NATIONAL ACADEMY OF SCIENCES

ALBERT EDWARD WHITFORD
1905–2002

A Biographical Memoir by

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Biographical Memoirs, VOLUME 85

PUBLISHED 2004 BY
THE NATIONAL ACADEMIES PRESS
WASHINGTON, D.C.

A. E. Whitford

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ALBERT EDWARD WHITFORD

October 22, 1905–March 28, 2002

BY DONALD E. OSTERBROCK

ALBERT E. WHITFORD WAS born, raised, and educated in Wisconsin, and then made his mark as an outstanding research astrophysicist there and in California. As a graduate student in physics he developed instrumental improvements that greatly increased the sensitivity of photoelectric measurements of the brightness and color of stars. For the rest of his life he applied these and later even better tools for increasing our knowledge and understanding of stars, interstellar matter, star clusters, galaxies, and clusters of galaxies, from the nearest to the most distant. He became a leader of American astronomy, and his counsel was sought and heeded by the national government.

Albert was born in Milton, Wisconsin, a little village halfway between Madison and Williams Bay, where Yerkes Observatory is located. When Albert was born, his father, Alfred E. Whitford, was the professor of mathematics and physics at tiny Milton College, and *his* father, Albert, for whom our subject was named, had been the professor of mathematics before him. Albert's mother, Mary Whitford Whitford, was his father's second cousin from Rhode Island, and he had one sister, Dorothy (later Lerdahl). Albert's Aunt Anna was the professor of German at the college, and his great-uncle, William C. Whitford, had been its first president. Young Albert grew up in a highly academic, small-college environment.

He entered Milton College in 1922; by then his father had become its president but still taught some classes. The young scion of this family was a star student, and after completing his B.A. in 1926, he went on to graduate work in physics at the University of Wisconsin. The level of the courses there was considerably higher than at Milton. Charles E. Mendenhall was the long-time chairman of the department; he and most of the other professors concentrated largely on experimental physics while theorist Edward H. Van Vleck taught nearly all the more mathematical subjects. Albert's progress slowed down but he never had any trouble with the courses. He was a motivated student who knew how to study, learn the material, and retain and use it. He finished his M.A. in 1928 and his Ph.D. in 1932, six years after his bachelor's degree, considered a long time back then. But, he had done very good work and opened up a new field for himself along the way.

In 1929 at the start of his fourth year at Madison, Whitford learned that Joel Stebbins, the professor of astronomy and director of the university's Washburn Observatory, was looking for a physics-graduate-student assistant. Stebbins was the U.S. pioneer of electrical (or electronic) astronomical photometry, measuring the magnitudes (or brightnesses) and colors (color indices) of stars. He had begun with selenium photoconductive cells, and then switched to more sensitive photoelectric cells, placed at the focus of the telescope. In 1929 he was still using a sensitive quartz-fiber electrometer to measure the voltage generated by the weak current from the photocell, proportional to the brightness of the star. No doubt on the advice of his colleagues in the physics department, Stebbins had decided to try a more up-to-date technique. By 1929 research physicists were using vacuum tube circuits to measure weak currents, and he wanted to hire a knowledgeable graduate student to design and build a good one for him. Whitford, who had not gotten an assistantship in physics that year, needed a job and he gladly took it in astronomy.

Whitford got the assistantship, tackled the problem, and solved it. It was not easy, but he had the right experimental approach, seeking all the advice he could, reading the latest papers, wiring a trial amplifier setup, and modifying it until he had one that worked. He put the photocell in a vacuum-tight chamber and evacuated the air around it, thus reducing the noise due to electrons produced by cosmic rays striking nitrogen and oxygen molecules. With these improvements Whitford increased the sensitivity of Stebbins's photometer by a factor of nearly four, so that he could measure stars 1.5 magnitudes fainter than before. This made a tremendous increase in the number of accessible objects and correspondingly in the accessible volume of space. Whitford published a paper on these instrumental improvements as part of his Ph.D. thesis in 1932. Back then a physics thesis at Wisconsin required new experimental results to go with a new instrument design. It is not clear whether results from a telescope would have qualified, but in any case there was no time for that. Hence the other part of his thesis was a more traditional paper on laboratory spectroscopy of the Zeeman effect in K II, which he did with the physics department's large Rowland-circle photographic spectrograph.

When Whitford finished his thesis in 1932, the United States was in the midst of the Great Depression. Jobs were hard to find everywhere, especially in universities for fresh Ph.D.s. Stebbins could keep him a year as an assistant on the same job he had held as a graduate student, and was eager to do so. The older man, a highly creative research scientist and an excellent observer, was a tyro in electronics.

He knew that he could not keep the photometer and amplifier in operating condition by himself, but Whitford certainly could and, furthermore, would probably come up with still more improvements. Moreover, Stebbins, a power in U.S. science, promised to recommend Whitford for a National Research Council Postdoctoral Fellowship, to start in 1933. The young Ph.D., with no other options before him, readily agreed and decided to become an astronomer, at least for the time being. He began designing and building better amplifiers and cold boxes for the photometers in the string-and-sealing-wax type shop he had inherited in the basement of old Washburn Observatory.

In 1932 planning for the 200-inch telescope was well underway in Pasadena, under the leadership of George Ellery Hale, who had secured the funds necessary to build it from the Rockefeller Foundation. He and everyone else connected with the project realized that the surprising velocity-distance relation for galaxies that Edwin Hubble had recently discovered with the 100-inch Mount Wilson reflector would be a key to understanding the nature of the Universe. Its study would be one of the big tasks for the 200-inch when it was completed, and Stebbins's photoelectric photometer would be one of the prime tools to carry it out. Stebbins understood this, too, and used it to gain access to the 60- and 100-inch telescopes, as preliminary work on this and other observing programs that would enable him and Whitford to use the instrument and thus gain experience and insights on how to make it better. With Hale and Stebbins's recommendations, Whitford got the NRC fellowship and spent two years at Caltech and Mount Wilson.

During his three postdoctoral years in Madison and Pasadena, Whitford learned astronomy from the ground up pretty much on his own. There was no graduate program in it at either Wisconsin or Caltech (except one astrophysics course at Caltech taught by Fritz Zwicky), and Whitford learned it by hard study, reading papers, and discussing them with Stebbins and the Mount Wilson astronomers. He kept a bridge open to physics too, doing a research project in laboratory X-ray spectroscopy of high stages of ionization of K (VI through IX) and Ca (VII and VIII). This was a specialty of Robert A. Millikan's physics laboratory at Caltech, where most of the experimental work was done by his former graduate student, currently his young faculty colleague, Ira S. Bowen (later director of Mount Wilson and Palomar observatories). Whitford got to know Bowen, as well as several of the Mount Wilson astronomers, especially Walter Baade and Hubble. The young postdoc lived in the "loggia," a large sleeping room for young single men upstairs in the Athenaeum, the very new Caltech faculty club. The friend Whitford always remembered from there was William A. ("Willy") Fowler, then a boisterous, outgoing physics graduate student, always the center of mischief and pranks designed to disturb the calm quiet that permeated the club but a star experimental student in the lab. Whitford also formed a lifelong friendship with Olin C. Wilson, who was a Caltech graduate student, received its first Ph.D. in astrophysics, and went on the Mount Wilson staff.

Whenever Stebbins could get leave from his teaching duties and come out to observe with the big Mount Wilson telescopes, Whitford would prepare for weeks in advance to be certain that all their apparatus was in working order and that supplies they would need were in place on the mountain. He would work at the telescope with Stebbins all night, troubleshooting and solving any electronic problems that arose. They were taking data with a galvanometer mounted rigidly in the dome, reading the voltage built up across a load resistor in a time signaled by a stopwatch, and recording the numbers by hand throughout the whole night. One of the first objects they measured at Mount Wilson was M 31, the Andromeda galaxy. Moving the telescope across it in right ascension and declination they traced how much larger it is, out to the faintest level, than is easily detectable on photographs. On his return to Madison in 1935 Whitford was promoted to research associate, a full-time position, and in 1938 to assistant professor of astrophysics, a new title at the time.

He continued observing with Stebbins, using the Washburn Observatory's 15.6-inch refractor whenever they could not get to Mount Wilson to use the bigger telescopes there. Chiefly they were measuring the "extinction" (absorption and scattering combined) of starlight by interstellar dust. This had been discovered by Robert J. Trumpler, using photographic photometry, but the photoelectric method Stebbins and Whitford had developed was much more accurate and thus provided better quantitative data on it.

In 1937 Whitford married Eleanor Whitelaw, whom he had first met as the sister of one of his fellow physics graduate students at Wisconsin, Neil Whitelaw. Born in Desoto, Kansas, she was a graduate of nearby Park College (Missouri); she earned a master's degree in education at the University of Chicago, where she worked in admissions before they were married.

In 1940, with war clouds looming over the United States, and France already fallen to Nazi Germany, Whitford was recruited as an experimental physicist to join the new Radiation Laboratory at MIT, the center for development of radar in the United States. He was convinced it was his duty to go. He, his wife, and their infant son, William, named for Albert's great-uncle, the first president of Milton College, moved to Cambridge, where he worked under wartime conditions until the end of 1945. The Whitfords' two daughters, Mary and Martha, were born there.

Albert had no time for astronomical research, though he did participate in writing parts of two papers with Stebbins on their results, all by correspondence. Two friends from the Wisconsin physics department, Ragnar Rollefson and Ray Herb, were at the Radiation Laboratory with him, and the three of them with their families kept in close touch with one another and with what was happening back in Madison. Very occasionally Whitford could get away from the laboratory for a few hours to attend an astronomy colloquium at Harvard, but otherwise he worked long hours six days a week He made one extended field trip to England to install a new high-frequency radar system in antisubmarine search planes and to train their crews in using and maintaining them.

When the war ended, Whitford was tempted by a job offer from Los Alamos, and then by a faculty position at Purdue University, both in physics, but by then he had become an astronomer, he finally decided. Like F. W. Bessel a century before him, he "chose poverty and the stars." And in fact the University of Wisconsin's central administration, worried by predictions of a postwar recession and a drop in student enrollment, was not very welcoming. The first idea that President E. B. Fred floated was for Whitford to be given a joint appointment in astronomy, physics, and electrical engineering. He refused it, and Stebbins worked successfully to get him back full-time in astronomy So Albert returned to Madison, still an assistant professor until the fall of 1946, when he was promoted to associate professor of astronomy. No doubt he suffered financially because of his strong attachment to Wisconsin.

He became more and more involved in measuring extinction by interstellar matter. The idea is simple: Light from a distant star shining through dust is absorbed or scattered more effectively at short wavelengths than at long, leaving radiation that has passed through it "reddened" because more blue light than red has been removed from it. We see this with our eyes whenever we look at the Sun close to the horizon, where the light is shining through a long path in the dust-laden air. Thus, comparing stars with the same intrinsic spectrum, the reddened one is the one whose light has passed through more interstellar matter containing dust, and the bluer is the one whose light has passed through less of it. Very nearby stars with no dust between them and us show their intrinsic colors, which are also the intrinsic colors of other stars "just like" them, that is, stars of the same spectral type.

Stebbins had begun this work with C. Morse Huffer, formerly his graduate student at the University of Illinois, who had come to Madison with him and in 1926 had earned the first Ph.D. in astronomy conferred by Wisconsin. Huffer had remained there on the faculty and observed eclipsing variables with Stebbins. Later they worked on interstellar extinction, but after Whitford's appointment as the junior member of the three-man astronomy faculty, Huffer had concentrated mostly on the variables. Stebbins's and Whitford's early observations were with two color filters, both in the blue spectral region where their photocells were most sensitive. Such measurements provided only a limited baseline for detecting interstellar reddening. As newer cells with extended sensitivity became available in the late 1930s, they started using their "six-color photometry," with bands ranging from the ultraviolet to the (near) infrared. During World War II, U.S. physicists developed highly sensitive infrared detectors for night warfare, and Whitford, aware of these advances, alerted Stebbins to their potentiality for astronomical research. They were hard to obtain and even harder to use effectively, but Whitford's contacts and electronic expertise were just what was needed. He and Stebbins used a PbS cell of this type, working at 2 μ, to penetrate through all the interstellar matter between us and the region around the center of our Galaxy. The early blue measurements of Stebbins, Huffer, and Whitford had proved that interstellar dust lies near the galactic plane, unevenly distributed in patches and "clouds," but that statistically the amount of it along a ray increases with distance. The total extinction along the line to the galactic center is about 25 magnitudes (a factor of 10^{10}) in the visual wavelength region, but is much smaller at 2 μ. Stebbins and Whitford traced the isophotes from their infrared measurements and showed the "bulge," the central part of the halo of our Galaxy, is analogous to the central part of the halo of M 31, seen from our vantage point outside it.

Stebbins retired in 1948 and on his strong recommendation, and the recommendations of several outside senior astronomers, Whitford was named director of Washburn Observatory and was promoted to full professor of astronomy. He analyzed all the photometric data they had on the wavelength dependence of the extinction and showed that it was, to a first approximation, the same in most directions out to all the distances they could measure, at most 2 kpc. This meant there was only one type of dust in those regions, at least in its extinction properties between 3000 Å and 2 μ. This "Whitford interstellar absorption curve" was used by astronomers studying galactic structure and the nature of interstellar dust for decades, until it was extended by new results in the ultraviolet spectral region obtained from orbiting telescopes above the Earth's atmosphere. Whitford was aware of a few anomalous regions in which the extinction was somewhat different, and mentioned them also.

Perhaps the least exciting photoelectric-photometry program that Stebbins and Whitford began, but also one of the most important ones, was measuring accurately the magnitudes of the stars in the North Polar Sequence. These had been adopted years earlier as the standards defining the photographic magnitude system. The idea was that they would always be observable, any time of the night or year, from anywhere in the Northern Hemisphere, and the sequence covered a large range in magnitude, from bright stars to very faint ones. In reality *one* star plus the definition of the magnitude scale are all that is needed, but the sequence was supposed to provide standard stars at all magnitudes that could be observed. It had been set up, mostly at Mount Wilson for the fainter levels photographically, but because of the nonlinearity and other difficulties of that method, it needed checking. Hubble and Baade wanted Stebbins to make this his top-priority observing program at Mount Wilson, and since he used the telescopes there as a guest observer, he listened seriously to what they said. They could use only the 60-inch reflector for this program, because the double-yoke mounting of the 100-inch telescope prevents it from reaching the north polar cap. Even with the 60-inch it is difficult to set onto a star near the North Pole, and time consuming to move from one star to the next. But they did the measurements whenever they could, and their results showed that in fact large errors existed at the faint end of the North Polar Sequence (with respect to the brightest stars in it, which were taken to define the zero point). These errors clearly affected the accuracy of Hubble's velocity-distance relationship, which depended on the measured magnitudes of the galaxies.

Baade favored setting up standard magnitude sequences to faint levels in a few of the more conveniently placed Selected Areas, defined originally by J. C. Kapteyn. Whitford continued this work with Harold L. Johnson, who was briefly at Wisconsin, appointed to the faculty position left open by Stebbins when he retired. They published the results for

Selected Areas 57, 61, and 68, the three considered best located in the sky by Baade in 1950. This program was then continued independently by William A. Baum, who had been added to the Mount Wilson and Palomar observatories staffs to do photoelectric photometry.

Undoubtedly the program Whitford liked best was measuring photoelectrically the magnitudes and colors of galaxies, still called "extragalactic nebulae" by most astronomers in the 1930s though they knew from the then-recent work of Hubble that they were galaxies and that our Milky Way Galaxy was one of them. It was a new, wide-open subject, the study of the whole Universe. Stebbins had tried to measure a few of the brightest galaxies in 1930, but his system, based on an electrometer, evidently was not sensitive enough to touch them, even with the 60-inch Mount Wilson telescope, for he never published any results from that trial. With the new amplifier Whitford had developed they could easily measure fairly bright galaxies. Whitford, who stayed in Pasadena most of the time from 1933 to 1935, measured the nearest, brightest galaxies on his own at Mount Wilson, using its photometer mounted on a 10-inch refractor, which was only infrequently used by other observers and thus usually available to him. He could experiment and tune up the apparatus as he collected data with it. This small telescope, with a correspondingly short focal length, was good for his program, because its small images of these nearby galaxies would fit into the diaphragm and the photocell. Hence he could measure these galaxies in just the same way he and Stebbins measured the apparently smaller, more distant galaxies with the larger 60- and 100-inch reflectors. The nearest of all, M 31, Whitford measured with a still smaller telescope, a 3.5-inch commercial lens with a correspondingly smaller focal length, and hence smaller image of the galaxy. In addition, Stebbins and Whitford traced across

M 31 with the 60-inch, integrating its light over its whole area.

Whitford's paper on the brightest galaxies, published in 1936, was his first solo publication on astronomical measurements. He and Stebbins published their paper on the big-telescope results in 1937; altogether it included 165 galaxies, together with the 11 in Whitford's paper. For many years these were the best magnitudes by far for calibrating the velocity-distance relationship. They had also measured color indices for most of these objects, which showed that as a group, E (elliptical) galaxies all had closely the same color, as did Sa and to a lesser extent Sb ("early-type") spirals. The Sc ("late-type") spirals were more heterogeneous, corresponding to the fact that they contain many more resolved supergiant stars than the other types. Stebbins and Whitford also showed that the few galaxies they could observe near the edges of the obscuring clouds of the Milky Way were reddened, just like the distant stars in our Galaxy they had previously observed, but there was no sign of intergalactic extinction.

After World War II Whitford concentrated more on galaxies and interstellar extinction with their new six-color photometric system, while Stebbins, approaching retirement, concentrated more on nearby stars and Cepheid variables. Together they found that E, Sa, and Sb galaxies tended to be brighter in both the ultraviolet and infrared spectral regions than G dwarf stars with similar colors in the blue and visual regions, and interpreted it as resulting naturally from a mixture of stars with all colors. As they measured galaxies with large redshifts (for that time, though very small in terms of the later-CCD era that Whitford lived into), they found the colors of the distant galaxies did not match those of the nearby ones, redshifted by the expansion, the so-called "K correction." The additional reddening and its interpretation came to be called the "Stebbins-Whitford effect." Theorists and cosmologists puzzled over it, as Whitford and Stebbins did, but it was an observed result, and they published it. Ultimately, in 1956, Whitford himself discovered the cause of the effect. It was not real, though their observational data were correct. The near ultraviolet spectra of galaxies, composites of stellar spectra, are full of discontinuities and groups of strong absorption lines, not smooth continua at all. Measured through a broad ultraviolet filter, they could not really be represented by a single effective wavelength, and it was impossible to calculate the true effect of the redshift on their light as if it were. Whitford and Arthur D. Code, who had replaced Johnson on the UW faculty in 1951, had built a one-channel scanning photoelectric spectrometer for use on the Mount Wilson telescopes, and with it Code obtained a scan of M 32, the nearby bright elliptical galaxy companion of M 31. Numerically redshifting this scan, which showed the discontinuities and absorption features in the near ultraviolet region, Whitford saw that it reproduced the observational data well. There was little if any Stebbins-Whitford effect in the distant galaxies, as Whitford, Code, J. Beverly Oke, and Allan Sandage subsequently confirmed in detail.

Whitford's other favorite, closely related observational program was the structure of our own Galaxy. His work was also linked to his studies of interstellar extinction, which hides distant objects near the galactic plane, as he knew better than anyone else. He had realized, even before World War II, that the spectral types assigned to distant OB stars by W. W. Morgan, observing at nearby Yerkes Observatory, were much more accurate than the older Harvard and Mount Wilson types. Whitford knew this because his color indices, reddening, and extinction determinations based on the Yerkes types showed less observational scatter than those based on the older types. From then on, Whitford and Stebbins used Morgan's types (which he furnished them before publication) and he used their extinction determinations. Morgan's first identification of spiral arms near the Sun in our Milky Way depended heavily on the Wisconsin photoelectric measurements, and Morgan, Whitford, and Code coauthored the definitive papers on this subject.

Likewise when Baade was able to locate large numbers of RR Lyrae variables close to the galactic center (itself hidden by large amounts of extinction right in the galactic plane), Whitford supplied the color measurements that made it possible to estimate the extinction along the line of sight to this concentration of Population II objects close to the nucleus. There were no normal OB stars observable there, but using the 100-inch telescope with his most advanced photoelectric systems, Whitford was able to measure the color of a globular cluster just beyond them. With the resulting extinction value Baade gave the distance to the galactic center as 8.3 kpc, a value that has held up for many years.

At the end of May 1948, as Stebbins approached retirement, President Fred summoned Whitford to his office for two long interviews. Albert stated his goals for the university's astronomy program as continuing as the leader in photoelectric photometry in America, frequent observing trips to use the big telescopes in California, and a new reflecting telescope about 36 inches in diameter at a dark-sky site off the campus but near Madison. It would replace the antiquated 15.6-inch refractor on Observatory Hill, which he had regarded as a relic ever since he first saw it as a graduate student in 1929. At this conference Whitford also agreed (and in fact strongly favored) incorporating Washburn Observatory into the College of Letters and Science. Under Stebbins and the earlier directors it had the status of a separate research organization directly under the president, though the director had regular teaching duties in the college. Whitford's appointment as director dragged on all summer (most of which he spent at Mount Wilson). Even after his return the observatory remained rudderless, probably because of its transfer to Letters and Science. Finally in October 1948 the Board of Regents promoted him to full professor (though without any salary increase) and named him observatory director. Stebbins had resisted integrating it into the college, preferring to keep it as his own independent research base, but Whitford realized that teaching more undergraduates and training graduate students in a regular program were important parts of a university and would lead to increased support.

Whitford, given the go-ahead by Fred, assigned Ted Houck, then a graduate student, soon to become Wisconsin's third Ph. D. in astronomy, to search for a dark site in the still largely rural area west of Madison. Using a portable photoelectric photometer Houck measured the sky brightness at numerous locations, and eventually Whitford chose Pine Bluff, on a hill some 15 miles from the campus. In 1950, when an opportunity arose to have a 36-inch primary mirror made for a low price at the Yerkes Observatory optical shop, Whitford got Fred's permission not only to order it but also to put it on the university's priority list for $275,000 from the Wisconsin Alumni Research Foundation, Wisconsin's own "little NSF," to start building the observatory. By 1952 the proposal had worked its way to the action part of the list, and Whitford with help from Code and Houck prepared a conceptual plan that was approved, and the foundation granted the money. Whitford planned and oversaw the construction of the 36-inch telescope optimized for photoelectric photometry and spectrophotometry, spending huge amounts of his time and effort on the project. The National Science Foundation provided additional funds, and it was completed in June 1958 and was dedicated at a meeting of the American Astronomical Society in Madison, just as Whitford himself was leaving for a new post as director of Lick Observatory, of the University of California. Pine Bluff Observatory was his legacy to Wisconsin, and Code, Houck, and other new arrivals, including myself, used it effectively with graduate students to build up the University of Wisconsin as a real power in astronomy.

Whitford and his wife loved Wisconsin and hated to leave Madison, but he believed that taking either the Lick directorship or the directorship of the new National Radio Astronomy Observatory, which he had been offered at about the same time, was his duty. He knew optical astronomy very well indeed by then and felt he could make a bigger contribution at Lick. It was a prestigious old research institution, still using telescopes built in the previous century. Its astronomers were waiting impatiently for a new 120-inch reflector to be finished, which when completed would be the second-largest telescope in the world. Probably the reasons Whitford was chosen to succeed C. Donald Shane, who was stepping down after 12 years as director, were his drive and mechanical knowledge, demonstrated in getting the Wisconsin 36-inch reflector and its auxiliary instruments completed on schedule. Two members of the Lick faculty, Olin J. Eggen (UW's second Ph.D. in astronomy) and Gerald E. Kron (who had earned a master's degree in astronomy there), knew him especially well, and his research qualifications were extremely high (he had been elected to the National Academy of Sciences in 1954). In addition, Stebbins was spending his postretirement years in California near Lick and visited it frequently. He had recommended Whitford strongly for the directorship. At Lick Whitford took hold immediately, plunged into the details of the telescope construction and optics, and got rid of one highly placed engineer. The new director had the telescope completed in 1959 and taking data on a regular basis in 1960. Before long, astronomers not only from Lick but from other University of California campuses, too, were using it for frontier research on stars, clusters, galaxies, and quasars.

Whitford was completely dedicated to astronomy, knew it very well, and worked hard at it. He was highly intelligent and had unmatched integrity. Astronomers trusted his judgment. In the 1950s, as one of the few Midwestern astronomers with a proven big-telescope research record, he played a leading role in the conferences and discussions that resulted in the founding of Kitt Peak National Observatory, later to become the nucleus of the National Optical Astronomical Observatories. Whitford served as a highly active, strongly research-oriented member of its Board of Directors as long as he remained at UW. For all these reasons he was chosen to head the first organized survey of the needs of U.S. astronomy, sponsored by the National Academy of Sciences. The panel he chaired included many of the leaders of all fields of astronomy. Under his leadership they held hearings and sought the views of research workers throughout the country. Whitford pushed for open democratic discussions and sought the views of all. The resulting "Whitford Report," published in 1964, became the overall guide to National Science Foundation priorities for a decade. It was highly successful, and as a result similar panels were set up in other fields of science; in astronomy a new survey was made each decade, successively headed by Jesse L. Greenstein, George B. Field, and John N. Bahcall.

Within a few years of his arrival at Lick Observatory, Whitford had a new, unexpected problem to deal with. The University of California administration, headed by President Clark Kerr, who took office in Berkeley in 1958, simultaneously with Whitford on Mount Hamilton, decided it did not want to continue Lick as a freestanding research institution with no students, reporting directly to the president. It and the Scripps Institution of Oceanography in La Jolla, the only other large unit of this type, were to become parts of the University of California campuses. Scripps became the nucleus of the new, science-oriented University of California, San Diego, and Lick was to be part of a completely new campus in the San Jose area. The site selected, Santa Cruz, was about 70 miles from Mount Hamilton, and all the faculty members who lived in the little astronomy village there would teach and have their offices on the campus. Several of the astronomers had lived on the mountain for years and liked it and the freedom they had to spend all their time on research. There was strong resistance to the idea of the move from some of them. Whitford, however, knew it was his duty to lead them to the campus and he did so in his businesslike way, assigning duties in planning the move to each of the senior staff members. A few of them left Lick Observatory and the University of California at that time, a few others grumbled but gave in, and the rest looked forward to being on a campus with professors in other fields and undergraduate students to teach. Whitford's leadership strengthened this group and did much to make the move a real success.

In the fall of 1966 the Lick faculty and staff moved down to the new campus in the redwoods. Chancellor Dean E. McHenry, supported by President Kerr, was innovative, putting into practice many "progressive" ideas for the 1960s, such as not having "old-fashioned" departments nor many required courses, and doing away with letter grades. Whitford, who had grown up at Milton College and spent 30 years at the University of Wisconsin, was used to being on a campus and knew what would be required. More than a year before the move Whitford had asked Peter Bodenheimer, then close to finishing the Ph.D. in theoretical astrophysics at Berkeley, whether he would be interested in a faculty job at Lick. Bodenheimer was, and after two years as a postdoctoral fellow at Princeton University he was back at Santa Cruz as the first theoretician on the Lick faculty. Graduate courses in astronomy and astrophysics started in 1967, with a first contingent of nine new students. There was no department, these were passé at Santa Cruz, but there was a "Board of Studies in Astronomy and Astrophysics" that looked like a department, acted like a department, and worked like a department, and included all the Lick faculty members. It was a separate unit, organizationally independent of Lick, but with almost complete overlap of membership with it. Whitford supported the new board strongly, did his share of the teaching in it, and provided sound advice and guidance to the "conveners" (as chairs were then called) beginning with George W. Preston. Whitford strongly approved the proposal for a large National Science Foundation "departmental improvement grant," which provided startup funds and the impetus to add several more theoreticians to the board faculty over the next several years. He and Kenneth Thimann, another National Academy of Sciences member and a plant biologist from Harvard, gave Santa Cruz a start and a big push toward frontier research in physical and biological sciences, which has continued and strengthened over the years.

At Wisconsin Whitford had taught hundreds of undergraduate students in elementary astronomy survey courses, but only a very few graduate students, in one-on-one "reading" or "research" courses: Eggen (who was largely Stebbins's student), Houck, John Bahng, Kenneth Hallam, and John Neff. At Santa Cruz he enjoyed teaching a regular graduate course in galaxies, in which he gave the students a thorough grounding in research techniques.

The 1960s were turbulent years in U.S. universities, nowhere more than at the University of California. The new president, Clark Kerr, who had taken office in 1958, the year Whitford arrived, was making it over into a "multiversity," with several coequal campuses. There were hard clashes between students, faculty, and administrators. The Lick astronomers were isolated from almost all of these on Mount Hamilton; at Santa Cruz Whitford did his best to shield them from it. He was their leader who negotiated for them with the campus and university-wide administrators, and was gradually ground down in these struggles.

Whitford's overall passion was research in astronomy, and he pushed it hard. His own specialty was photoelectric photometry, but he strongly supported the other Lick astronomers who were developing other auxiliary instruments for the new 120-inch telescope. He took a keen interest in what they were doing, questioned them closely, and made frequent suggestions. Some of them resented his approach, but it worked, and Lick Observatory was producing a lot of good research results with the coudé spectrograph, image-tube dissector scanner, and fast nebular spectrograph they developed.

In 1968, after 10 years as Lick director, Whitford stepped down but remained an active faculty member as a professor of astronomy and astrophysics until he reached the mandatory retirement age in 1973. He had spent all his time and effort on the directorship for a decade, but now he plunged back into research, taking up where he had left off with six-color photometry and galaxy research. After his retirement he could do no more observing at the big Lick telescope, but he made several trips to Chile to use the Cerro Tololo Inter-American Observatory, the southern branch of the U.S. National Astronomical Observatories he had done so much to get started. Later he worked on interpreting published data or new observational results obtained by younger collaborators, especially on stellar populations in the central bulge of our Galaxy, harking back to his early papers on M 31, the Andromeda galaxy, Now the data came from much more advanced detectors than the first near-infrared photocells and PbS cells he had used earlier, and were recorded and reduced digitally. He had come a long way in astronomical photometry.

Whitford's main interest remained astronomy all his life. He came to the office daily; attended all the colloquia, research seminars, and public lectures; read the journals; and was an unofficial adviser and font of wisdom to several graduate students, including David Burstein, R. Michael Rich, and Donald Terndrup. Albert loved to see his children and grandchildren; he could remember as a boy studying Latin at Milton Academy and going to his grandfather's house and reading to him from Virgil. The old man, though he could no longer see the words on the page, would correct young Albert from memory if he skipped or mispronounced a word. Albert himself loved the outdoors, especially hiking in the Sierra, which he had first encountered in his postdoctoral years in California. Later in his life he would lead family camping trips into them well into his eighties.

Albert's wife, Eleanor, died in 1986, ending a long, highly compatible marriage. He lived on in Santa Cruz, still coming to the campus daily and working on stellar populations until 1996. That year a symposium on stellar populations was held in his honor at Santa Cruz, under the redwoods outside Kerr Hall, where he and all the other astronomers' offices were then located. Soon after that he returned to Madison, where his son, Bill, was a professor in the law school and one of his grandsons a graduate student at the University of Wisconsin. In Madison Albert lived in a senior citizens' complex only a few blocks from the Capitol, between it and the campus. In the astronomy department he was especially welcome as a visiting emeritus professor and had a desk in an office, to which he came frequently to discuss astronomy with students and faculty alike, to keep up to date on the latest research in the current journals, and to revisit his old haunts. Until the last few months before his death he continued to go there frequently, and he died after only a short illness.

Whitford was a man of tremendous integrity. He found it difficult to speak anything but the whole truth and nothing but the truth, not necessarily the best tactic in all situations for the director of a large research institution. He was interested in astronomy and research to the last, always wanting to know more about the evidence for any new discovery. Never domineering or aggressive, he was always willing to discuss astronomy and pass on his accumulated wisdom, based on hard study and experience. And he was a keen judge of human beings, scientists especially. He had learned to understand and predict what they could and could not do. Over the years he made many important contributions to our knowledge of the Universe, and his peers acknowledged them by making him the Henry Norris Russell lecturer of the American Astronomical Society in 1986 and awarding him the Catherine Wolfe Bruce medal of the Astronomical Society of the Pacific in 1996. The Whitford interstellar extinction "law" and the Whitford report are his best-known legacies to us.

THIS BIOGRAPHICAL memoir is based mainly on Whitford's published scientific papers, and on many letters to, from, or about him in the University of Wisconsin Archives, Madison, and in the Mary Lea Shane Archives of the Lick Observatory, University Library, University of California, Santa Cruz. My own conversations and discussions with him over the years from approximately 1950 to 2001 were also insightful. Some of the latter, after his retirement in 1973, were

interviews on which I kept notes. Albert's own published autobiographical article, "A Half Century of Astronomy" (*Annual Review of Astronomy and Astrophysics* 24[1986]:1-13) is informative but typically modest. His son, William C. Whitford, and daughters, Mary W. Graves and Martha W. Barss, provided additional biographical details at my request, and several faculty colleagues who had known him at Madison, Santa Cruz, or Mount Wilson made helpful suggestions or comments on earlier drafts of this memoir.

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