solar System studies at all; the main reason for their inclusion was that the instrumentation required and still to be developed for planetary programs (e.g., I-R spectrometry, photometry, polarimetry) would be equally applicable to stellar programs, and we then had the leading expert in the field of stellar photometry, the late Dr. Harold M. Johnson, as a member of our research staff.

By the beginning of 1962, little more than a year after getting ourselves set up on the campus, the personnel of LPL had tripled to 30, with consequent strain on our available space. The list was as follows, the letters following each name indicating broadly the research interest in the programs listed earlier:

Dr. Gerard P. Kuiper, Director and Research Professor *(a,b,c,d,f,h)*
Dr. Aden B. Meinel, Research Professor† *(b,f,i,j,m)*
Dr. Harold L. Johnson, Research Professor *(g,h,i)*
Dr. Tom Gehrels, Associate Professor‡ *(a,b,c,d,e,g,l)*
Dr. Stuart Hoenig, Associate Professor, part time *(b,k)*
Miss Barbara Middlehurst, Research Associate *(f,j)*
Mr. David Arthur, Research Associate *(a)*
Mr. Ewen Whitaker, Research Associate *(a,c)*
Mr. Alika Herring, Research Associate *(a)*
Mr. Richard Mitchell, Research Associate *(g,h)*
Mr. Richard Goranson, Research Assistant *(b,h)*
Mr. Thomas Teska, Research Assistant‡ *(e,g,l)*
Mr. Tobias Owen, Research Assistant *(b,j,m)*
Mr. Harold Spradley, Research Assistant *(a)*
Mr. William Hartmann, Research Assistant *(a)*
Mr. Elliott Moore, Research Assistant *(a)*
Miss Ann Geoffrion, Research Assistant *(a)*

†Joint appointment with Steward Observatory.
‡ Joint appointment with Institute of Atmospheric Physics.

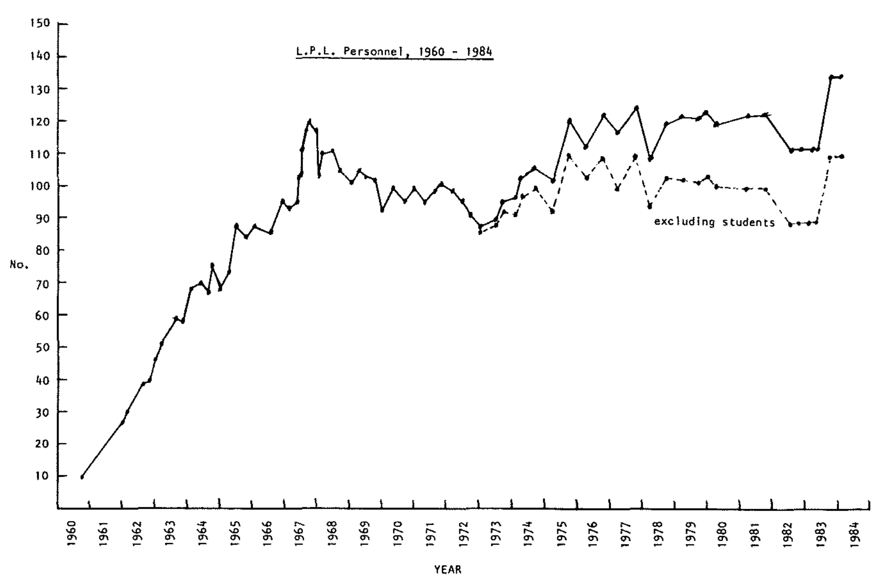
Mr. Carl Huzzen, Research *(a)*
Mr. Alan Binder, Research Assistant *(b)*
Mr. Donald Collins, Research Assistant *(b,k)*
Mr. Dale Cruikshank, Research Assistant *(b)*
Mr. Dwight Hoxie, Research Assistant *(b,f,j,m)*

Most of the research assistants are on half time, pursuing also a graduate program; Mr. Goranson and Mr. Spradley are full-time assistants. Secretaries are Mrs. D. Heisler, Miss C. Morris and Mrs. S. Marinus (office); and Mrs. C. Norman (editorial); while Mrs. Alice Fabe, Miss Patricia Mitchell and Mr. Charles Wood assist in the lunar reduction program; Mr. Pellicori in the balloon project; and Mrs. Fabe in drafting.

Yet another project was the commencement of a series of publications, named "Communications of the Lunar and Planetary Laboratory," designed to promulgate shorter reports, announcements, bulky tabular material, etc. The first issue appeared in about March 1962, and the series flourished for about 12 years, when changing conditions made it more economical to publish in the established journals. Number 1 of the series was authored by Kuiper and consists of a comprehensive review of the status and activities of LPL at the beginning of 1962; some of the foregoing material was taken directly from that 20-page article, to which reference is recommended for a more detailed treatment.

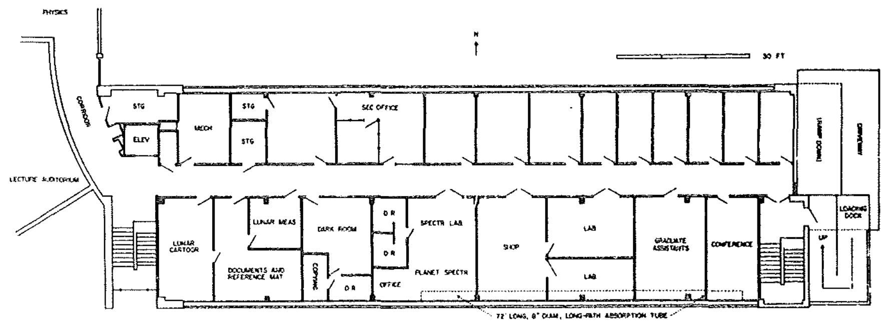
Five more years of expansion

The increase in personnel and consequent activity that took place in 1961 continued at an almost constant rate until about the autumn of 1967, when the total of all personnel peaked at 119. Obviously our 4500 sq. ft. of floor space could not even begin to support such numbers; so where did the extra area come from? Even the 30 persons listed above could not all be accommodated in the available space; the Mathematics Dept., located on the fourth floor of the PMM building, kindly made available to us the 2500 sq. ft. area situated directly below our own fifth floor location, while others were accommodated in a room in the basement of the building, loaned by the Physics Dept.



Graph showing number of LPL personnel and students

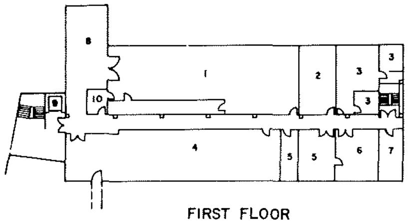
Hut T6 was vacated and, together with the three other similar huts on the site, dismantled in about mid-1962 to make room for the new Science Library. The lack of space was, of course, foreseen by Kuiper, and at about the same time the Physics Dept. needed more room to house a projected Van de Graaff generator; these requirements may have triggered the addition of the south wing to the PMM building, although the building had been designed to accept such an extension in the first place. The upper (second) floor was available for our occupation towards the end of the year. This gave us 8000 sq. ft. of floor area, about a third as much again as we had previously, but needless to say, the fact that we were all together in one building, and on one floor to boot, made for notably greater efficiency.



Plan of LPL premises in south wing of PMM building; 1962

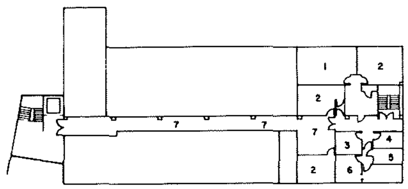
The following year (1963) we again breached our boundaries in order to accommodate a large machine that could grind and polish large telescope mirrors, since Kuiper considered that it would be easier in the long run to achieve optical perfection with an in-house production than to entrust the operation to an external shop. This and some other smaller machines were installed in an empty shop at 1530 E. Broadway, one half mile south of our campus location. The 3-ft. diameter hemisphere and projection system for rectifying lunar images was also again set up at the same place.

Adding new personnel at the average rate of 15 per year, it was not long before we were feeling the pinch in our new location, and some people were obliged to transfer to a small empty shop at 1019 E. 6th Street. This soon proved to be inadequate, and much more spacious premises were occupied at 2026 E. Broadway. This was clearly only a stopgap measure to alleviate what would obviously be a recurrent problem. In October 1963 Kuiper wrote a proposal to add another floor above our existing premises in the PMM south wing, but this apparently failed to materialize. Because the lack of space was beginning to hamper LPL's commitments to NASA programs, on 15 May 1964 Kuiper wrote a much more ambitious proposal to NASA requesting funding for a completely new Space Sciences building to house not only LPL but also portions of Departments having Space-related programs. The proposal was for a five-story structure with about 51,600 sq. ft. of floor area, the cost estimated to be in the neighborhood of $1,200,000. It would be located near the south-west corner of Hawthorne Street and Warren Avenue, both of which were uninterrupted residential streets at that time. The funding was indeed approved and the contract awarded to the W.F. Conelly Construction Co. with a low bid of $1,121,351. The architects were William Wilde and his partner Dennis Brizee. Construction got under way in 1965 (thus 1985 marks the 20th anniversary of this event) and was complete by early Fall, 1966.



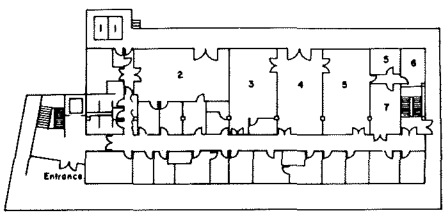
FIRST FLOOR

1. Optical Shop
2. Lunar Model Room
3. IR Labs.
4. Building Heating and Cooling Equipment
5. LPL Publications
6 Instrument Storage
7. Plate Vault
8. Optical Shop Loading and Storage Area
9. Elevator
10. Optician's Office



MEZZANINE

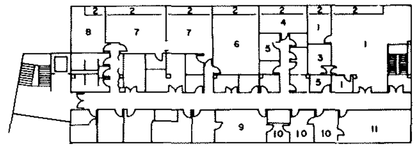
1. Main Office, Photography
2. Darkrooms
3. Office
4. Film Storage
5. Mann Measuring Machine
6. Automatic Processing
7. Globe Projection Tunnel (Moon, Planets)



SECOND FLOOR

1. Loading Dock to Optical Shop
2. Polarimetry Lab.
3. Electronics Lab.
4. Machine Shop
5. IR Lab.
6. IR Detector Production
7. IR Test Lab.

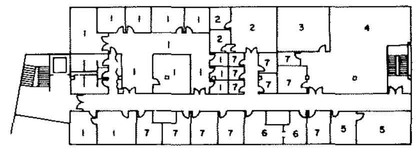
Un-numbered: LPL Offices



THIRD FLOOR

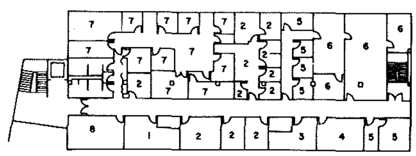
1. Physics Lab.
2. 130-ft. Long Absorption Tube
3. Darkroom
4. Editorial Office
5. Orbiter and Apollo Documents Storage
6. Conference Room
7. Library
8. Drafting Room
9. LPL Main Office
10. LPL Executive Offices
11. Director's Office

Un-numbered: LPL Offices



FOURTH FLOOR

1. Astronomy Lab. and Offices
2. Optical Sciences Lab.
3. Lunar Crater Studies
4. Computer Room
5. Planetary Sciences
6. U. S. Naval Liaison Office
7. LPL Offices



FIFTH FLOOR

1. Smiths. Astr. Obs. Office
2. LPL Lab. and Offices
3. LPL Chemistry Lab.
4. Graduate Students
5. Geochronology Offices
6. Geochronology Labs.
7. Psychology Lab. and Offices
8. Lecture Room

Plans of six floors of Space Sciences building, as of 1966

I mentioned that the preliminary plans called for five floors. They also allotted an unimaginatively small space, somewhere on the third floor, for a darkroom complex. I had been in charge of darkroom operations since Yerkes days, and I can recall pointing out to Kuiper, probably not without at least a hint of acrimony, that other operations were all being allotted considerably expanded space why not the darkrooms too? He agreed, and asked me to design a minimal complex. This I did, but only at the expense of adjacent offices and laboratory rooms. The situation was clearly quite unsatisfactory, so we called in Brizee to see what might be done. He soon solved the problem by noting that there was nothing to stop us from adding a partial floor and connecting corridor halfway between the basement and the ground (second) floor; this would provide another 2700 sq. ft. or so of floor area plus adequate space in the corridor for the lunar globe projector. What an excellent solution! Brizee and I sat down then and there and laid out plans for a truly spacious darkroom complex, based on the current and immediately foreseeable needs. The squeaky wheel certainly gets the oil! The diagram shows the floor plans and allocations as of the first few years of operations. Many structural and allocational changes have taken place since that time.

PROGRAM

THURSDAY, JANUARY 26

9:30 a.m. SESSION I — Student Union Junior Ballroom

Presiding: Dr. Richard A. Harvill
President of the University

A. GREETINGS AND CONGRATULATIONS FROM:

I. The Governor of Arizona

II. Arizona Board of Regents:
Mr. George Chambers, President

III. The National Aeronautics and Space Administration:
Dr. Homer Newell
Associate Administrator for Space Science Applications

IV. Industry:
Dr. C. L. Hogan
Vice President, Motorola, Inc.

B. Address: SPACE SCIENCE AND PUBLIC POLICY
Dr. Frederick Seitz
President, National Academy of Sciences

1:45 p.m. SESSION II — Main Entrance, Space Sciences Building

DEDICATION CEREMONY

Presiding: Dr. David L. Patrick
Coordinator of Research, University of Arizona

2:00–2:45 p.m. INSPECTION OF SPACE SCIENCES BUILDING

3:00 p.m. SESSION III — Steward Observatory, Room 102

Presiding: Dr. Bowen C. Dees
Vice President, University of Arizona

SPACE SCIENCE PROGRAMS IN ARIZONA –

I. At the Kitt Peak National Observatory:
Dr. Nicholas U. Mayall, Director

II. At the Lowell Observatory:
Dr. John S. Hall, Director

III. At the Astrogeology Branch of the U.S. Geological Survey:
Dr. Eugene Shoemaker, Director

IV. At the Smithsonian Astrophysical Observatory:
Dr. Fred L. Whipple, Director

V. At the University of Arizona –
– In the Lunar & Planetary Laboratory:
Dr. Gerard Kuiper, Director
– In the Steward Observatory:
Dr. Bart Bok, Director
– In the Steward Observatory's Optical Sciences Laboratory:
Dr. Aden Meinel, Director
– In all other areas:
Dr. Albert B. Weaver
Chairman of the University's Space Sciences Committee

CONSTRUCTION OF THE SPACE SCIENCES BUILDING AT THE UNIVERSITY OF ARIZONA WAS MADE POSSIBLE BY A GRANT FROM THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.

Associated with these dedicatory exercises is a Symposium on the Lunar Surface, which is scheduled to extend for two days, January 27–28, 1967. An abbreviated version of the program for this symposium is presented on the following page.

SYMPOSIUM ON THE LUNAR SURFACE
Room 102
Steward Observatory

FRIDAY, JANUARY 27

9:00 a.m. Opening of the Symposium
Dr. Gerard Kuiper
Director, Lunar and Planetary Laboratory
University of Arizona –
Chairman of the Symposium

SESSION I — THE GROSS FEATURES OF THE LUNAR SURFACE
Presiding: Dr. Eugene Shoemaker
USGS

2:00 p.m. SESSION II — SURFACE STRUCTURE FROM TELESCOPIC RADIATION MEASUREMENTS
Presiding: Dr. Frank Low
University of Arizona and
Rice University

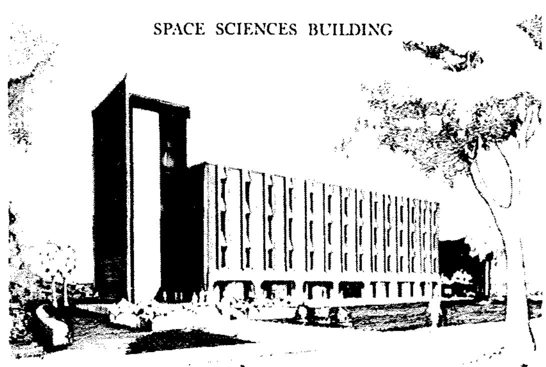
SATURDAY, JANUARY 28

9:00 a.m. SESSION III — RESULTS FROM PHOTOGRAPHIC SPACE PROBES AND SOFT LANDING VEHICLES
Presiding: Dr. Homer Newell
NASA

2:00 p.m. SESSION IV — COMPARISONS OF TERRESTRIAL AND LUNAR SURFACE STRUCTURES
Presiding: Dr. John Salisbury
USAF

Persons interested in the topics to be discussed at this symposium are invited to apply to the Lunar and Planetary Laboratory, University of Arizona, for an admission card.

DEDICATION
OF THE
UNIVERSITY OF ARIZONA
SPACE SCIENCES BUILDING



TUCSON, ARIZONA
JANUARY 26, 1967

Program for dedication of Space Sciences building, January 1967

Whitaker

SYMPOSIUM:
THE LUNAR SURFACE
Fri, Sat, Jan 27-28, 1967
9-12 AM, 2-5 PM, Steward Observatory, Room 102

Opening of the Symposium, G. P. Kuiper
Remarks by Mr. Oran Nicks, NASA

I.	THE GROSS FEATURES OF THE LUNAR SURFACE	
1)	Role and Potentialities of Earth-Based Observations	G. P. Kuiper
2)	The ACIC Lunar Mapping Program	W. Cannell
3)	The USGS Geologic Mapping Program	D. Wilhelms
4)	Figure of the Moon and Selenodesy from Earth-Based and Satellite Data	D. Eckhardt, D. Arthur
5)	The Reverse Side of the Moon, I. USSR Data	A. A. Mikhailov
6)	The Reverse Side of the Moon, II. Orbiter Data	W. E. Brunk
7)	Measures, Classifications, and Nomenclature of Telescopic Lunar Craters	D. Arthur
8)	The Gross Features of the Lunar Maria	G. P. Kuiper, R. Strom
II.	SURFACE STRUCTURE FROM TELESCOPIC RADIATION MEASUREMENTS	
9)	Photometry and Polarimetry Observations	T. Gehrels
10)	Photometry and Polarimetry, Laboratory Comparisons	C. E. KenKnight
11)	Color Maps of the Moon	E. Whitaker
12)	Infrared Spectral Measurements	J. Salisbury
13)	Hot Spots and Other Thermal Anomalies	J. M. Saari, R. W. Shorthill
14)	Thermal Properties from Far IR Observations	F. Low
15)	Review of Radar Results	T. Hagfors
16)	Lunar Eruptions and "Events"	B. Middlehurst
III.	RESULTS FROM PHOTOGRAPHIC SPACE PROBES AND SOFT LANDING VEHICLES	
17)	Results from Luna Series	A. I. Lebedinsky
18)	Results from Ranger Series	G. P. Kuiper, E. Whitaker, R. Strom
19)	Results from Surveyor I	L. Jaffe, E. M. Shoemaker
20)	Results from Orbiter Series	L. C. Rowan
21)	Potentialities of Future Lunar Missions	P. E. Culbertson
	SURFACE STRUCTURE FROM SPACE PROBES	
22)	Mare Structure, I: Lineaments, Ridges, Rilles Faults, Domes	R. Strom
23)	Mare Structure, II: Craters, Depressions	G. P. Kuiper, E. Whitaker
24)	The Crater Copernicus	J. Green
IV.	TERRESTRIAL AND LUNAR SURFACE STRUCTURES COMPARED	
25)	Impact Experiments in Laboratory and Field	D. Gault, W. L. Quaide
26)	Identification and Frequency of Terrestrial Meteorite Craters	M. Dence
27)	Impact Rates of Meteorites on Earth and Moon	M. Dubin, F. Whipple
28)	Interpretation of Lunar Crater Counts, I, II	W. Hartmann, R. Le Poole
29)	Large Endogenic Circular Structures	W. Elston
30)	Geophysical Observations and Experiments	H. Dole, W. Dobar
31)	Chemical Fractionation in the Solar Nebula	J. Larimer
32)	Evolution of Earth-Moon System	G. P. Kuiper

Program for two-day symposium to mark dedication

Although we had completed the move into our spacious new quarters by about October 1966, dedication ceremonies were not held until the following 26 January. These were followed by a two-day symposium on the subject of the lunar surface, presented by LPL personnel and guest speakers. The brochure and list of symposium speakers are reproduced herewith. The three Italian cypress trees situated in front of the building, which blend in so well with the building's higher western portion, were transplanted from the front garden of a vacated house on the south side of 3rd Street (now the south lane of the Mall) just west of the intersection with Martin Ave.

Gerard Kuiper died on 24 December 1973, and as a tribute to the singular role he played in procuring the building, it was renamed the "Gerard P. Kuiper Space Sciences" building at a ceremony in April 1974.

LPL growth in other directions and areas

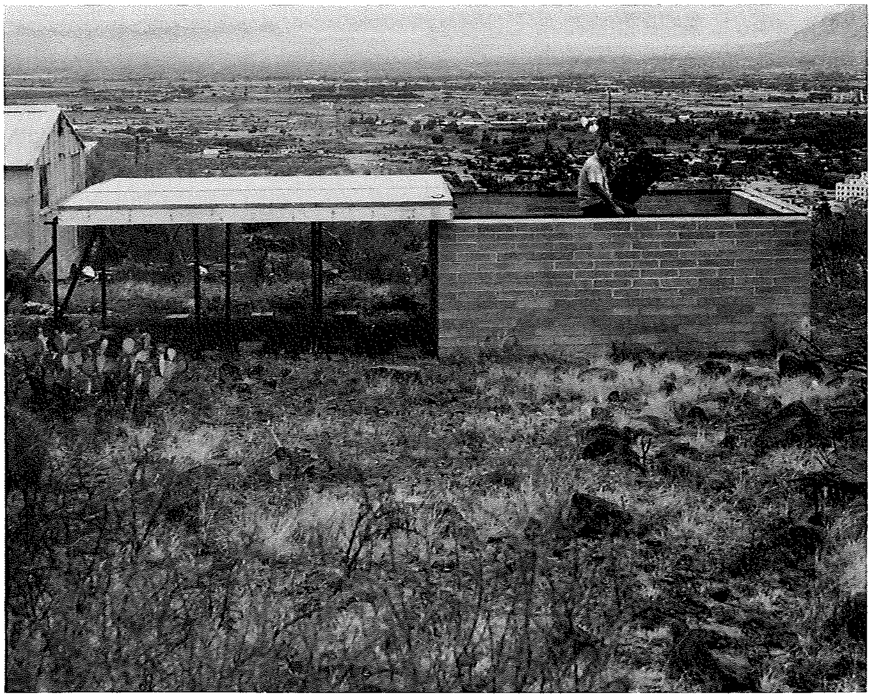
We have jumped ahead of ourselves by singling out the growth of our campus facilities and complement of personnel, but so many different projects and programs began in 1961-1962 that it no longer makes sense to treat the overall spectrum of operations in chronological sequence. I will therefore place these various operations into the following categories, and deal briefly and, in some cases, quite incompletely (as noted in the Foreword) with each.

a) telescopes and site-testing programs
b) involvement in NASA missions
c) lunar programs
d) polarization programs and balloon flights
e) planetary atmospheres and I-R programs from aircraft
f) planetary photography; comets; satellites
g) stellar photometry programs
h) editorial, publications
i) teaching, formation of Planetary Sciences Dept.
j) construction, shops, design, maintenance
k) office, secretaries, library

a) Telescopes and site-testing

I mentioned earlier that our first telescope was to be a 21-inch reflector; it was designed by Harold Johnson with a view to low fabrication and maintenance costs, following his design for a similar successful instrument at Lowell Observatory, Flagstaff. The main LPL instrument was to be a 60-inch Cassegrain reflector of conventional design, but with the optical figures of the mirrors to be as near perfection as humanly possible. Also, a 28-inch reflector would be added shortly after the 21-inch was in operation. A separate project was the design and production of large telescopes with reduced tolerances for infra-red programs; problems encountered in making large metal mirrors limited this project to one 40-inch and two 5-ft. (to distinguish them from the optical 60-inch) reflectors.

The task of finding and acquiring a site or sites for these instruments was an early one that Kuiper had to face. On Kitt Peak, AURA needed all the available space for foreseeable developments, while the small area assigned to Steward Observatory was too restrictive. The highest peak in the nearby Santa Catalina Mts. (Mt. Lemmon) was occupied by an Air Defense radar station, while the second highest peak (Mt. Bigelow) was surmounted by TV towers and a Forest Service fire lookout post. Undaunted, Kuiper chartered flights in a small aircraft and flew at various altitudes over these and other areas of the Catalinas, also over Kitt Peak, the Santa Rita Mts. south of Tucson (now the site of the Fred L. Whipple Observatory with its Multi-mirror telescope - Whipple chose this site for the establishment of an observatory for the Smithsonian Institution largely on the recommendation of Kuiper), the Graham Mts. southwest of Safford (now selected as the site for the planned Sub-Millimeter Telescope), and other fairly nearby peaks. He took note of such factors as air turbulence, ground cover (trees, scrub), general absence of haze and smelter smoke, and so on. He also studied such records of rainfall, cloud cover and general climatic data as were available, and weighed these factors in conjunction with the following criteria: a) relative closeness to the campus, b) accessibility during winter snows, c) sufficient altitude to lie above the average level of the inversion layer (i.e., the upper boundary of the haze and dust layer that lies in the surrounding valley), and d) low values of average water vapor content of the atmosphere above the site, important for I-R programs.



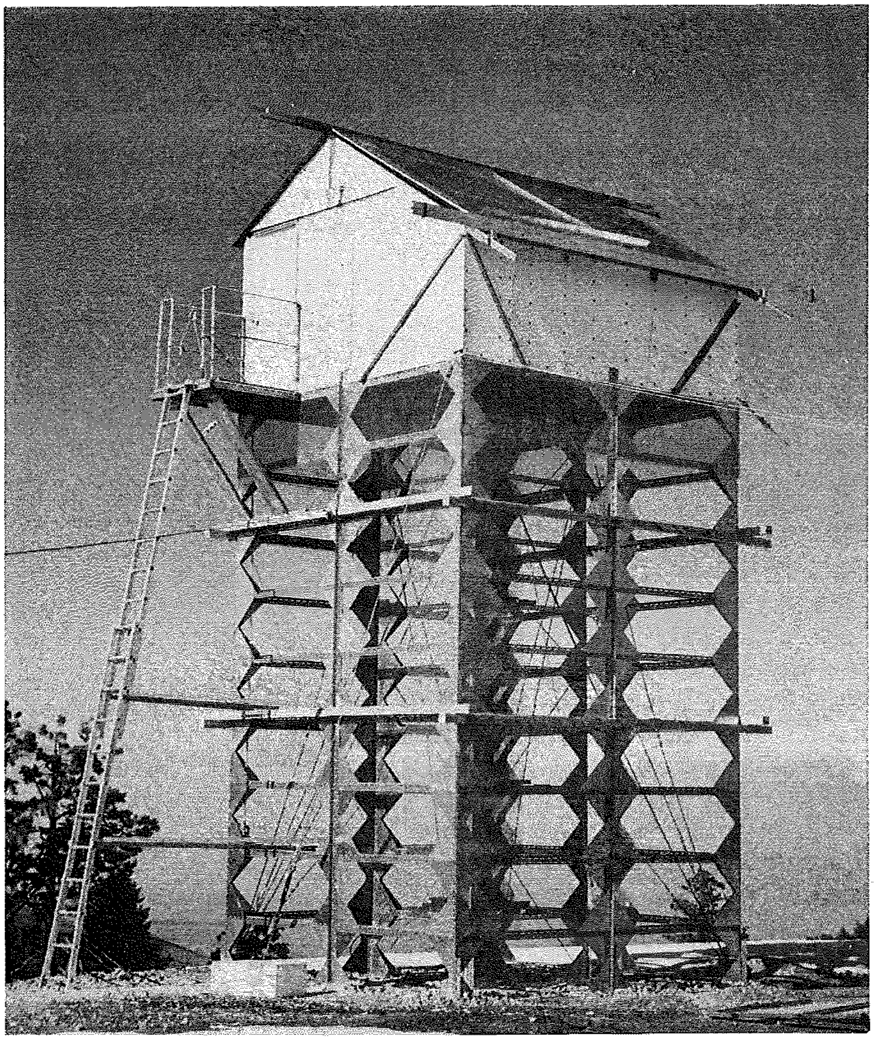
First Lunar and Planetary Laboratory Observatory on Tumamoc Hill. A.K. Herring and 12½-inch telescope. Early 1962

Taking all aspects into account, he opted for a site in the Catalinas, specifically on or near a small knoll surmounted by a fenced Mountain States Telephone installation, that was readily accessible by a short spur from the back road (graded dirt) to Bear Wallow. Thus power and a telephone line were already available at the site. In the spring of 1962 Kuiper heard that the phone company intended soon to vacate the installation - what could be more opportune! He initiated a modest test program to evaluate the seeing conditions at the site. This was undertaken by Alika Herring, an experienced lunar observer, artist and optician who had joined our staff in 1961, and who was the owner of two excellent reflector telescopes - a 6-inch and a 12½-inch. Using the former instrument he compared the seeing in the city with that at the site for a period of four months.

I must now back up somewhat and note the fact that Kuiper had also considered Tumamoc Hill, situated some 5 miles west of the campus, as a possible site for the smaller telescopes. The University's Geochronology Lab was already occupying a small site about a third of the way up the north side of the hill, which simplified matters considerably. A small shelter with runoff roof was built at the site early in 1962, and Herring's 12½-inch reflector installed in it for both tests of seeing and observations of the then poorly known lunar limb regions, the interpretation and mapping of which was Herring's current project.

LPL obtains a good site for its telescopes

In July 1962 the phone company abandoned its microwave installation in the Catalinas, and Kuiper obtained a lease on this and a small area of surrounding land from the Forest Service. A couple of months later the site was prepared for receiving the 21-inch reflector and its housing, a 20-ft. diameter building and dome. Erection of this observatory and installation of the instrument, a normal



20-foot test tower at Site I; autumn 1963

Cassegrain reflector constructed by Astro-Mechanics of Austin, TX, with optics by the Perkin-Elmer Corp., was completed in January 1963, not without hindrance from snowstorms; observations by Johnson and his group commenced at the end of the month.

In the early Fall of the same year, a somewhat flimsy test tower 20 ft. high was erected on a leveled area closely west of the 21-inch, and Herring's 12½-inch was transferred to it from Tumamoc Hill. The earlier tests with the 6-inch had indicated that seeing at the site could be very good, but a larger aperture was needed to obtain more definitive results (the optics of the 21-inch did not have sufficient precision to do this). Herring carried out seeing tests plus his lunar limb program in these cramped and unstable quarters until the summer of 1964; supplementary experiments with smoke bombs and free helium balloons were conducted in attempts to determine the nature of the wind flow (turbulent or laminar) over the site.

The results were positive enough to convince Kuiper that this site would likely be as good as any for the 61-inch precision optical reflector then under construction (the blank for the main mirror was large enough to allow an extra inch of diameter). The test tower was dismantled in mid-1964. The 61-inch building and dome was erected in 1965 and the completed instrument installed and operational by the first week of October that year. Kuiper, of course, kept a very watchful eye on all phases of this major operation, commuting frequently between the campus and the site, which later was designated "Site I, Catalina Observatory." A 10-room dormitory-lodge with covered access (because of winter snows) from the telescope area was erected a short distance down the north-facing slope of the knoll in 1966-67.

Other sites in the Catalinas

Kuiper leased another small parcel of land lying about halfway between Site I and Mt. Bigelow, which was designated Site II and was specifically for the use of Johnson and his group. The 28-inch telescope, basically a Johnson design, was the first to be erected there. It was housed in an inexpensive but effective roll-off shelter constructed of heavy-gauge corrugated steel, another Johnson innovation for cutting costs. A second-hand trailer was purchased and installed nearby for the use of the observers. I will return to the saga of Johnson's metal-mirror telescopes later in this account.

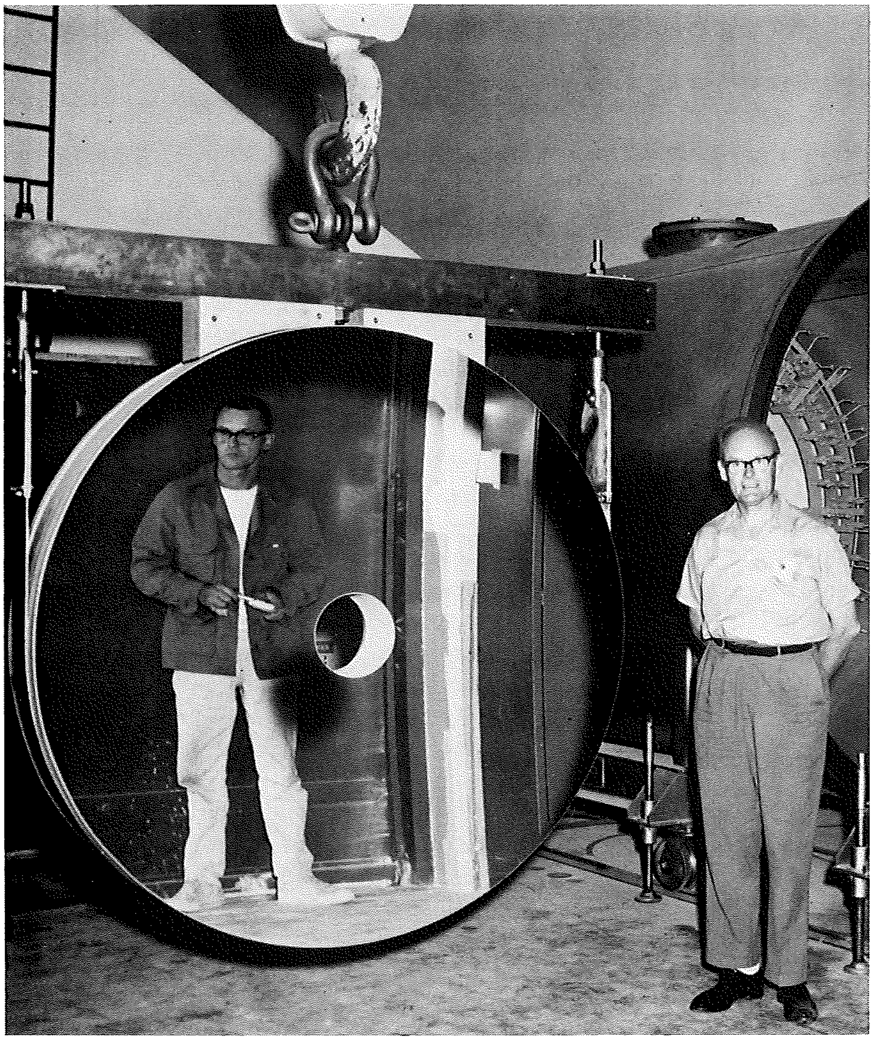
Kuiper had had his eye on Soldier Peak, a conical, tree-covered hill lying between Sites I and II that was about 300 ft. higher than Site I, for some time. The only snag - the FAA had an installation at the very top. In 1969 Kuiper obtained permission to place a telescope at that location; the 40-inch was duly installed there, but winter snows made access very difficult.

In 1970 the Air Defense Command vacated its radar station on the summit of Mt. Lemmon; several plans for the area were put forward by various groups, but Kuiper's proposal to convert it into an Infra-red Observatory won out. The 40-inch and two 5-ft. reflectors were moved to this site, Site II being cleared out and returned to the Forest Service.

The showpieces

Kuiper's pride and joy, however, was the 61-inch optical reflector and the nearby dormitory-lodge at Site I. A whole book could be written on the various trials and tribulations that accompanied the design, fabrication, installation and subsequent operation of the 61-inch. The basic mechanical design was set out by Johnson, using readily obtainable commercial items as a cost-cutting measure. Thus the main yoke was constructed from steelplate welded into hollow box-like members, while the drive was made from a comparatively inexpensive stepping-motor and variable-frequency square-wave generator, an innovation of Johnson's. The details were left to the late Sam Case, an engineer with no experience in telescope design. The mounting and framework tube of the instrument were constructed by Western Gear in Lynwood, CA. An expensive item was the worm gear for the drive; they had installed it at the factory, when one of the cables supporting the out-of-balance tube gave way, allowing the tube to crash into the gear! This accident cost the firm many thousands of dollars, and delayed delivery of the telescope. The declination axis of the instrument had been under-designed, causing visible flexure when the full weight of the tube and optics were applied to it. Every project has skeletons in the cupboard!

The heart of any telescope, of course, is the optics, and mechanical shortcomings can often be tolerated if the optics are good. The main and two secondary mirrors for the 61-inch were fabricated in-house as already noted. This onerous and exacting work was carried out by Robert L. Waland, yet another Britisher (actually Scottish) who had accepted Kuiper's invitation to



61-inch mirror after aluminizing. Mr. R. Waland standing at right; 1965

transplant himself and produce these mirrors. Waland had recently successfully completed the optics for a large Schmidt camera for St. Andrews Observatory, a sure test of competence in the field of optics fabrication.

He arrived about March 1963, three months before the glass (Pyrex) blank for the 61-inch was delivered. Outfitting the optical shop at 1530 E. Broadway with the necessary machinery and getting the blank set up for edging and smoothing occupied most of the rest of the year. Work on the mirror started just before Christmas, but was not completed until the end of March 1965, even though Waland and his assistants Bob Crawford and the late Ed Plamondon devoted long hours and most weekends to the project.

In the critical final stages of polishing and figuring the mirror, temperature fluctuations in the shop were sufficient to have an adverse effect on the operations; Waland therefore had to work when temperatures were most stable, which was the early morning hours (4 a.m. on), ceasing operations if the temperature rose too much. His devotion to the job, patience, skill, and strict routine paid off, the final figure of the mirror being no more than one fortieth the wavelength of visual light from a true parabolic figure (while in the shop), thereby excelling all other mirrors of comparable size.

Construction of the housing for the 61-inch was started in September 1964 and completed by May of the next year at which time the telescope itself was installed in the dome. Putting in the control console and the complex wiring, and getting the instrument into general working order occupied the next four months, and on 7 October 1965 the news came that the telescope was finally ready for use. Kuiper, Waland and I eagerly drove up to the observatory that evening, armed with lenses and such low-power eyepieces as we could muster. We set the telescope on the bright star Vega, as I recall, and examined the image as well as we could (there was no eyepiece holder then) with various powers - it looked quite sharp and symmetrical. These unceremonious observations constituted the event of "first light" for this telescope, yet another event for which 1985 marks the 20th anniversary. The next night Dennis Milon and I took a trial series of photographs of the Moon, using a 5x7-inch camera that Kuiper had had made for the 1956-57 photography program with the McDonald 82-inch. The shutter mechanism was not too reliable, the speed of the roller-blind changing as it traversed the image, and varying with the angle of the camera. Little did we know that this contraption would be used throughout our entire intensive program of lunar photography, which included every clear night that the Moon was accessible from October 1965 to March 1967! A complicated camera to take 7-inch roll film was finally designed by F. de Wiess and constructed in our own workshop, but the lunar photography program had been almost phased out by the time it was operational!

Here's a similar story—we purchased five or six good quality eyepieces (Clavé Plössls), which were quite expensive, for use with the telescope. To prevent their being tossed into a drawer along with Allen wrenches and the usual paraphernalia associated with machinery, I made a temporary storage box for them and some other related items from an old "Saniflush"carton, equipping it with a hinged lid to exclude dust and to prevent damage to the contents. Imagine my surprise a few months ago when, wishing to borrow the eyepieces temporarily for tests on the 16-inch Flandrau Planetarium reflector, they were delivered in the same old "Saniflush" carton, now lidless and rather battered after more than 18 years of use!

High resolution photography of the Moon and planets took precedence over all other programs for the first year and a half of operation, planetary photography maintaining high priority for several years more. The fine optical quality of the instrument, together with the generally favorable conditions and altitude (8250 ft.) at Site I combined to produce some of the most detailed photographs of these bodies that have ever been achieved from the ground.

Site II and metal mirrors

The 5-ft. diameter metal mirrors to be used in low-cost I-R telescopes were yet another Johnson idea, supposedly being cheap, quick and easy to make. Traditional Pyrex glass mirrors are necessarily heavy, take a year or more to grind and polish, and require rather complicated support systems to prevent flexure in the telescope. The tolerances for I-R photometry are quite a bit less stringent, and Johnson hoped to succeed with mirrors made from cast aluminum blanks in which the centers were the thickest part, the edges being quite thin. The blanks could also be cast with the reflecting surface being of roughly the right shape to start with. These would then be coated with a layer of

Kanigen (nickel sulphide) which could be polished and then aluminized in the normal manner.

After the completion of the 61-inch mirror, Waland had the task of carrying out the polishing and figuring of three of these 5-ft. mirrors. Problems were encountered at every turn; the castings flexed under the weight of the polishing tool - the castings slowly changed shape as they aged - temperature changes warped them - and so on. Waland worked valiantly on these recalcitrant monsters, but for an optician who was used to producing mirrors of the highest precision, these were abominations.

The three mirrors were eventually mounted in virtually identical telescopes, two being taken to Site II and erected in shelters similar to that for the 28-inch, the third having already been erected at the San Pedro Martir site in Baja California for the U. of Mexico. Johnson's 40-inch telescope on Soldier Peak was provided with a Pyrex mirror after the problems with metal mirrors had become apparent, but the same thick center - thin edge concept was used. Two more trailers were installed at Site II, and the 21-inch transferred from Site I, making Site II a veritable hive of activity. As mentioned earlier, when the summit of Mt. Lemmon became available in 1970, the 40-inch, 28-inch, and the two 5-ft. instruments were transferred to that site, and Site II was returned to the Forest Service. The 21-inch was refurbished and relocated at the southern extremity of the summit of Tumamoc Hill, to be used for planetary photography.

Other site-testing programs

Although Kuiper was very pleased with Site I in the Catalinas, he still nursed a desire to find the best site on planet Earth for a lunar and planetary observatory. His first involvement with searches for and testing of potentially favorable sites occurred in 1959 when he directed such a program for the Director of the Observatory of the University of Chile, Dr. Rutllant, who wished to find a favorable site for a new observatory in that country. Here is an excerpt of a letter from the late Dr. C.D. Shane, well-known astronomer who was Director of Lick Observatory in California for 13 years:

> "My only scientific connection with Gerard was in connection with the Chilean project which ultimately resulted in the Cerro Tololo Interamerican Observatory. It started with the A.A.S. meeting in Toronto in 1959. He told me of his efforts in connection with Rutllant to get a southern observatory started and of the site survey work begun by Stock. He pointed out that their hopes of adequate funding were small and suggested that AURA of which I was then President might take it over. This resulted in consultations with representatives of the Univ. of Chicago and the Univ. of Texas and also with Rutllant representing the Univ. of Chile. The outcome was that AURA took over the project, obtained support from the U.S. Air Force and the N.S.F. and thus got the project established.
>
> I think that among Gerard's accomplishments this should be counted among the more important ones. It was he who developed the initiative."

Cerro Tololo now boasts an impressive array of major telescopes. Two other nearby sites, La Silla and Las Campanas have also sprouted major groups of observatories in recent years, but all three groups are largely devoted to various stellar and galactic researches of the southern skies.

Kuiper set up a small program to test observing and seeing conditions at Cerro Tololo and one other Chilean peak (La Peineta), Herring making the tests with local telescopes. His assessment that the seeing was poorer than the best seeing at Haleakala in Hawaii (about which more shortly) led Kuiper to discontinue searches in Chile.

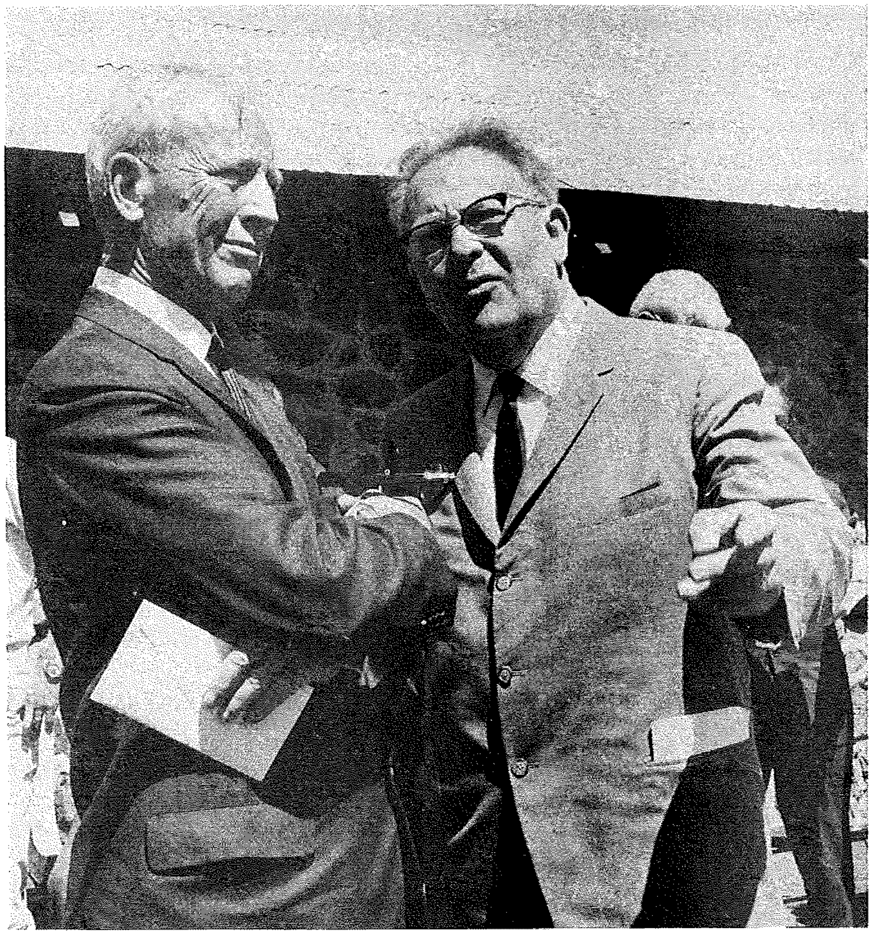
He examined many other possible sites at various times, often making flights over and around them in small aircraft. Among these were the southern tip of Baja California near La Paz, the San Francisco Peaks north of Flagstaff, White Mountain on the California-Nevada boundary, Mt. Shasta in California, and San Pedro Martir in northern Baja California. The last site was developed for the University of Mexico after site testing had been carried out by Herring, this time using the LPL's own 12½-inch test telescope. A sudden and unexpected snowstorm isolated him during the session of testing, necessitating a rescue by helicopter! An 8-mile road to the top of the mountain had previously been cut by Arnold Evans, our own Observatory Superintendent, who put in nine very long and tedious days to complete the task.

However, Kuiper had long suspected that a site surrounded by the sea might be superior to any that was located on a major land mass, because of minimal area subjected to solar heating to produce turbulent, rising currents of air. The obvious choice here was one of the peaks on one of the Hawaiian Islands; the highest of these reach altitudes of almost 14,000 ft., while their situation in the tropics (latitude about 20° north) ensured that the Moon and planets could, in general, be observed near the zenith where seeing is best and the water vapor content the least.

In the fall of 1962, Kuiper set up a program to test observing conditions on the rim of Haleakala ("House of the Sun"), an extinct volcano of 10,000 ft. elevation and the only one of the Hawaiian Islands' three major mountains that had a good road to the top. Herring was again called upon to carry out the tests, using the LPL test telescope but this time fitted out with his own excellent 12½-inch mirror. A problem was soon encountered from the fact that the large caldera (i.e., crater) at the summit of the mountain acted as a reservoir for cold air; this caused a fog to form quite frequently, which would usually spill out over the rim - or if no fog formed, then the turbulent cold air would cause bad seeing. However, when this did not occur, seeing could be quite excellent.

In 1963, Howard Ellis, a veteran scientist at the weather station that is situated on the upper northern slopes of Mauna Loa ("Big Mountain"), suggested to Mitsuo Akiyama, then manager of the Hawaii Island Chamber of Commerce, that Mauna Kea ("White Mountain") might well make a superior site for astronomical telescopes. Akiyama wrote to many astronomers in June 1963 stressing the possible potential of this site, but Kuiper was the only one who followed this up. Having seen the problems with Haleakala, he had already cast an eye in the direction of the two big mountains, and Akiyama's letter arrived at the opportune moment. The following January, which was the first opportunity that presented itself, Kuiper visited Akiyama at Hilo. They visited the late Governor John Burns, who was very receptive to Kuiper's suggestion that the summit of Mauna Kea be checked out for observing possibilities. He provided some seed money to extend the graded dirt road from its termination at Hale Pohaku—a group of stone shelters at the 9200 ft. level—to the summit at about 13,800 ft.

In May of that year, Evans, armed with a bulldozer, quickly carved a rough but quite serviceable road through the volcanic lava and ash to the summit of Puu Poliahu ("Hill of the Snow Goddess"), a cinder cone situated a mile or so to the west of the highest summit of Mauna Kea. Kuiper obtained funds from NASA, who were also interested in the discovery of superior observatory sites to provide backup data for their projected lunar and planetary missions. A small observatory building was erected that same month, and the Herring-LPL test telescope once again mounted in order to conduct tests of the seeing, trans-



Governor Burns and Dr. Kuiper at dedication ceremonies, Mauna Kea, 20 July 1964

parency, etc. On 20 July 1964, almost 200 persons drove up to the observatory for its dedication, but the ceremonies were conducted at Hale Pohaku where temperatures were more congenial. Kuiper gave a short address to the assembled group of officials and guests; the following is an excerpt:

> "This mountain top, our tests have already shown, is probably the best site in the world—I repeat—in the world, from which to study the Moon, the planets, the stars. The factors which make this so are lasting factors. We are here far away from the sources of industrial soot, smoke, smog and other air pollution. And this will remain. On the Mainland the industrial growth has caused a blanket over the land that all of you who have flown the jets have seen. This cannot happen here! The trade wind brings ever-fresh air, cleansed by the rain. . .
>
> Now the future: Mr. Governor, as a scientist who has worked in Europe, Java, the Mainland, Chile, and on Haleakala, I want to tell you that, to use the words of Mr. Alika Herring, our first observer, "This mountain is *it*." It is a jewel. This is the place where the most advanced and powerful observations from this Earth can be made. I believe that as citizens of the U.S., it behooves us to strengthen the scientific position of this country by developing the potentialities of this mountain top. I hope that ways can be found, in collaboration between the University of Hawaii, the U.S. Government Agencies, the Lunar and Planetary Laboratory, and other interested groups, to develop the opportunities now open."

Kuiper receives a rebuff

Herring continued his isolated and arduous stint of assessing and recording weather and observing conditions at the mountain top for about another four months, confirming the general superiority of the site over all others so far tested. However, Kuiper's plans for a joint U. of Hawaii/LPL observatory with a proposed 60-inch reflector, to be funded by NASA, were repeatedly stymied by that Agency. Flimsy excuses were put forward, suggesting that some internal politics were delaying matters. NASA asked Harvard U. to submit a competing plan, but the final upshot was that neither LPL nor Harvard got the contract - it went to the U. of Hawaii! That, of course, was hardly what Kuiper had in mind, since it effectively excluded him and LPL from any further say in the project. He had lost out to a university that did not even have an astronomy department!

By all accounts Kuiper was quite put out at the time by this turn of events, and I can imagine the stream of letters that must have been fired at NASA and others; however, although we knew that the Mauna Kea plans were not going quite as hoped, I do not recall any acrimonious remarks or personal accusations coming directly from him at this time. He later mentioned to me that although Mauna Kea was generally superior to our Catalina Site I in regard to seeing, sky darkness and transparency, the problems and expenses that would have been encountered in the full-time use and maintenance of an observatory located over 3000 miles away more than outweighed these advantages.

The man who wrote the proposal and saw the project through, Dr. John T. Jefferies, one of four then recently-arrived solar physicists at the U. of Hawaii, would no doubt have agreed at the time that administering the construction and subsequent upkeep of the new observatory, with all the inevitable problems, pitfalls and setbacks, was a big enough headache even when conducted from relatively close by. His proposal called for an 84-inch reflector; construction commenced in the Fall of 1967 and the observatory was dedicated in June 1970, the final diameter of the instrument being 88 inches.

The truth of Herring's assertion that "This mountain is *it*" has since been well borne out by the fact that no less than six major observatories have now been established on the site, and plans are at present afoot for the U. of California to erect what will be the world's largest telescope, a 400-inch (10 meter) reflector, at the same place by 1990. Even though Kuiper was brushed aside after he, Herring, Akiyama and Evans (literally in his case!) had completed the spadework of opening up Mauna Kea and announcing its virtues to the astronomical community, he may rest content that his visions for the development of the site have rapidly come to fruition.

As a point of interest, Jefferies, who became Director of the Institute of Astronomy at the U. of Hawaii after the initiation of the 88-inch telescope project, was named Director of the recently consolidated (1983) National Optical Astronomy Observatories (NOAO), which includes Kitt Peak National Observatory, Cerro Tololo Inter-American Observatory (Chile), and the recently formed National Solar Observatory (consisting of Kitt Peak's solar instruments and those at Sacramento Peak, New Mexico). Another U. of Hawaii researcher, Dr. Sidney C. Wolff, who was Associate Director of the same Institute from 1977-84 and was responsible for the operation of the 88-inch, has been named Director of KPNO and Associate Director of NOAO as of 1 September 1984. In the former of these concurrent positions she will be replacing Dr. Geoffrey Burbidge, who was one of the anti-Kuiper dissidents in 1958 at Yerkes. Wheels within wheels!

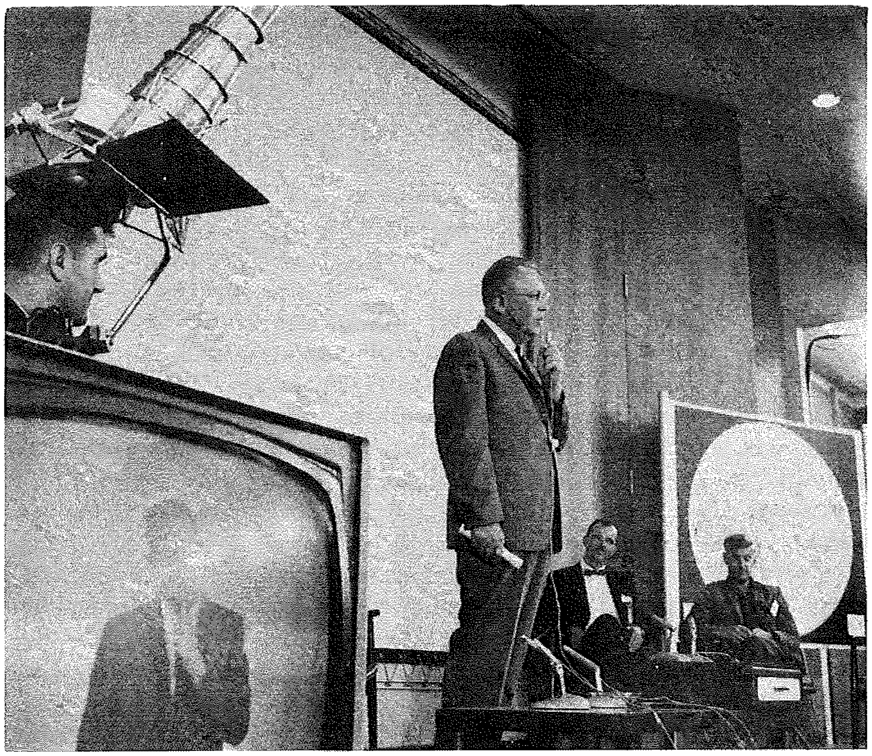
b) Involvement in NASA missions

The Ranger program

I mentioned earlier that in 1961 Kuiper had been invited to serve on committees for both the lunar Ranger and Surveyor series of missions then being planned by NASA. The Ranger Project, which was being developed and managed by the Jet Propulsion Laboratory (JPL) in Pasadena, CA, was ahead of the Surveyor Project for various reasons. Kuiper took his obligations very seriously, soliciting our cooperation and advice as occasions arose. I accompanied him at planning meetings at JPL, which in those early days had its offices located in tiers of trailers with a maze of interconnecting walkways. The Ranger series was breaking new ground in just about every aspect, and it is hardly surprising that the earlier missions all failed for one reason or another. I can remember the excitement at JPL as each Ranger approached the Moon, and the disappointment when the TV recorders disgorged nothing but "snow." As a matter of interest, the mirror of the telescopic optics of Ranger 3 was fabricated by Herring before he transferred to Tucson and LPL.

In 1963, the whole project was reorganized, and Kuiper was named as Chief Experimenter (the title nowadays is Principal Investigator). Urey, Shoemaker, and Ray Heacock, a JPL engineer, were retained as co-experimenters, and I was added as a fifth member of the team. Four re-designed spacecraft were constructed for this phase of the project (Rangers 6 - 9), each to be equipped with six TV cameras and no other experiments. LPL played an important role in the planning and testing stages. One test that Kuiper insisted on was to take the PTM (proof test model) of the spacecraft to a lunar-like landscape and try it out on the actual scenery rather than by only using test slides and patterns. Because of the sensitivity of the PTM's TV electronics, a large copper-sheathed shelter had to be constructed to conduct the tests, which took place at JPL's Goldstone Station in the Mojave Desert. The general camera operations were carried out by Ralph Baker, who later joined the staff of the Optical Sciences Center here.

A main concern of the Experimenter team was to choose impact points for the four missions, to recommend camera-pointing angles and so on. General criteria for optimizing these inputs with respect to scene brightness and contrast had already been worked by JPL personnel, and Shoemaker and I had briefly discussed the general type of lunar terrain to aim for (generally smooth areas with a minimum of suspected small craters and rocks). In those days of considerable informality, it somehow fell to my lot to choose impact sites for each of the six or so days of the available "launch window" when a suitable trajectory to the Moon was possible. This I did, giving reasons why some sites, and thus launch dates, were preferable. This happened for both Rangers 6 and 7; the other experimenters approved of my choices, and both spacecraft were targeted for the optimum sites, where they impacted. Ranger 6 was yet another failure, but Ranger 7 was completely successful, and marked this country's first tangible results from another Solar System body. The jubilation at JPL was unbelievable! Champagne corks popped, cigars were handed out; success at long last! Activity in JPL's photo-lab reached fever pitch as the Press and other media clamored for pictures. However, as Experimenter team, we had the privilege of seeing the first hurriedly produced prints, and our excitement can be imagined as we viewed the lunar surface with up to 1000 times higher resolution than had ever been available before! This was also heralding the era of instant science—a national TV, radio and press conference was scheduled for 9 p.m.



G.P. Kuiper announcing successful Ranger 7 results at nationally televised news conference, 31 July 1964. E.M. Shoemaker and writer at right, R. Heacock at left.

that evening (31 July 1964) and we had just a few hours to examine the pictures and come up with answers to all the questions that had ever been asked about the Moon!

The conference probably marked Kuiper's finest hour. Here he was, on coast-to-coast TV and in front of an array of reporters, announcing the first results from this country's first successful mission to the Moon. "This is a great day for science, and this is a great day for the United States," he declared. The news made headlines nationwide, of course, but the Experimenter team now had 3 months to produce a comprehensive report on the findings gleaned from the photos—our work was just starting in earnest! Kuiper recommended that a comprehensive selection from the more than 4300 images be reproduced in the form of a loose-leaf atlas of photographic prints. LPL undertook to see this through; the actual production of the prints was entrusted to a local photographic concern (Ray Manley Commercial Photography), who produced some 50,000 prints.

Rangers 8 and 9, which impacted in February and March 1965, were equally successful. As with Ranger 7, these missions involved several Experimenters' meetings, as well as our presence at JPL for the impacts and our initial assessments of the returned photographs. These occasions brought Kuiper and Urey into face-to-face situations, and one wondered whether the sparks might fly. They did not, in fact, and I cannot recall anything more than a slight coolness between the two, even though their ideas on the evolution of the Moon were still poles apart. Indeed, on one occasion Urey offered Kuiper and me a lift back to JPL in his huge Lincoln Continental ("I like big cars," he said); they sat together in the front, and the conversation was positively amiable!

With regard to the Moon, Urey maintained, rather vociferously, that although the Ranger pictures showed us many new details, photographs alone would never answer the questions; "Wait until we get our hands on some samples, *then* we'll give you the answers!", he would proclaim.

Eventually, of course, we did get samples, and they did provide answers to many of the basic questions. They certainly settled the main point of difference between Kuiper's and Urey's ideas on the evolution of the Moon, which dated back to those 1955 papers that started the rift in the first place. Urey maintained throughout that the Moon had never melted—that it was just an accumulation of rocky, meteoritic debris, unchanged except for the impact scars left by the falling in of the last of this debris. Kuiper agreed that the Moon had indeed accreted in this way, but that it had gone through a phase in which most, if not all of it had melted. It turned out that Kuiper was right and Urey was wrong; the Moon rocks were all either volcanic or igneous in origin. It is interesting to speculate that had these two leading scientists not disagreed in the first place, neither might have had the incentive to prove his point by pushing quite as hard as he did for lunar research—Kuiper by means of ground-based studies, and Urey through the use of spacecraft.

Analysis and interpretation of the Ranger photographs involved a major effort by the Experimenters and their colleagues. Here at LPL, Robert Strom, who specialized in the geological aspect of the Moon's surface features and who had joined us in the spring of 1963, plus William Hartmann and a Dutch astronomer, Rudolf le Poole, collaborated in this work. Kuiper arranged flights over and field trips to several volcanic fields in this part of the U.S., to the Pinacates in Mexico, and to Hawaii; several other LPL personnel participated in these trips — all aimed at gathering data to compare with the Ranger photographs. He obtained the services of an artist/sculptor from the Art Department (Ralph Turner, who was unusual in having a scientific aptitude as well). Turner made exact models of lunar surface features, and also of a collapse crater on a lava flow in New Mexico (Carrizoso) which he surveyed himself, for comparison purposes. He also sculpted the bronze bust of Kuiper that is on display in the Kuiper Hall of the Flandrau Planetarium.

The photographs were just about milked dry of all data, the results of the analyses being published in two volumes. One important result obtained by Kuiper was an estimate of the bearing strength of the lunar surface. At that time, vociferous proclamations of doom and gloom were being made by Dr. Thomas Gold, a respected theoretical astronomer at Cornell U. According to his ideas, the dark areas of the Moon were very deep "oceans" of fluffy dust into which landing spacecraft would sink without trace. The existence of a dust layer was definite enough, but the general consensus was that the thickness could be measured in centimeters or, at the most, a few meters. From a close-up photo taken by Ranger 9, which showed, near the limits of resolution, rocks ejected from a small impact crater, Kuiper calculated the bearing strength of the lunar surface to be on the order of 1 kilogram per sq. cm. (about 14 lbs. per sq. in.)—ample to support landing spacecraft or astronauts' footsteps. This result largely allayed NASA's fears that their landed spacecraft might be swallowed up in unfathomable depths of "Gold dust"; results from the later (June 1966 to January 1968) unmanned Surveyor spacecraft gave a bearing strength of about 8 lbs. per sq. in. at 2 inches depth. The astronauts would be safe; more kudos for Kuiper!

The Surveyor program

Although Kuiper was an early member of the Surveyor planning group, the set-up for this series of missions was different from that for the Ranger series, the prime contractor here being Hughes Aircraft and not JPL. I had attended several training sessions in preparation for the missions, but changing circumstances and priorities meant that neither of us had any participation in the first two missions. The first mission of this soft-landing series of seven spacecraft was more a test of the engineering and technology than of science. As it so happened, it was successful. The only post-flight input from LPL was my estimate of Surveyor's landed position, plotted from some low hills visible on the horizon in the mosaicked panoramas which were identifiable on our ground-based photos of the region. My position differed from both of JPL's estimates, which were obtained from the spacecraft's landing radar signal intensity. Subsequent close-up photos by Lunar Orbiters showed the spacecraft very close to my estimated position (another one up for LPL!).

The Surveyors were multi-experiment spacecraft, and each experiment had its own team of investigators, numbering about 50 in all. Kuiper and Urey were on the Lunar Theory and Processes Working Group, while I was a member of the Television Investigator Team (the P.I. being Shoemaker). As such it was my job, amongst others, to try to pinpoint the landed positions of the four successful remaining spacecraft on previously obtained close-up photos of the general target sites taken by Lunar Orbiters. This I did for the three cases in which it was possible. In the case of Surveyor 3, which required some 26 hours of searching, NASA later decided to target the Apollo 12 manned lunar mission to a point very near the rim of the crater in which Surveyor 3 had landed. The spacecraft was invisible in the shadow when the astronauts touched down, but I breathed a sigh of relief the following day when they announced that its top was illuminated by the Sun.

The astronauts later visited, examined and photographed the inert craft, which had endured 2½ years of exposure to space, removing some pieces and returning them to Earth. For my own very modest role in all this I received a personal letter of commendation from President Nixon. Kuiper, who ever had an eye open for good publicity and kudos, immediately had a whole batch of copies made, sending them to President Harvill and other administrative officials at this University, to some of the top NASA brass, program monitors and funding officers, and who knows where else. All rather embarrassing, but I suppose another one up for LPL.

Pioneers 10 and 11

The other early missions in which LPL personnel played a major role were Pioneers 10 and 11, designed to send multi-experiment spacecraft to Jupiter and Saturn. Planning for these missions began in the early 1960's; one of the on-board instruments was to be an imaging photopolarimeter, for which Dr. Gehrels was Principal Investigator. The instrument was designed and developed at LPL under his guidance, with major collaboration from co-Investigators David Coffeen, Charles KenKnight and Martin Tomasko. Pioneer 10, which was finally launched in March 1972, was the first spacecraft to venture beyond the planet Mars and through the Asteroid Belt. Although not primarily designed to produce images, the Pioneer 10 photopolarimeter gave us our first close-up views of Jupiter in December 1973; some of these were taken from angles impossible to attain from Earth. Other data from the photopolarimeter provided invaluable information about Jupiter's atmosphere.

Pioneer 11 reached Jupiter some 15 months later, supplementing the Pioneer 10 images with new views that showed the changed pattern of atmospheric belts and zones that had occurred during that period. The trajectory of this spacecraft was adjusted so that Jupiter's gravity would deflect it to a rendezvous with Saturn in 1979. This was accomplished, providing us with unprecedented views of that planet and its rings.

Other NASA missions

Since those early days of the pioneering Ranger and Surveyor programs, LPL personnel have been closely involved in almost all of NASA's lunar and planetary missions such as Lunar Orbiter, Apollo, Pioneer Venus, Mariner 10, Vikings 1 and 2, Voyagers 1 and 2, etc. Kuiper was a member, along with Strom, of the Investigator Team for the Mariner 10 mission to Venus and Mercury, but unfortunately he died while the spacecraft was en route to these planets. In recognition of his contributions to the program and to planetary sciences in general, the brightest crater seen on the approach side of Mercury was named "Kuiper," and is unique in that all other craters on Mercury that have received names commemorate persons renowned in the Arts (music, literature, painting, etc.).

While on this subject, let me digress a little - back to Ranger 7 in fact. This spacecraft impacted in a comparatively small, unnamed dark area that is largely surrounded by bright hills. At the Hamburg Congress of the I.A.U. held in August 1964 where the new close-up photos of the Moon were being viewed by a substantial cross-section of the astronomical community for the first time, Kuiper suggested that this small but distinct area should receive a name in recognition of its being the site of the world's first close-up views of the lunar surface. He suggested two names for consideration, Mare Exploratum and Mare Cognitum; after some discussion, the latter ("the Sea that has become known") was preferred, and has been part of the standard lunar nomenclature since then. The largest crater in this "sea" was given the name "Kuiper" in 1976, at the Grenoble Congress of the I.A.U., in recognition of his part in the Ranger program. At the same Congress, a crater on Mars was also named after him; it is situated near other craters bearing names of some of his astronomical acquaintances, and not too far from such names as Copernicus and Newton! His is the only name appearing on three different bodies of the Solar System.

c) Lunar programs

The gridding of the edge regions of the Moon by Arthur and Horvath was completed in 1960, the final product again being printed by Shandling's, thereby completing Edition A of the Orthographic Atlas. Edition B, carrying both the standard grid lines and the latitude-longitude lines, was published in 1961. These atlases still constitute a standard reference for positions of features on the Moon's nearside.

The program of re-photographing lunar images on the 3-ft. matte white hemisphere, initiated by Arthur at Yerkes, passed out of his hands because of other commitments. Early in 1961, after we had set up the apparatus in hut T6, Kuiper became anxious to proceed with the production of what would be Supplement 3 to the Photographic Lunar Atlas - an atlas of "rectified" (i.e., astronaut's-eye) views of the lunar surface. He and I planned the general content, size and layout of the atlas, after which Harold Spradley and William Hartmann proceeded with the task of taking several hundred photographs of selected areas of the images projected on the globe. This work continued through the summer of 1962, with concurrent production of photographic prints from the negatives so obtained. One consequence of rectifying the Moon's limb (i.e., edge) areas was to emphasize the paucity of named craters there. Arthur and I therefore added names to the more prominent craters to produce an equitable distribution, adhering to the IAU rules and recommendations. We added 65 new names in all, which were later approved at the 1964 Hamburg Congress of the IAU, and are thus now part of the standard lunar nomenclature. The atlas, titled "Rectified Lunar Atlas," was again printed by Shandling's and, as with the preceding Orthographic Atlases, published by the Univ. of Arizona Press.

Hartmann continued the program of rectifying lunar images by this method, but concentrated on specific features such as the maria (dark areas), features near the Moon's limb, etc. This resulted in the recognition of the maria as fillings of huge, ancient craters which displayed concentric rings of topographic features. Strom initiated a program of mapping lunar lineaments - alignments of ridges, etc. - and analyzing the direction trends of these features, which resulted in important information on the nature of internal stresses in the Moon.

Arthur's program to correct, augment and update the 1935 IAU Map and Catalogue of lunar formations commenced in 1961 and was not completed until 1966. It was a major operation, involving the positions, diameters and other parameters of many thousands of craters, which required the services of about four assistants for most of this period. Three of these endured the whole five-year task - Horvath, Charles Wood and Alice Agnieray. The latter had the monumental job of mapping all 17,000 craters, adding the official names or letters of those so designated; she has provided a short remembrance of Kuiper which is given, with one or two others, after this account.

The final product of this program appeared as nos. 30, 40, 50 and 70 of the LPL Communications; the lunar map, which was reproduced in 44 sections there, was later combined into four maps of the lunar quadrants, with added coloring for the dark areas of the Moon. These documents were approved by the IAU in 1964 and 1967 as representing the official, international lunar nomenclature, but limited distribution of the Communications somewhat thwarted that ideal.

Arthur's selenodesy program, an attempt to determine the true figure of the Moon's nearside, ran into problems because of the rather low contrast of many of the small spots chosen to make the determination when viewed in the microscope of the measuring machine. However, the plates were more than adequate to determine accurate positions for a large number of lunar features. The tedious task of making many thousands of measurements was carried out by Harry Connors, using a Mann two-axis machine purchased by the Air Force. Digitizers were later added to the machine to help relieve the boredom and to eliminate transcription errors. The final catalogue of positions, titled "The Tucson Triangulation," was published in 1968 as LPL Communication 131, and is probably the most accurate available.

The one remaining item that Kuiper hoped to complete for his series of supplements to the Photographic Lunar Atlas was a collection of the highest resolution photos ever obtained. With the prospect of a glut of much higher resolution images to be transmitted by the five Lunar Orbiters from August 1966 to August 1967, he decided against this. However, the quality of the lunar photos being obtained with our 61-inch reflector was so good that it seemed a pity not to take advantage of the fact; Kuiper was so impressed with the advantages of original photographic prints over halftone printed copies, as exemplified by the recently-produced Ranger atlases, that he decided to go the same route here. Since photography of the Moon could be carried out on clear nights for about three weeks out of each month, many people were recruited to carry out the program, using the simple but outdated 5x7 inch camera body already referred to. Our night assistant was Dennis Milon, who soon knew every pothole on the Catalina Highway - and how to avoid them!

Many thousands of negatives were taken, and Herring had the job of selecting those of better quality (almost 5000). Strom and I made the final choice of about 225 from these, and 11x14-inch copy negatives were prepared mostly by John Fountain and Stephen Larson. The job of preparing 225 prints from each negative was again undertaken by Ray Manley Commerical Photography. Since each negative required individual "dodging," we had to be present for the setting up and trial prints for each one. The "Consolidated Lunar Atlas," as it was titled, was completed in 1967, but was never published as a commercially available item. It was distributed to universities, libraries, government agencies, etc. It is the finest lunar atlas ever produced from groundbased photography, and is also probably the last. Despite the magnificent imagery obtained by the Apollo missions, the Atlas photos cover areas that were inaccessible to those missions; even the Lunar Orbiter imagery misses low-profile features that are obvious enough on our photos.

Even after our major lunar programs involving the publication of several different atlases, catalogues, maps, and reports on the Ranger missions had been completed, lunar studies at LPL were still very much to the forefront. The mass of photographs from the five successful Lunar Orbiter missions provided us with more data than we could cope with, especially as they included quite comprehensive coverage of the Moon's farside—a whole new area to research. Such apparently straightforward issues as the assignment of new names to the newly-seen farside craters turned out to be major items, and Kuiper was in the thick of international discussions and negotiations to reach a satisfactory settlement. Several of us devoted much time and energy to this project, and a mutually satisfactory compromise was reached at the 1970 IAU Congress.

Before leaving this subject, I must return to the case of the Army Map Service and its early lunar mapping program which I mentioned earlier. Their maps were notably inferior in all aspects to those produced by ACIC. Kuiper asked Arthur to write a review of the maps, as requested by some agency or other. Arthur, who could scarcely be regarded as the epitome of diplomacy, and who could always be relied on to "tell it like it is" straight to anyone's face, wrote a perfectly accurate but fairly bluntly worded review, illustrating the gross inaccuracies and other shortcomings of the maps. This phase of the AMS lunar mapping program was soon conspicuous by its absence; we heard later that one head had almost rolled because of the poor showing in comparison with the ACIC maps.

Later, when a big hassle developed over new and unapproved names being used to designate craters on a new series of lunar maps being sponsored by NASA, we found that letters of protest had zero effect. Worse yet, LPL was deliberately excluded from the distribution list for the maps. We soon discovered that the person then in charge of the NASA lunar mapping program was the one whose head had nearly rolled because of Arthur's review! He, plus the late Dr. Donald H. Menzel who was Chairman of the IAU's Working Group for Lunar Nomenclature, plus one or two others, had formed an impenetrable syndicate; no wonder we were 'personae non gratae.'

d) Polarization programs

Tom Gehrels, who was a collaborator on Kuiper's program for asteroid statistics, joined LPL in 1961 and is still with us. He hailed from the U. of Indiana, his chief interests being in asteroids and in developing the instrumentation and techniques for multi-color photometric polarimetry, which is a powerful method for probing the nature of any surfaces or atmospheres that scatter light. He organized his own subsection within LPL to pursue these interests, attracting astronomers, instrument makers, electronics technicians, etc. His first collaborator was Sam Pellicori, who has contributed a reminiscence of Kuiper at the end of this account, followed by Tom Teska who is still with us, Ed Roland (instrument maker), Dave Coffeen, "Tex" Belschner, and Jack Frecker who has remained with the Gehrels section since 1965. This group has pioneered in the design and optimization of various instruments and pieces of apparatus for this particular technique, including the construction of a lightweight telescope designed to be lofted by large, helium-filled plastic balloons. This "Polariscope" project had several successful flights, some from Glen Canyon (before Lake Powell had filled) but mostly from Palestine, Texas.

The whole technique of multicolor photopolarimetry has added very significantly not only to our understanding of Solar System bodies, but also of gas and dust clouds in deep space. Combined with the results from other observational methods, our knowledge of, for example, the asteroids has increased tremendously, with data on such parameters as diameters, densities, polar orientations, spin periods, shapes, surface reflectivities and physical conditions, and even broad compositions.

More recently, Gehrels has followed in Kuiper's footsteps by editing several IAU Symposium volumes and similar books on such subjects as Jupiter, Saturn, Planets Stars and Nebulae, Asteroids, etc.

e) Planetary atmospheres; I-R programs from aircraft

One of Kuiper's earliest Solar System interests was the study of the atmosphere of the planets, especially their chemical compositions. These may be determined from the fact that different gases, vapors and aerosols produce unique patterns of absorption lines in the I-R portion of the spectrum. However, two problems present themselves in pursuing this field of investigation. The first is the requirement, ideally, of an observing site situated above the Earth's own atmosphere, so that terrestrial water vapor etc., do not swamp faint signatures from the planets. The second is the necessity of a very long path length in a tube when preparing laboratory comparison spectra for identification purposes. Another important requirement is a sensitive I-R detector and supporting equipment, a specialized branch of technology of its own.

The first requirement was one reason for Kuiper's search for high-altitude telescope sites - an attempt to get above as much of the Earth's atmosphere, in particular its water vapor, as possible. In order to get even higher he had the idea of using high-flying jet aircraft, with a small telescope hermetically sealed into a window. A NASA Learjet was first used for tests of this method of observation, Dr. Frank J. Low carrying out the actual observations. Low, who joined LPL in 1962, was the inventor of the Germanium bolometer, a very sensitive detector of I-R radiation which, however, needs to be cooled with liquid helium.

These early tests proved to be successful, and Kuiper's next step was to construct spectrometers with more resolving power, to be used in conjunction with larger telescopic optics. A NASA Convair 990 jet plane, based at the Ames

Research Center near San Jose, California, was used for these programs until it crashed while carrying out a separate NASA program. Drs. Uwe Fink and Harold Larson were responsible for carrying out this I-R spectrometry. Since then, a NASA Lockheed C-141 StarLifter jet aircraft has been adapted to accommodate a 36-inch reflecting telescope with all the ancillary equipment necessary for I-R spectrometry. It is the world's largest flying observatory, and was named the "Gerard P. Kuiper Airborne Observatory" at a dedication ceremony held at Tucson International Airport on 21 May 1975. Thus, 1985 marks the tenth anniversary of this event. One of the keynote speakers was Dr. Carl Sagan, widely known for his scientific best-sellers and especially the "Cosmos" series of TV programs, who was one of Kuiper's doctoral students at Yerkes (1959-60).

The second requirement, for a long tube into which various gases could be introduced to obtain comparison absorption spectra, was also one which was foremost in Kuiper's mind while we were still at Yerkes. Dr. G. Herzberg of the Canadian National Research Council had set up a temporary tube 22 meters in length more than a decade earlier at Yerkes, using Kuiper's then new I-R spectrometer to record spectra, but Kuiper clearly needed a more permanent installation. During his visit to Tucson in January 1960, and on learning that our quarters-to-be and those of the IAP were still in their early stages of construction, he asked for the installation of a tube in the upper south wall of the 5th floor. The right strings were pulled and a 22-meter (72-ft) tube, 8 inches in diameter was duly affixed in place. Unfortunately, it never was put into operational order, our transfer to the south wing of the building occurring much sooner than expected. Kuiper anticipated this and had an identical tube installed there. This one was put into operation by dint of hard work by graduate assistants Toby Owen, Alan Binder and Dale Cruikshank. Owen had also set up a 2-meter tube, loaned by Herzberg, for some experiments with carbon dioxide to investigate the "greenhouse effect" as it applied to the planet Venus.

A much more ambitious tube was installed on the 3rd floor of the Space Sciences building. It is 130 ft. long and 2 ft. in diameter, and is made of stainless steel. It can reputedly take up to 10 atmospheres pressure (over 30 tons on the endplates), but I am not sure that this limit has ever been tested. I think I would prefer to be absent if such a test were ever made!

Kuiper's early I-R spectrometer was outdated by the time of our move to Tucson, due largely to the rapid growth of I-R technology. He learned of a small such instrument being used by Leon Salanave of IAP; here is an excerpt of Salanave's account of what transpired:

> "I cannot recall that our paths crossed again until 1960, at the University of Arizona. I had just begun studies of the optical spectrum of lightning at the Institute of Atmospheric Physics; Gerard had just organized "The Lunar Lab" and was occupying temporary quarters in the Institute on the top floor of the so-called PMM building. In fact, his office was two doors down the hall from mine. He appreciated the already promising results of my application of *slitless spectroscopy* as derived from well-known astronomical techniques, but he was more interested in an instrument I had just designed and built for the atmospheric physicists: an Ebert-type spectrometer for scanning the red and near-infrared transmission of sunlight through the atmosphere. This was interesting enough to meteorologists, but Dr. Kuiper saw the possibility of attaching the instrument at the focus of a large reflecting telescope and studying *planetary atmospheres.* With characteristic vigor and persuasiveness he proceeded to enlist my aid, and that of A. Richard Kassander, director of the IAP, to adapt the spectrometer to the 82-inch Cassegrain at the McDonald Observatory in Texas. This was accomplished, and in due course we transported the device to Fort Davis and tried it out on the big telescope observing

Mars, I recall. It didn't work very well, for optical and mechanical reasons that are apparent in hindsight, but I vividly recall how *intense* Gerard was about this project and its possibilities for extending the range of planetary spectra. During our first night at the telescope the need for certain modifications became apparent. The next morning, after a few hours of sleep, Gerard spoke to me about making some mechanical alterations of the grating drive and, looking at me earnestly, spoke of how *important* it was to do this. Needless to say, I did it then and there in the observatory's shop!"

The partial success of the Salanave spectrometer whetted Kuiper's appetite for pursuing this subject actively, and to those of us not directly involved, it seemed that bigger, better and more sophisticated spectrometers were constantly being planned and fabricated. Owen, Binder and Cruikshank, who with Kuiper were the chief ones to be involved in all this, left LPL towards the end of the 1960's. The whole program was taken over at that time by Drs. Uwe Fink and Harold Larson, and is still in their charge.

Low's Germanium bolometer is ideally suited for observing the longer I-R wavelengths, and has pioneered not only in observations of Solar System bodies, but more especially in stellar and galactic studies, where previously unknown objects have been detected by their output of heat radiation.

f) Planetary photography; comets; satellites

During the period of Lenham's collaboration with Kuiper at Yerkes, Kuiper initiated a program of planetary photography aimed at obtaining high-resolution images of planetary surfaces. The Yerkes workshop had adapted two inexpensive (let's be honest and say "cheap and nasty") 35mm camera bodies for use on the telescopes, and Lenham had used these on the McDonald 82-inch for the photography of Mars in 1956. As soon as our 61-inch Catalina instrument became operational (October 1965), Kuiper wished to get the planetary photography program going again. We looked askance at the old cameras, since it was impossible to use them efficiently. Milon, our photographer and night assistant, quickly solved the problem by using a single-lens reflex camera, which allowed rapid centering of the image, focusing and, above all, monitoring the image visually and catching the moments of best seeing. He was responsible for getting this program under way, making the preliminary tests for both black-and-white and color film suitability, judging correct exposure times for each planet, varying the image scale with supplementary lenses and eyepieces, and so on.

This program was integrated with the lunar one until the phase-out of the latter in 1967, when Stephen Larson and John Fountain largely took over the duties and continued them into the early 1970's. At that time the program was transferred to the refurbished 21-inch reflector on Tumamoc Hill, but changing priorities phased this program out.

The name "Van Biesbroeck" is prominently and indelibly written in the annals of observational astronomy. The late Dr. Georges Van Biesbroeck, or as he was known to his numerous friends and colleagues, "Van B.," to whom I referred earlier as a collaborator on Kuiper's 1949-58 asteroid program, managed to leave his native Belgium soon after the onset of World War I, and joined the staff at Yerkes as a visiting professor. He succeeded in moving his family to Yerkes at the height of the War, and then concentrated on a program he had started while in Belgium - the measurement of double stars. He soon broadened his program to include the determination of the orbits of double stars, and observations of comets and asteroids with the 24-inch reflector. For the latter program he obtained numerous photographs on plates, which he then measured, using the results to obtain the positions of those bodies. He also took a very active role in the planning and construction of the McDonald Observatory and its 82-inch reflector.

He would have officially retired in 1945 at age 65, but his outstanding zeal, enthusiasm and stamina would certainly not permit such an occurrence. In fact he was active right up until his death on 24 February 1974, at age 94! I can recall on one occasion in the early 1970's, when some cub astronomers were comparing their numbers of years in the profession (all well short of a decade), I mentioned that I had started *long* before they had—way back in 1949 in fact. Van B. overheard this, and in his typical quiet and unassuming manner, informed us that *he* had retired from astronomy four years before I had even started! The perfect squelch!

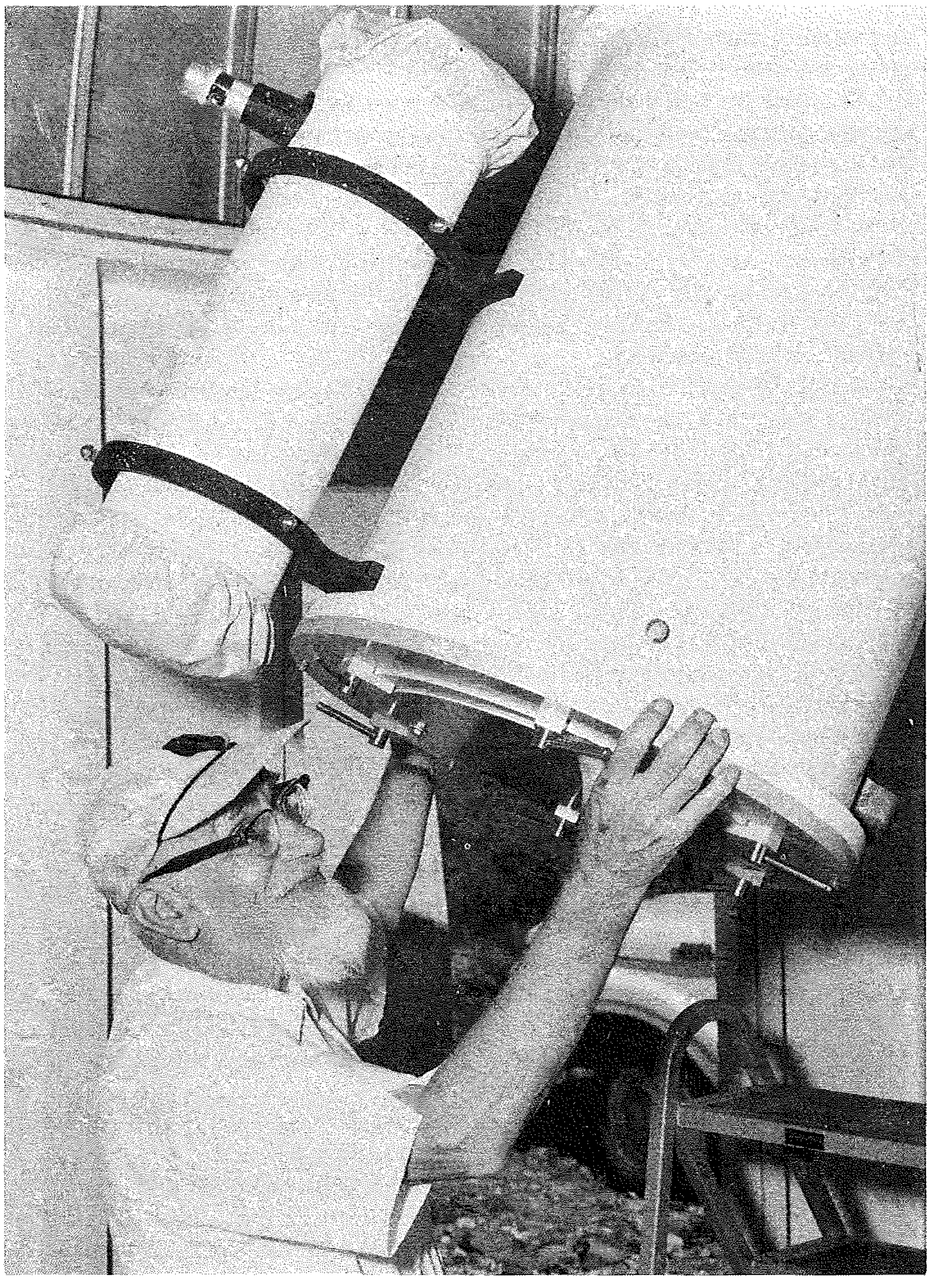
Van B., his wife and sister, remained at Yerkes when the Lunar Project left in 1960, since he was not involved in that Project in any way. Mrs. Van B. had given up making their home available to visiting astronomers and students by then (in 1957, full 3-meal-a-day board there was $24 per week!). In 1963 Kuiper heard that Van B. had been banned from using the Yerkes telescopes "for his own safety." He immediately offered him a position at LPL, once again demonstrating his loyalty to old friends and colleagues. Van B. wasted little time in moving down to Tucson, and in signing up for observing time on the McDonald 82-inch. However, for a man who would gladly work all night every clear night, the occasional runs at McDonald were nothing more than teasers. Kuiper had a 16-inch off-axis reflector made and installed for him at the summit of Tumamoc Hill, but problems with city lights and other factors in the unconventional design prevented Van B. from being able to obtain useful photographs with this instrument.

A little later on, Van B. was able to use our 61-inch Catalina reflector, Kitt Peak's 84-inch reflector and Steward Observatory's new 90-inch reflector. Appropriately, he observed with this latter instrument on his 90th birthday; a misplaced footstep at the end of his stint caused him to fall from the platform and knock himself unconscious. He was rushed to hospital by concerned colleagues, but was almost immediately back at work and "a'rarin' to go." Van B.'s name designates two comets, over 30 double stars, the intrinsically faintest star known, an asteroid, and a lunar crater - fully deserved recognition for this perennially energetic and enthusiastic man.

In 1966 an astronomer renowned in the field of comet research joined our ranks. This was Dr. Elizabeth ("Pat") Roemer, who was unsurpassed in the exacting art and science of obtaining high-quality photographs of faint comets, especially of periodic comets on their return from invisibility (to ground-based telescopes) in the outer reaches of the Solar System. Unfortunately, the 61-inch was not designed for making long, guided exposures on slow-moving objects, which adversely affected her comet recovery program.

g) Stellar photometry

The section of LPL engaged in this fundamentally important branch of astronomy was organized by Harold Johnson in 1961, following a little more than a decade of pioneering work in this field. Prior to Johnson's work, star brightnesses ("magnitudes"), as determined at different observatories, differed by significant amounts. This resulted from the use of different detectors (photographic emulsions, photocells, photomultipliers), insufficient attention to absorptions in the telescope and atmosphere, and so on. The problems were compounded when unstandardized color filters were interposed in order to obtain data on the colors (hence temperatures) of stars.



Dr. Georges Van Biesbroeck and 16-inch telescope, Tumamoc Hill, 14 May 1965

Johnson had largely standardized the techniques, instrumentation, detectors, filters, etc., for obtaining reliable and consistent results in this field prior to his joining us, and his "UBV" system, i.e., magnitudes in the *u*ltra-violet, *b*lue and *v*isual (this latter corresponding closely to the response of the human eye), portions of the spectrum, was adopted internationally. I should perhaps add here that accurate determinations of the magnitudes of stars, the Sun, the planets and the satellites are absolutely essential for such fundamental data as stellar distances, temperatures, masses, etc., and planetary reflectivities, diameters, and so on.

During his affiliation with LPL, Johnson improved and extended his system into the red and infra-red portion of the spectrum, so that the standard wavebands are now UBVRIJKLM. His first co-workers were Richard Mitchell and David Steinmetz, who remained with him throughout this affiliation, plus Kathryn Sheffer and others who remained for shorter periods. A major contribution of this group was the production of the monumental "UBVRIJKL Photometry of the Bright Stars" (LPL Communication 63) in 1966, which lists accurate magnitudes for over 5000 stars in up to eight wavebands. This has remained the international standard for star magnitudes since that date, and such prestigious and universal publications as the Astronomical Ephemeris quote from it exclusively. Another co-worker was Wieslaw Wisniewski, who is still with LPL, and who subsequently broadened his range of observations to include, among other things, the nuclei of distant comets, thereby obtaining new information on these faint and elusive objects.

Both Johnson and Kuiper were dynamic and restless characters, and not unnaturally they sometimes viewed matters somewhat differently. Johnson, whose voice normally had a stentorian quality, would then step up the volume so that his part of the conversation would be audible, if not decipherable, anywhere on the same floor of the building. To be present in the same room during even a friendly argument between these two, or for that matter, between Johnson and one of his staff, was a never-to-be-forgotten experience.

Johnson also earned somewhat of a reputation for applying what became known as the "Johnson treatment" to various pieces of apparatus that he had made or would be using. Telescope time is expensive, and unreliable equipment can waste not only money and valuable observing time, but also shorten tempers, with possibly fatal effects on some piece of apparatus. Johnson, therefore, made sure that his equipment was rugged and reliable by dropping it on the table, giving it a kick or two, yanking on protruding cables, giving moving parts a good workout, and so on. If it passed these tests, it was suitable for use on the telescope! Johnson left LPL in 1969 after having some differences with Kuiper, affiliating first with Steward Observatory and later with the U. of Mexico. He died on 2 April 1980, aged 59.

h) Editorial; publications

Barbara Middlehurst continued as co-editor for the two major series of volumes, "The Solar System" and "Stars and Stellar Systems" which Kuiper had initiated while at Yerkes, and also performed similar duties for the LPL Communications. She worked in Steward Observatory until our move to the south wing of PMM permitted her joining the rest of us. Her first assistant was Carolyn Norman, followed by Betty Fink who remained with her until Middlehurst's resignation in 1968.

Middlehurst was able to devote part of her time to research work, and became very interested in the subject of "TLP's" (transient lunar phenomena). These are sightings of "events" on the lunar surface that cannot be readily explained by terrestrial atmospheric conditions or any expected phenomena. She laboriously gathered up all the scattered reports of TLPs which, on analysis, showed a preferential spatial distribution on the lunar surface, but more importantly, showed maxima of activity at about the times of the Moon's greatest and least distances from the Earth hence probably associated with tidal stresses. Despite this, Kuiper was not convinced of the validity of the observations (akin, he said, to UFO sightings), and repeatedly delayed publishing them and the analyses in the Communications. Hence Middlehurst's resignation. She subsequently held a position at Encyclopedia Britannica in Chicago until her retirement. Editorial work for the LPL Communications was later taken over by Micheline ("Mickey") Wilson, one of Van B's daughters who, like her father, is still working here after her official "retirement." Chief editor for the Gehrels series of volumes is Mildred Matthews, daughter of another famous astronomer, the late Harlow Shapley.

i) Teaching

From the very beginning it was Kuiper's hope to establish a Department of Lunar and Planetary Science, to be a separate unit from Astronomy which gave only very limited instruction in this subject. While still at Yerkes, he suggested that Arthur and I might take courses leading to a Ph.D. degree, but pressure to complete the Photographic Lunar Atlas clearly made this a quite impractical proposition. Even though we had four people in the professorial ranks by the beginning of 1962, there was no hope whatever of setting up a Department then; the number of students that it might attract would be very small indeed. Kuiper approached the Administration on several occasions during the 1960's, but it was not until 1972 that the Department of Planetary Science became an official entity. Teaching faculty were Kuiper, Gehrels, Roemer, Strom, Dr. Donald Davis (adjunct) and Dr. William B. Hubbard, newly arrived and a graduate student at Yerkes during our final year there (1960). Our first student was Wayne H. Slattery. The newly-formed Dept. attracted new faculty and students, leading to its current flourishing status.

j) Construction, maintenance, etc.

In the early days prior to our move into the Space Sciences building, the fabrication of instruments, accessories, etc., for use on the telescopes or in the labs was carried out in the Creative Laboratory in the basement of the north wing of the PMM building, under the direction of Carl Perceny. As our operations broadened, the need for a drawing office became apparent; Sam Case was in charge of this facility which started early in 1963, his assistants being Kent Underwood and Charles Yerington. In 1965 we were joined by the late Ferdinand De Wiess, a very capable and knowledgeable engineer with an inexhaustible fund of personal experiences, who designed and oversaw the production of numerous pieces of equipment, including the 28-inch Schmidt camera installed at Site I in 1972. Soon after our move to this building, Harold Miller and James Percy were put in charge of the mechanical workshop and electronics laboratory respectively. Kuiper foresaw the need, well before the 61-inch telescope was installed, for a small maintenance crew to get and keep the instrument in good running order, as well as seeing to the preparation of the site, keeping the access clear of snow in winter, and so on. He hired Arnold Evans at the close of 1964 to undertake these duties, who was later joined by Leonard Kelley and José Garcia. The development and general smooth running of all the LPL observatories is a tribute to the hard work and devotion to duty of this crew.

k) Office, secretaries, etc.

Our first secretary/typist following the move from Yerkes was Gail Moore, wife of Elliott Moore as already mentioned. She held the fort until more experienced people could be found, such as Dollie Heisler and Lin Owen (wife of graduate assistant Toby Owen). The situation stabilized in 1962 when Mrs. Ida Edwards became Kuiper's personal secretary, a position she held until his death, after which she spent about seven months in filing the stacks of personal papers and other items that Kuiper had retained in his office, and in cataloguing the entire collection (almost 40 full file drawers) for the Kuiper Archive. Mrs. Shirley Marinus became personal secretary to Gehrels at about the same time, a position she still holds.

The main LPL office was run by Camille Morris at that time and until the end of 1967. Our first full-time bookkeeper was Kay Osburn who joined in mid-1966 and only recently retired. By 1962 Kuiper felt the need for a business manager, and hired Carl Gillespie, who retained that position for a while and was succeeded by Bram Goldman. From the last part of 1964 to the present time, this position has been held by Melvin Simmons—an unglamorous but absolutely vital part of LPL operations. After 20 years, "Mel" knows all the do's, don'ts, right people, where the money goes and comes from, who's doing what and where and why, — you name it.

The library, started up by Dai Arthur as already mentioned, soon began to grow as LPL became involved in various different projects. By early 1963 things were getting somewhat out of hand, and we hired our first librarian, Carol Loden. She was soon succeeded by Marion Potts, but in spring 1964, Faye Summers took over the position and retained it for eight years. For the first two years of this period she shared duties with Troy Macdonald.

Gerard P. Kuiper - the man

So far, I have made only a few short references to Kuiper's character and demeanor. Obviously anyone who could accomplish as much as he did, both in setting up a major research institute and telescopic facilities while carrying on research at the very cutting edge of all aspects of Solar System astronomy, would be an extraordinary person. He clearly did not get where he did by always being a "pussycat," or by sitting back and admiring his past accomplishments. As I have already indicated, he was normally very concerned for all aspects of the general welfare of those who were loyal to him. He could sometimes be quite difficult, such as repeatedly delaying the publication of something of which he did not quite approve. Occasionally he would get himself disliked by short-circuiting the accepted channels of communication through some administrational hierarchy by going directly to the person at the very top. He has been called "the benevolent dictator," but although often stubborn over what we saw as generally trivial matters, he was certainly not inflexible. This characteristic carried over into scientific matters, and both Arthur and I were able to convince him on several occasions that his thinking was not quite correct.

The following character sketch of Gerard Kuiper by Dai Arthur is, in my opinion, a pretty accurate one. Arthur had some fairly serious differences of opinion with Kuiper over some matter that I cannot even recall now, and resigned from LPL in the summer of 1967; he thus had no reason to paint a falsely rosy picture of Kuiper's character.

20 March 1974

> My acquaintance with Dr. Kuiper started in the fall of 1958, when I arrived at Yerkes to join his lunar project. He was then in his mid-fifties. His manner was friendly but reserved, and I found this quite characteristic. With new acquaintances and colleagues his attitude was always quite reserved. He took relatively little notice of academic qualifications, or the recommendations of others, unless he knew these others very well.

MEMORANDUM

4 April 1967

TO: LPL Staff

SUBJECT: Damage to 61-inch Telescope

Two or three events have been reported to me all concerning the F/13 secondary mirror of the 61-inch telescope.

(a) The mirror was wiped carelessly (presumably in an effort to clean it) which has caused much recent photography, particularly of faint satellites near bright planets, to be marred by streaks.

(b) The central pin of the mirror holding it to its mount was loosened and the lock nut holding it in place was gone.

(c) One of the three adjustment screws in the back was found recessed, having been turned four complete revolutions of its proper position. This screw is difficult to move and it requires a screw-driver to turn it.

Items (b) and (c) have caused a collimation error that got progressively worse and was corrected by Mr. Waland on March 23. The streaked mirror was removed early on April 2 and has now been re-aluminized at Kitt Peak. It will be installed today, April 4.

I have attempted to understand how it was possible that anyone would, in such a serious way, tamper with equipment on which so many of us depend for our research. I must ask the cooperation of all persons, using the 61-inch or entering the dome, to observe with the utmost care the obvious operating procedures. No one but Mr. Waland is authorized to touch the optics; no one but Mr. Evans is authorized to make the changes between F/45 and F/13 and touch the adjustments.

Gerard P. Kuiper

NOTICE

6 January 1969

TO: 61-inch Observers

It has come to my attention that the electric heat in the observers' lounge on the ground floor of the 61-inch dome is often turned up excessively. I have found this condition myself at times, disbelieving that anybody would want to be in such an oven. Rumors were passed on to me that the day-time staff was responsible, but we have convincing proof that this is not correct. Hence, my request to you to please leave the electric heat as you find it, adjusted to a reasonable temperature. The high temperatures are not merely wasteful, but can cause injury to health (the electric rate we pay is twice that in Tucson).

Gerard P Kuiper

Gerard P. Kuiper

GPK:ie

Four typical memoranda distributed by Kuiper to try to right some wrongs

MEMORANDUM

10 May 1971

TO: LPL Staff

SUBJECT: Use of 61-inch Telescope and Dome

Sunday afternoon, May 9, during an inspection of the Catalina and Mt. Lemmon Observatories, I encountered a situation which truly distressed me. Two or three of the junior scientific staff were about to move a heavy piece of equipment with the dome crane through the trapdoor, in violation of safety rules that have been in effect since Observatory operations began in 1965. Also, the Observatory door was unlocked and the gate was open, with one visitor car parked near the dormitory entrance. Furthermore, this violation was presented as a perfectly normal problem that had been "solved" several times before.

I want to reiterate that the 61-inch telescope, made to high precision for specialized planetary studies, is not a university-provided institutional instrument, but is NASA property, assigned to me as Principal Investigator of a NASA-sponsored continuing planetary research program. In view of this I have developed over the years certain operating procedures and safety rules that I have found compatible with my responsibility. These rules include that the movement of major equipment be done by the daytime staff, who are always on call in case of emergency; that the dome, dormitory entrance, and gate should always be kept locked because of the large number of tourists in the vicinity. If these rules are violated repeatedly, I shall be forced to deny the offenders the use of telescope and dome. I have given the Superintendent instructions to lock the crane in the dome to prevent unauthorized use.

Gerard P. Kuiper

Gerard P. Kuiper

GPK:ie

MEMORANDUM

8 June 1971

TO: LPL Staff

The 61-inch mirror has been re-aluminized and the coat appears satisfactory, except that the scratches that we hoped would be eliminated are still showing. These scratches were caused by one of the astronomers and his assistants dropping a piece of plywood on the mirror. The 61-inch telescope was made under my personal direction for high-resolution planetary photography and spectroscopy. Mr. Waland made it the best optical surface ever made for such a large mirror, 1/40 wave. He was distressed at the very considerable deterioration of the surface through scratches and marks, during the past 4 years. I suppose that all I can do is to repeat my request that all possible care be given to the safety of the 61-inch telescope in future operations. I want to receive reports of even minor damage immediately after this happens and not learn about it weeks after indirectly.

Gerard P. Kuiper

Gerard P. Kuiper

GPK:ie

The same thing carried over into his attitudes to applicants for employment on his projects, or in LPL. People recommended to him by his friends, or close acquaintances, or other people he could trust, were much favored. Similarly in assessing applicants, he relied very strongly on those around him for opinions.

There was thus this constant thread in Dr. Kuiper's character of wanting people around him on whom he could rely completely, both technically and personally, the latter being the more important. Technical deficiencies he could tolerate, provided that due allowance was made in the person's position and remuneration. Personal defects he was not so inclined to overlook. There was something of the old Dutch uncle in his character. Kindly, but stern.

But if he demanded loyalty, he also gave it. He always sought lasting friendships, and he always stood by old friends and protected them. But it went far beyond that. He had an unmatched sense of responsibility towards every employee and every associate and friend. At Yerkes a research associate employed by another faculty member was summarily dismissed—and perhaps not without reason. This act outraged Dr. Kuiper (who had no particular liking for the employee concerned). He overruled his colleague and reinstated the man, saying "Research Associates at Yerkes are *never* summarily dismissed."

This sense of responsibility revealed Dr. Kuiper as a man whose kindness was sometimes too much for his own good. He was always reluctant to dismiss an incompetent assistant, and sometimes could not bring himself to do it. On several occasions it fell to me, at his request, to inform the unfortunate that his services were no longer required. Even then, if there were difficulties in the direction of re-employment, Dr. Kuiper prolonged the period of the dismissal notice to help the man out financially.

Despite all this, he had no time for fools and these could cause momentary breaks in his usual politeness. His most conspicuous personal failure was a tendency to rely on first impressions. In this he reminded me of a Blackfoot Indian. If a graduate assistant made a bad first impression on Dr. Kuiper, it was almost impossible to put matters completely right subsequently. He made an incorrect assessment of one of my assistants (Huzzen) who he unfortunately took to be a fool. This was a natural but quite mistaken reaction to Huzzen's nervous volubility. Dr. Kuiper's estimate of this student's ability was quite wrong, but he never really changed it despite frequent urgings from myself.

Dr. Kuiper was an extremely orderly and methodical person and must have resembled the British astronomer Airy in some ways. Untidy or unresolved situations dismayed him and always resulted in a stream of memoranda and instructions aimed at clearing up the mess.

He was contemptuous, not so much of authorities, as people who quoted authorities. A graduate student who quoted authorities, instead of reasoning matters out was sure to drop in Dr. Kuiper's opinion.

Gerard Kuiper has been described as a controversial astronomer, but this is not in the least in accord with his character. He avoided controversy in every way. Even when he had a most critical and adverse opinion of a fellow astronomer, he almost never stated it in writing, and only quite reservedly in conversation, and only then with intimates. His advice to his associates was to attack the thing, never the man. I remember his words to me at the conclusion of the lunar nomenclature session at the Brighton IAU meetings in 1970, when I strongly and repeatedly criticized some rather half-baked proposals by Menzel: "That's the way to do it, Dai—keep it technical and avoid personalities."

He almost completely ignored criticisms of himself, some of it quite unfair and intemperate. On one occasion when he had been subjected to personal criticism by a well-known scientist—and criticism of a type which could very easily have been refuted, I asked him why he never replied to this kind of thing. His answer was that he was a very busy person with a very definite set of priorities—and that these latter did not include getting into personal arguments which he regarded as a waste of precious time.

This brings up another facet of his character. He was quite conscious of his place in astronomy. Gerard Kuiper was above all, a dignified person who did not unbend too easily. He was very much aware of his mortality—and very determined to leave something of himself in the way of scientific achievement, to posterity. This is the nearest he came to personal vanity.

Every character has its darker side. I think with Gerard it was his determination to have his way in those matters he considered very important, and his rather oblique way of getting his own way on occasions. There was a touch of Machiavelli in him. He rather enjoyed making a situation go his way without showing his hand in the matter. Unfortunately, he was never able to grasp the alarm and dislike these methods caused. I believe it is this very characteristic which may cause many of his contemporaries to be less fair than they might be in their assessments of his character and capabilities. Certainly very few of them were conscious of Gerard Kuiper's essential honesty and kindness.

I have said nothing here of his ability as an astronomer, because our fields of competence lay so far apart. I know, however, that he was a most acute and careful lunar observer, noting things which very able and experienced observers repeatedly missed. It is a tragedy that he died when his superb organizing abilities were most needed in the matter of lunar and planetary nomenclature.

David W.G. Arthur
USGS Dept. of Astrogeology
Flagstaff, Arizona

Here are some impressions of Kuiper from Alan Lenham who, you may recall, worked with Kuiper at Yerkes and McDonald Observatories from 1956 to early 1959.

15 January 1983

GPK

I found GPK quiet, friendly and considerate. He was a busy man, too active for the good of his own health (nervous) at times, but always willing to break off to help me - perhaps to look up his stellar proper motion file cards. He kept in some degree of correspondence after I returned to England and several times invited me over to LPL. We exchanged Xmas cards for many years. He drove like he worked - for very long periods - and towards the end of the day he frequently nodded at the wheel.

He was a very humane man deploring the discrimination against the negro in the U.S.A. His dislike of the treatment of the natives by the Dutch in Java (which he saw on a solar eclipse expedition to Sumatra in 1929) caused him to leave Holland for good. Up to 1958 the only time he had been on Dutch soil was during the war when his duties with the ALSOS mission forced him there.* (Rumour had it that he refused a high order from Holland).*

He appeared to be genuinely very pro-British and always took our side when international disputes arose (e.g., Suez 1956). He was European and had a formality with those with whom he was not well acquainted that may have seemed to distance him from some young Americans who were used to less formal ways. This was really shyness - to those he knew well he had a cheerful smile and ready greeting. At least when I knew him he could relax and indulge in a rather heavy-handed humour. Of course, during this period his load of responsibility towards others was very light compared to what it became at LPL.

He was a democrat (with both big and small D) when I knew him. He told me that if he lived in England he would support the Labour Party.

GPK's main shortcoming came from his over-enthusiasm. He tried to do too many things at the same time. He had several major projects, each one too much for one man, going at the same time - two series of books; lunar atlas; observing; running Yerkes. There were casualties of this, one of them happening to me. He asked me to write a review article on visual and photographic observations of the planets for Vol. 3 of the Solar System series. I did as asked, including a deep historical research (including French and German

*Mrs. Sarah Kuiper Roth tells me that this is far from the truth; Kuiper had visited Holland on four occasions during this period, and had accepted the Order of Orange Nassau.

sources). GPK wrote "Your chapter contains a large amount of material not presented elsewhere and will, I am sure, be of permanent value." That was written to me in *1964* - the chapter was given to GPK in *1958* (he read it then and said he like it). It waited so long to be published that it was effectively killed by the space probes and has never appeared. Yes! - the man could occasionally be exasperating! We never had a harsh word while I knew him.

Alan P. Lenham
43 Newcastle Street
Swindon, Wilts., England

Sam Pellicori, the author of the following reminiscences, remained at LPL from 1961 to 1969. He was more closely allied with the polarization programs of Gehrels than with Kuiper's projects.

My Impression of Dr. Kuiper, Scientist and Man

My first personal encounter with Kuiper occurred on a summer evening in 1960 when I visited Yerkes Observatory. I introduced myself as an astronomy student at Indiana University who was raised 30 miles from Yerkes, in the city of Kenosha. The staff showed me around, including the office of Dr. Kuiper. At a certain moment, everyone proceeded out to the south lawn to see the passage of one of the Sputniks. We watched the blinking light slowly traverse the sky overhead. Kuiper explained the blinking as probably due to the irregular shape of the rotating satellite. Suddenly, the tiny light went out! Everyone scratched their head in puzzlement. I then suggested that it had entered the earth's shadow. Kuiper, quick on the uptake, said "Yes, yes, that is it, of course!" in his Dutch accent. I recall gliding back into the observatory as everyone left the lawn, my feet never touching the ground.

A couple years later, when I joined the University of Arizona to continue to work with Tom Gehrels, I found myself in Kuiper's Lunar and Planetary Lab ("Luny-lab"). Gehrels was GPK's student and he had nothing but supreme admiration for the man. Kuiper's secretary and his crew from Yerkes, consisting of Ewen Whitaker, Dai Arthur, Van Biesbroeck, and others, referred with semi-serious affection, to the famous Kuiper by his equally famous initials, and many of us adopted the practice. There were messages from EAW or TG; DWA was working on lunar maps; TO was quietly mixing gases; the spectroscopic twins AB and DC were accelerating down the halls of LPL to quickly do some measurements for GPK.

Kuiper's personality and presence loomed heavily over LPL - LPL *was* Kuiper. Kuiper was also LPL. I remember being invited to his spacious, booklined office. There in his kingdom he generated answers to questions and questions to answers. When passed in the hallway, he seemed embroiled in thought. He brow was wrinkled. He rarely would grant an audience. Only when he was behind his desk would his expression sometimes ease.

When important personages visited LPL, GPK was very personable, at times he might approach what might be described as jolly. His reaction to the visitor was tempered by the importance of the visitor. If the person was a NASA administrator or a Walter Sullivan, GPK was all smiles; if it was Harold Urey, respected tolerance. But astronomers tend to be stubborn and opinionated people. Kuiper's professional battles with Urey over questions of lunar genealogy are well known in the history of science.

While Kuiper was confident in his interpretations, he had that practical quality that distinguishes a good scientist from a mediocre one. He could suggest an experiment that had a better than average chance of providing a meaningful result. One aspect that impressed me greatly was his ability to call upon a wide range of knowledge in integrating pertinent results from diverse disciplines to form a hypothesis or a conclusion. Few scientists have such a span of resources at their immediate command.

One of the highlights of my eight years' association with LPL as a student and research assistant was the rare presentation that GPK would give to the assembled staff about preliminary Ranger results. We saw the first closeup photos of the lunar surface and heard his interpretations directly. Later, as he became more involved in the administration of the Lab. and telescope building, these treats went by the wayside.

While he was a large and powerful man, he was never threatening. He didn't cultivate personal involvement with his employees. He expected respect, European style, although he spent all of his professional career in the U.S. There was never an argument to be heard through his office door. His responses were quick. When the situation called for charm, it seemed that his Dutch accent tuned up. Whenever he was annoyed or disagreeable, he would shake his head rapidly, causing the loose skin of his jowls to whip violently! The same image comes to me of Urey, Kuiper's professional opponent!

While the contributions of the man as a scientist made a deep impression on those who worked in his presence, especially us initiates, it is difficult to have much insight into the man as a person. He had a strong and energetic personality and was totally dedicated to his work and his laboratory. His only other pleasure that was evident to me was his love of gardening. And his eyes would brighten with fatherly pride at the sight of his daughter, Lucy, when she visited her famous dad. I think his wife, Sarah, must have been very tolerant and understanding.*

Many of GPK's original crew have dispersed, for one reason or another. Yet many remain to continue the work begun under him. Whatever our disposition, we all remember GPK with admiration, and perhaps a little reverence.

S.F. Pellicori
Santa Barbara
11 Jan. 1984

Here are some interesting recollections from Alice Olson, who joined LPL in 1961 and, among other things, drafted the complicated maps of the four quadrants of the Moon which were accepted by the IAU as representing the official lunar nomenclature.

September 19, 1983

I hope Dr. Kuiper, wherever he is, can forgive my inability to describe his exuberant life spirit that so impressed me. I liked being asked to meet with him in his office to discuss a drawing project he had for me, as his energetic mind and manner, and his fine old-fashioned courtesy and dignity were a special pleasure to me. His attention was powerfully focused on his goals, but he dealt with me in a pleasantly persuasive way that lead me to accept jobs I sometimes thought awkward, his confidence undaunted by my arguments. I'm aware that to strongly oppose him when he was determined would present a view of him I never had.

He was a big man yet he would leap out of his chair without hesitation if he needed some reference item; he always had a pencil about an inch and a half long in his pocket, one of his inventive conveniences. He liked using an up-to-date expression occasionally and I smile remembering his telling me someone had made a "boo-boo," I found this so out of character. His speech had a quaintly foreign touch, I thought.

He was appreciative of my artistic interests for he had done some painting in his youth and had thought for a while of being an artist. His landscaping of the house on Sawtelle showed me his talent and his pleasure in creating a wilderness in miniature. Yes, it did need considerable watering, but conservation was not an issue then. The bank of hose connections alone would take a paragraph to describe.

Once he asked me to work overtime to finish a job for him, and nearing sunset a summer storm had ended and moved from the west in time to let a marvelous last glow light the campus against a dark sky. I couldn't stand being at my desk and I went out on the hall landing to watch. He joined me shortly, to my embarrassment, but he was enjoying the view also. Busy as he was he had an interest in small events in nature, describing in detail on one occasion

*Mrs. Sarah Kuiper Roth informs me that she enjoyed the interesting but often hectic lifestyle, which however was punctuated by many relaxed interludes when her husband would quietly discuss with her the latest developments and problems.

how moths on the window pane at Bigelow drank drops of water. Conversation with him was seldom so hurried that he wouldn't share a thought or listen to one. As he was preparing a report in November, 1963, he told me his view of the current scientist: "He produces when prompted by the 'king' as the artist or musician once did."

Someone else will surely mention how he distrusted long distance connections, and customarily helped his receiver hear him better with sheer volume, his closed door not blocking his message from those of us with nearby offices. I have another telephone story: on one of his trips he had a brief 15 minute chance to call the Lab before boarding a plane in San Francisco. A young girl in the main office put him on 'hold' while answering another call and forgot about him. He announced later in the hearing of all that he never wanted to be put on hold again.

Such vigor! One of the fellows told me that Dr. Kuiper would catnap on the iron floor of an observatory and get up refreshed, the rest of them frankly exhausted. I like remembering the spirit of the Lab, an extension of himself assuredly, in 1961 (when I was hired by his secretary as a typist; I had an art degree and no training of a practical nature). He discovered my ability and in two days I was shifted into drafting illustrations, learning the technique on the job. The organization was free wheeling, fast expanding, exciting. Dr. Kuiper will remain in my memory as a man of marvelous proportions. I'm sorry my words can give only a pale image of him.

Alice Pefley Olson

I hope that the foregoing character sketches and personal anecdotes will convey to the reader at least some feeling for Kuiper's overall personality. As one who worked with varying degrees of closeness (depending on our current projects) with him for over 15 years, I can vouch for their general accuracy and typicality. They may perhaps be biased by the fact that we were all involved more with his scientific side than his administrative side; we were naturally not privy to his dealings and meetings with people on purely administrative and related matters that did not directly concern us, and those who opposed him without good foundation may have seen a somewhat less congenial side of his nature. Conversely, there were occasions when we became irked by Kuiper's actions; we sometimes wished that our residential telephone numbers were inaccessible to him! His whole existence centered around the advancement of our knowledge of the Solar System, and sometimes this led to the postponement of dull chores such as the preparation of funding proposals or progress reports, a type of procrastination to which every one of us can equally plead guilty. There would then be a last-minute rush to beat the deadline, entailing our relinquishing part of what should have been a leisurely weekend or holiday. But these were really only minor irritations, which faded into insignificance when compared with the exciting and fulfilling programs and projects we were involved with.

POSTSCRIPT

This project commenced in December 1981 when Dr. Laurel L. Wilkening, Director of LPL and Head of the Planetary Sciences Department at the time, anticipating the 1985 Centenary/25th Anniversary celebrations, wrote to several people who had dealings with Gerard Kuiper at the beginning of the 1960's soliciting recollections of those early days. "One of the things that I would like to accomplish for this occasion is to get the story of the founding of the LPL written down.". . . "I would like a lively, anecdotal account. Gerard Kuiper's personality played an important role in the success of the Lab as well as some of its problems, and I hope our account will reflect his personality." I wrote similarly to a number of other people but the number of replies with memorabilia or anecdotes was fairly small, which explains the preponderance of my own experiences.

So, please, gentle reader, bear with me if your favorite story about GPK is missing, or if your name is totally missing from this account, even though you may have devoted many years of faithful service to LPL. I have done my best, with the time and materials available, to implement Laurel's wishes quoted above, and I feel that the story is reasonably accurate and complete up to about the beginning of 1962. For anyone wishing to delve a little deeper into the factual history of LPL and Kuiper's dealings with a multitude of people, institutions, agencies, etc., I include an appendix of sources and references that may be useful.

APPENDIX

As noted in the Foreword and Postscript, this account is selective and incomplete. Any future historian who wishes to compile a more definitive treatment will find the task both rewarding and time-consuming. It is hoped that the following lists and notes may prove to be useful in pointing such a person in the right direction to find the right sources of material.

1) The Kuiper Archive

After Ida Edwards, Kuiper's personal secretary, had filed all of his loose papers and other related items into their appropriate places, the whole collection was transferred into cardboard filing boxes, each the size of a normal filing-cabinet drawer, and then placed in the vault in the Special Collections division of the Main Library of this University. There are about 38 boxes in all, the total weighing on the order of a ton. A box-by-box listing of the contents is available there; this listing occupies 40 typewritten pages. The collection contains all of Kuiper's correspondence from the Tucson era, plus much of that from 1927-1960. Some of the earlier letters are held in the Mary Lea Shane Archives at Lick Observatory, U. of California, Santa Cruz, while the remainder are in the Archives of Yerkes Observatory.

Besides the correspondence there are numerous memorabilia such as handwritten notes, programs of meetings, newspaper cuttings, photographs, desk calendars, miscellaneous brochures, etc.; also manuscripts for papers and articles, presentations at meetings, etc.; reprints; proposals; annual reports; grants and contracts; Dictaphone tapes of telescope observations; observing notebooks from 1929 onward; card catalogues of stars; reports on surveys for optimum observatory sites; reports and data on LPL observatories; air pollution surveys, and so on.

2) Other Kuiper Archive items

As of the time of writing, many items have not yet been properly sorted or catalogued, neither do they have a final resting place. These are such things as pieces of original apparatus, a collection of books dealing with the early history of NASA, a large collection of photographic plates and films, mostly taken by Kuiper himself but some of much older vintage, which are currently stored in a chest of drawers in the LPL-Steward Observatory plate vault located in the basement of the Flandrau Planetarium. Also stored there is a valuable collection of movies and tape recordings (both audio and video) of lectures, TV programs, etc., given by or relating to Kuiper, most of which have never been viewed or listened to. Kuiper's disk meter is currently stored at the Mt. Lemmon Observatory. A large collection of 35mm color slides, taken by Kuiper over the years, also resides in the plate vault; it consists mainly of aerial photos of potential sites for telescopes, or of geologically interesting features, together with shots of dome construction, etc.

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AFTERWORD

to

Ewen Whitaker's History of LPL's Founding

Eugene H. Levy
Department Head & Laboratory Director
Department of Planetary Sciences
University of Arizona

AFTERWORD

This history of the founding of the Lunar and Planetary Laboratory would not be complete without a few words about the years since 1972. I will not attempt a detailed review of this more recent history here. Rather, I think it illuminating to describe briefly what the Laboratory and Department have become during the intervening years. Gerard Kuiper's goal, to establish an academic department, was realized with the founding of the Department of Planetary Sciences. In 1972, the Department and the Laboratory were established as a combined entity, within the University, dedicated to education and research in the planetary sciences.

The first Department Head and Laboratory Director to lead the combined units was Charles P. Sonett, a prominent and accomplished scientist who had played a leading role in space and lunar science during the previous fifteen years. Sonett brought a broad scientific perspective to the job, with which he and the initial faculty built on the Laboratory's already outstanding base of planetary astronomy, and began a period of important intellectual growth for the combined Department and Laboratory. The scientific path along which LPL and the Department had been started by Kuiper and Sonett has been followed under the leadership of William B. Hubbard and Laurel L. Wilkening, before me.

Today LPL and the Department carry out an integrated program of education and research in Solar-System science. This broadly construed program encompasses a wide range of science, with faculty and researchers drawn from the disciplines of astronomy, chemistry, geology, and physics, having their common interests in Solar-System research.

There are now approximately 25 research faculty in the Laboratory; some fifteen of those also hold professorial appointments in the Department. Together with some twenty additional research staff, postdoctoral associates, and technical staff, as well as clerical and administrative personnel, the Department and Laboratory staff totals about 140.

The academic department is devoted largely to the graduate program which, for some years, has been held to a steady enrollment of about 25 graduate students. The primary aim of the graduate program is to train students for careers in scientific research; most of the graduates go on to positions in universities or research laboratories. In addition, the Department offers several undergraduate courses to University students.

The scientific development of LPL and the Department mirrors the overall intellectual development of planetary science. Indeed, University of Arizona scientists have helped to shape the course of modern planetary science, both by their scientific contributions and by their participation in national and international planning councils for space science.

Modern planetary science is concerned with the origin and evolution of the Solar System, the formation of the planets, satellites, and minor bodies of the Solar System, the processes of planetary evolution, the present states of the planets, and the physical processes which characterize Solar-System phenomena.

As our knowledge of planets has grown in detail, planetary and Earth science have developed a host of important connections. Many physical planetary processes can be approached in their truly scientific generality, observed on several planets under a variety of circumstances. As our knowledge of the early Solar System—during its birth—becomes deeper, and as astronomical observations of protostellar objects become available, planetary science and stellar astronomy are also developing many close connections. Today, we think of the Solar System as one instance of a, hypothetically, more general class of planetary systems; work is now beginning to explore the skies for planetary systems of other stars, and to undertake detailed studies of the systems that will be discovered.

In 1960 the empirical foundation upon which planetary science was built consisted of the relatively limited information which could be gained with crude astronomical instruments from beneath Earth's atmosphere. Some extraterrestrial matter—from meteorites—was available on Earth for analysis; but the analytical capabilities with which meteorites could then be examined were still relatively crude. The technical capabilities available to planetary science in 1985 far exceed those of 1960. LPL's research program has expanded in scope to keep step with, and often to lead, this scientific advance. In 1985 the research program encompasses extensive laboratory and theoretical work in addition to astronomical observations. Spacecraft-borne instrumentation and data from spacecraft missions also loom large in LPL's scientific research.

LPL's planetary astronomy includes a vigorous program of asteroid studies, ranging from visual and infrared spectrometry to innovative techniques developed for the discovery of near-Earth asteroids. Along with the asteroid scientific research, some LPL efforts are directed at developing approaches to the possible exploitation of asteroids as a material resource for future space activities. The Laboratory is involved in the recent renaissance of comet science, which is largely provoked by the 1986 apparition of Comet Halley and by the realization that comets are critical to our understanding of primordial Solar-System matter. One leader of the International Halley Watch is on the LPL research staff; several LPL scientists are participating in the Soviet Union's VEGA mission to Comet Halley. Plans are being made to propose LPL's participation in NASA's anticipated Comet Rendezvous Mission.

Ground-based astronomical observations of the planets remain a rewarding endeavor. Observation of stellar occultations by planets has been developed, at LPL, to the point that significant information about planetary internal structures is being extracted from the planetary figures obtained through occultation measurements. Earth-based spectroscopic observations continue, in LPL's 25th year, to make important contributions to our understanding of Solar-System objects and their atmospheres. Planetary astronomy has moved into space in a big way—along with the general move of space science into space, which was enabled by the advancing technology of the latter part of the twentieth century. The Laboratory participated in the Pioneer and Voyager Projects, which acquired imaging and other data that created entirely new levels of understanding of several planets. Because of such investigations, the Jovian and Saturnian systems are no longer mere patches of luminous fuzz in a telescopic image seen through our own murky atmosphere; rather they are known to be systems rich in dynamic behaviors which push us toward deeper levels of understanding.

The move into space has done more than sharpen our images of previously fuzzy objects. The opening of new spectral windows brings whole new domains of planetary phenomena under our scrutiny. The Lunar and Planetary Laboratory has a major program in ultraviolet space astronomy. An ultraviolet instrument mounted aboard the Voyager Spacecraft studies the relatively high-energy processes in planetary upper atmospheres. Infrared studies, using data from the Infrared Astronomical Satellite, are expanding our understanding of asteroids.

The Department and Laboratory have a distinguished tradition of construing the range of their activities broadly. Research groups are encouraged to pursue lines of scientific inquiry at the peripheries of their main research. This is one of the means through which critical intellectual ties, to both Earth-science and stellar astronomy, have been established and maintained. These ties are essential to the unified approach to planetary science practiced at Arizona: an approach which seeks to investigate the Solar System—including Earth—in its cosmical perspective. In the ground-based and space-based astronomical programs, several areas of stellar and interstellar research occupy important positions in LPL's program. Infrared studies of star-forming nebulae have been carried out with Earth-based instruments; studies of stars are an important component of the space-based ultraviolet-astronomy program. This broad practice permeates throughout LPL's programs, as will be mentioned presently.

Spacecraft enable a wide range of planetary investigations. Among the most riveting experimental developments is the advent of *in situ* planetary studies, in which the human empirical presence is extended to distant objects through the use of automated scientific instruments. LPL participated in the Pioneer-Venus mission with a project to measure radiation transport directly on a probe into the Venusian atmosphere.

In the future, we expect LPL to expand its scientific activities in space. At the time of this writing, plans are being put together for ultraviolet investigations of Mars and of a comet, using instruments on deep-space spacecraft. Earth-orbit-based observations of the upper atmosphere and of deeper space are being planned for Space-Shuttle and Space-Station-based instruments. In the area of cosmochemistry, also, the Laboratory is planning an expansion into space-based research. Proposals are being prepared for participation in the chemical analysis of the Martian surface and of cometary material through the use of a gamma-ray spectroscopic technique.

The new research thrust toward *in situ* cosmochemistry is an outgrowth of LPL's existing program of laboratory cosmochemistry, which was instituted in LPL at about the time that the Department was established. At present, LPL has two major laboratory cosmochemistry programs, focused on the intensive analysis of ancient extraterrestrial matter—meteorites and lunar samples—and including the supporting research necessary to interpret analytical findings. The goals of this research are to discover what conditions characterized the protoplanetary nebula before and during planet formation, and to understand the evolution of the Moon and terrestrial planets. Chemical and physical analyses of extraterrestrial matter have proven to be extremely revealing of the history of the Solar System and the planets.

One of the most exciting new areas of planetary research is aimed at the discovery and study of planetary systems around other stars. This is an area in which LPL pioneered. A program to develop techniques for the detection of planets about other stars was begun in the early 1970's. That program is just now coming to fruition as an exquisitely sensitive device for measuring the oscillatory radial velocity of stars is beginning to take data; an oscillation in the radial velocity of a star is a signal of a companion orbiting about it. A new program recently begun at LPL is exploring the development of a new generation astrometric telescope to be flown in space for the purpose of discovering and carrying out detailed studies of other planetary systems.

The origin and evolution of planetary systems is closely entangled with the behavior and fate of circumstellar solid matter. During the past few years techniques have emerged for the detection and investigation of such material. Indeed, the first real image of a dusty disk around a main-sequence star was obtained recently with an instrument designed and built in the Laboratory. Research is underway to discern whether such disks signal the presence of associated planetary systems.

The Laboratory maintains several programs of solar, interplanetary, and magnetospheric physics. The long-term behavior of the Sun is being investigated through the use of surrogate geological indicators of climate and solar activity. Theoretical studies in the Laboratory have elucidated possible causes of some of the observed cyclical behaviors of the Sun. Planetary upper atmospheres and magnetospheres research is carried out with a heavy emphasis on data returned from spacecraft missions. The Pioneer and Voyager missions have played a large role in this work; the soon-to-be-launched Galileo mission will further LPL's research in studies of Jupiter's magnetosphere, as well as studies of the planet's atmosphere.

Theoretical investigations of cosmic rays, at LPL, as well as of the interplanetary and interstellar media have led to important new understandings of cosmic-ray modulation and acceleration in the Solar System and in the galaxy. Observational investigation of the heliosphere will be carried into the third dimension by the International Solar Polar Mission, to be launched in 1986. Information obtained through that project is expected to provide important tests of some of the ideas developed at the Laboratory during the past decade. Several LPL scientists are participating in the project.

At LPL, theoretical studies of the behavior of matter, under the high pressures and temperatures which occur in planetary interiors, are combined with structural models to investigate interiors of the giant planets. An understanding of the structure and evolution of giant-planets' interiors is expected to provide clues about their formation during the birth of the Solar System. Investigations of the origin and behavior of cosmical magnetic fields encompasses the terrestrial magnetic field, as well as that of the planets, the Sun, and protostellar nebulae.

Geophysical research in the Laboratory includes studies of the physics of impact-cratering on planets and the fate of high-energy ejecta from craters. The possibility that crater ejecta from other planets—notably Moon and Mars—has made its way to Earth has been the subject of recent inquiry. Provoked largely by morphological studies of lunar craters and landslides, a novel theory of landslides and earthquakes has recently been developed. Studies of the chemical and physical mechanisms responsible for the formation of the Solar System and its constituent bodies are being pursued from several directions in LPL. This research ranges from studies of the Moon and other planetary satellites.

Altogether, the research programs of the Department and Laboratory encompass an impressive range of science. The faculty and research staff are making numerous important contributions to the advance of understanding about the Solar System and related scientific subjects. Students trained to the Ph.D. here are taking their places among the young leaders in planetary research. This small book has told the story of LPL's founding. That story has significance less for the events themselves than for what those events ultimately led to. The founding and early years of the Laboratory were a prelude. That prelude was followed by the growth of a distinguished academic and research program in the Department and Laboratory—a program built on an increasingly rich set of themes. This is the legacy of the Lunar and Planetary Laboratory's early years. As LPL moves into its second quarter century, the present staff is challenged to carry on with a level of scholarship and research that will add further significance to the story so ably told here by Ewen Whitaker.

Tucson, August 1985
Eugene H. Levy
Department Head & Laboratory Director