Robert P. Kraft

1927- 2015

BIOGRAPHICAL *Memoirs*

A Biographical Memoir by
Sandra Faber

NATIONAL ACADEMY OF SCIENCES

ROBERT PAUL **KRAFT**

June 16, 1927–May 26, 2015

Elected to the NAS, 1971

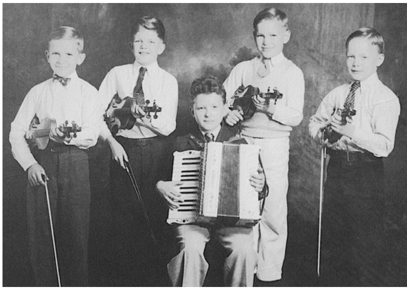
Photography by UCSC.

By Sandra Faber

Robert P. Kraft was a leading stellar spectroscopist and a gifted administrator, shaping the future of astronomy at the University of California during his two terms as director of Lick Observatory and the University of California Observatories. He showed that novae are mass-transfer binary stars and that magnetized winds slow down stellar rotation. His pioneering measurements of stellar abundances helped to lay the foundations of what is now Galactic "archaeology." With Mathews and Greenstein, he was the first to suggest that binary stars might emit detectable gravitational waves. Administratively, he presided over the founding of the Board of Studies in Astronomy and Astrophysics at the University of California, Santa Cruz (UCSC) and orchestrated numerous key events during the creation of the Keck Observatory. A man of passion and intensity, he was devoted to great wines, great music, and social justice. Though lauded, he was ever humble, crediting fate and friends for his many successes.

Robert Kraft came from families of farmers and workers. His father, Victor Paul Kraft, descended from German peasants who emigrated in the 1840s to Bethel, Missouri, as members of a Protestant religious group. He was the oldest child of ten who survived. After a stint as an airplane repairman in World War I, Victor took off for Los Angeles with his brother to take up the wonders of the new "motor trade," i.e., auto repair. Kraft's mother's people were Irish, both sides having come to the United States to escape the potato famine of 1847. They were peasants, too, save for his maternal grandfather, the only professional in Kraft's background, who taught himself maritime engineering and wound up as chief engineer of the *Baranoff*, the largest vessel of the Alaska Steamship Company. Kraft's mother, Viola Eunice Ellis, had been a handful as a teenager and was sent away to live with her older sister in LA. There she met and married Victor in 1926. The couple removed to Seattle to be with her family, where Kraft was born on June 16, 1927, ever an only child.

The family eked out a blue-collar living during the Depression years. Viola and Victor did not get along, and Kraft grew up under the sway of his mother's people, who lived nearby. Though Irish, they were not religious, and Kraft was free to find his own philosophical way. He embraced the values of the Enlightenment without knowing that there was such a thing. These values, self-generated, were a guiding light throughout his life.



The Olympic View Grammar School Orchestra, Seattle, 1937 (RPK, center). (Credit: Kevin Kraft.)

It was the Shirley Temple era, and his mother groomed him for a career as a child movie star. Kraft played the guitar, banjo, and piano from the age of four and appeared on stage and local radio. He sang, took elocution lessons, and appeared in plays and musicals. When a quirk of fate landed him in a high school that offered trigonometry and calculus, Kraft's interest in math was piqued. At the same time, vistas of a different kind were opened by the school's large record collection of 78 RPMs, which showcased classical composers, performers, and orchestras from around the world. Through these and his own piano studies, Kraft developed a lifelong devotion to classical music, especially Mozart, Beethoven, and opera.

Undergraduate and Graduate Degrees

Money was tight in Kraft's family during the Depression, when demand for auto mechanics was scarce. Mindful of the need to earn a living, Kraft entered the University of Washington (UW) in 1945 with the modest goal of teaching high school math. There he met Theodor Jacobsen, an associate professor who taught math but was really an astronomer, having earned a Ph.D. from the Lick Observatory in California. Jacobsen became a friend, introducing Kraft not only to astronomy but also to the scenic wonders of the Northwest Cascades. For his master's degree with Jacobsen, Kraft wrote a thesis that analyzed differences in the radial velocities of pulsating Cepheid variables as a function of level in the atmosphere. As part of this work, Jacobsen sent Kraft to the Dominion Astrophysical Observatory (DAO) in Victoria, British Columbia, to hone his skills in measuring radial velocities. DAO was a leader in stellar astronomy at the time, hosting such luminaries at Kenneth O. Wright, Andrew McKellar, Joseph A. Pearce, and Robert M. Petrie. Kraft measured radial velocities of B-type stars taken with the DAO 72-inch reflector. The skills he learned there would later land him a job at a critical time and determine the future course of his career.

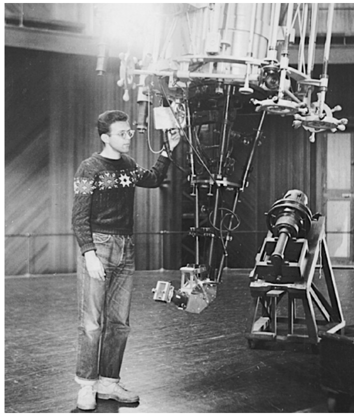
Bob and Rosalie at Mt. Rainier, c. 1948. Matching sweaters! (Credit: Kevin Kraft.)

The second main event of Kraft's UW years was meeting and marrying Rosalie Reichmuth, a journalism major. They met at a dance at the University Unitarian Church, where Kraft and a buddy were scouting for female companionship on ski outings. Rosalie's family were a notch above Kraft's on the social scale—her dad an insurance company salesman and her mother a life master and teacher of contract bridge—but, like Kraft, Rosalie was "unchurched," to use his word. The two hit it off and were married in 1949 as he was finishing his degree.

Still planning to become a math teacher, Kraft accepted an instructorship at Whittier College, a small private Quaker college in Whittier, California. It was his first foray into the world beyond Seattle and the beginning of his political education. He met Quakers, some "authentic" and some not (in his view), and encountered prejudice against African Americans, which shocked him. Whittier had a small observatory with an 18-inch reflector, and Kraft applied for a grant to build a 1P21 photometer. Measuring the light curve of the β Cephei variable HD 199140 was his first solo observing. More influential, though, was his discovery of the worlds of quantum mechanics and theoretical astrophysics while teaching freshman physical science. Math now seemed sterile, and, capitalizing on the fair bit of astronomy he already knew, he made a major career change and entered the Ph.D. program in astronomy at the University of California, Berkeley (UCB) in 1951.

I pause here to describe the status of Berkeley astronomy in Kraft's time. During the 1940s, the University of Chicago's Yerkes Observatory had been arguably the most fertile and powerful institution in American astronomy. Led by luminaries such as Subrahmanyan Chandrasekhar, Otto Struve, William W. Morgan, and Gerard Kuiper, Yerkes had produced some of the decade's most important discoveries and educated an enormous number of promising young scientists who had passed through its hallowed halls. Now, riven by internal disagreements, Yerkes was dissolving, and two western institutions, the California Institute of Technology (Caltech) and Berkeley, were snapping up its departees. Otto Struve, the world's foremost stellar spectroscopist, was lured to Berkeley in 1950, bringing with him two other Yerkes alumni, Louis Henyey, stellar structure theorist, and John Phillips, molecular spectroscopist. With these three and others, the stage was set for Berkeley's leadership in stellar astrophysics, which was in full bloom at the time.

A better fit for Kraft's interests and experience than UCB could hardly be found. There was only one problem: he had a wife, a son by that time (Kenneth), meager savings, and no job, having been admitted without support. Nevertheless, trusting to luck, the family moved anyway, and within two weeks a seeming miracle occurred. The assistant who measured Struve's spectrograms suddenly quit, leaving Struve in possession of a treasure trove of spectra on loan from the Mount Wilson Observatory but no way to measure them. In fact, Struve's current project was β Cephei variable stars, just like HD 199140, which Kraft had recently photometered at Whittier and measured at Dominion! In short, "the stars aligned," and Kraft settled in to work as Struve's assistant.



Kraft as graduate student with the Mills spectrograph on the 36-inch refractor at Lick Observatory, c. 1955. Same sweater! (Credit: Kevin Kraft.)

Kraft's Berkeley thesis explored the Cepheid variable X Cyg, which develops puzzlingly strong chromospheric Ca II emission on the rising branch of the light curve. Struve and Lick astronomer George Herbig gave Kraft 100-inch spectra from Mount Wilson, and Kraft took more spectra with the 36-inch refractor at Lick Observatory, where he became a Lick Observatory Fellow in 1953 (Herbig at Lick was his thesis supervisor). Kraft found that many absorption lines were doubled and concluded that there are really two atmospheres, one ejected in the previous cycle and now falling inward and colliding with a photosphere expanding from below. The colliding region lay quite deep, supporting Eddington's theory that the Cepheid instability arises from the properties of the hydrogen convection zone.

A second work from this time had even more impact. It was a collaboration with fellow graduate student John Crawford, a more experienced physicist and veteran of the Manhattan project whom Kraft greatly admired. In 1954, the Berkely department was visited by Herman Bondi, who lectured on his now-classic theory of interstellar medium accretion onto stars that he had been developing with Fred Hoyle. Inspired by Bondi's talk and well informed on binary stars thanks to Struve's influence, Crawford and Kraft took a new look at the nova-like system AE Aqr, which exhibits irregular flickerings in brightness. A prevailing model said the system had a hot star with a shell of gas around it that was spilling onto a red dwarf companion. Crawford and Kraft turned that around to say that the red dwarf spills matter through its inner Lagrangian point onto a ring or disk, which is gradually being accreted by the hot white dwarf.[1] The spilling would naturally be driven by the dwarf's tendency to swell up during stellar evolution. This paper was the first of many examples in astronomy in which a larger body sheds mass through its Roche lobe (tidal boundary) onto a smaller, denser object; it is the basic mechanism that powers many novae and dwarf novae (accretion onto white dwarfs) and X-ray binaries (accretion onto neutron stars or black holes). It was a remarkable insight for two young graduate students.

In the mid-1950s, the National Science Foundation (NSF) was expanding its one-year postdoctoral fellowship program, and Kraft was the first astronomer to win an award, which he elected to take at Mount Wilson Observatory. There, with his first access to "big glass," he began what turned into a years-long campaign to validate the Crawford-Kraft binary model by detecting orbital motions in novae and dwarf novae. But the light-gathering power of even the Mount Wilson 100-inch proved too feeble. All too quickly the year came fruitlessly to an end, a second son (Kevin) had now arrived, and the relentless pressure to find a permanent job reasserted itself.

In those days, openings for research astronomers were few. Precisely two were suitable for Kraft that year. One was a classic six-year, up-and-out appointment at Harvard University, and the second was a one-year assistant professorship at Indiana University, replacing department chair Frank Edmonds, who was serving as Astronomy Division director at the NSF. The six-year appointment at Harvard had obvious attractions for Kraft, the family man, but Indiana owned three weeks of annual observing time on the 82-inch telescope at McDonald Observatory in Texas (the third largest in the world at the time), most of which Kraft could commandeer. Struve advised him to go to Indiana, and he did.

Indiana, Yerkes, and Mount Wilson

The single year at Indiana stretched into two, as Edmonds bargained a permanent position for Kraft in return for his own agreement to remain at Indiana. In Kraft's memoirs, the highpoints of the Bloomington years were the availability of high culture (the Boston Symphony and the Viennese Philharmonic toured regularly) and his and Rosalie's growing involvement in the Unitarian Church. He discovered that he really liked teaching, he took copious data at McDonald and stored them away for future papers, and he impressed such leaders as Chandrasekhar, Kuiper, and Morgan at nearby Yerkes, which was trying to rebuild after Struve's departure. Halfway through his second year at Indiana, Kraft received an invitation to become a permanent staff member at

Yerkes. Saying to Rosalie, "This is the big time, you know," he accepted, and the family moved again. It was 1958.

Every astronomer who worked at Yerkes in those years (1940s–1950s) remembers its distinctive geographical setting and intense atmosphere. Founded by George Ellery Hale in 1892, Yerkes sits on the banks of Lake Geneva in the remote hill country of southern Wisconsin. Though owned and operated by the University of Chicago, the observatory was 100 miles distant, and Yerkes astronomers had free rein to forge their own close-knit community. On site was the world's largest refractor, the 40-inch, and Yerkes also ran McDonald Observatory, with its 82-inch reflector and smaller telescopes. Other assistant professors during Kraft's time included Geoffrey and Margaret Burbidge, Helmut Abt, Kevin Prendergast, and Nelson Limber. Morgan, Kuiper, Chandrasekhar, Stromgren, and Hiltner were on the senior staff. In short, Yerkes was still a "who's who" of American astronomy with an enviable balance of observations and theory.

On staff at Yerkes, Kraft branched out in a new direction encouraged by Al Hiltner, co-inventor of the then-new field of photoelectric photometry. Photon-counting with the 1P21 photomultiplier tube was providing astronomers with their first precision measurements of the apparent brightnesses of astronomical objects. A major problem was measuring accurate distances, and so-called "standard candles"—objects of known brightness—were highly sought after. Chief among these were the Cepheid variables, the same pulsating stars whose spectra Kraft had studied for his Ph.D. Cepheids are standard candles because their intrinsic luminosity varies closely with their period. Hence, measure the period and apparent brightness, combine with the inverse-square law for luminosity, and voilá, you have the distance to the object…except for one big problem: interstellar dust. Dust is expelled from the atmospheres of stars and supernovae into the Galactic interstellar medium, where it pervades the gas. Though each grain is only about the same size as a particle of cigarette smoke, the absorbing power of dust adds up along long Galactic sight lines, dimming the light of Cepheids by up to a factor of ten. To calculate accurate distances, this dimming effect must be precisely measured and removed.

Thankfully, interstellar dust not only dims, it also reddens, and the amount of dimming can be deduced from the color change. Building on his prior knowledge of Cepheid spectra, Kraft surmised that the strength of a prominent molecular absorption band, called the G-band, would establish the intrinsic color of a star, and this, when compared to the apparent color, would determine the reddening. Encouraged and supported by Hiltner, Kraft embarked on an 18-month program at McDonald to measure the G-band strengths and apparent colors of Cepheids. The result was a landmark calibration of the dust-dimming of Cepheid variables and a revision to the period-luminosity relation,[2] which became a fundamental cornerstone in determining the cosmic distance ladder, the Hubble constant, and the size of the Universe.

The second high point of Kraft's Yerkes stay was sparked by a letter from Jesse Greenstein at Caltech, who had finally succeeded in obtaining excellent spectra of an eclipsing nova, DQ Her, with the 200-inch "Big Eye" at Palomar Observatory. Hearing of Kraft's interest in novae, Greenstein wondered if the younger astronomer would be interested in helping him analyze the data. Indeed he would! The spectra were spectacular and clearly showed two emission components, an expanding shell generated in an outburst back in 1934 and a much smaller rotating disk of gas orbiting a white dwarf. Importantly, the spectra confirmed DQ Her as a binary star, notching a second data point in favor of the Crawford-Kraft binary model.[3]

Kraft's work on Cepheids and novae was now becoming widely known, and so it was not surprising that halfway through his first year at Yerkes, he received an offer from director Ira Bowen to join the astronomical staff of the Carnegie Institution of Washington in Pasadena. This was a premiere opportunity, providing access not only to the Mount Wilson telescopes but also to the world-leading 200-inch on Mount Palomar. Moreover, though not formally tenured, Carnegie appointments were de facto permanent. Declining this offer was inconceivable, and so the family moved again, in 1960.

At Carnegie, Kraft quickly settled in and launched several new scientific initiatives that exploited these powerful new facilities. The first was a renewed attempt to verify more completely the Crawford-Kraft binary model for novae. Based on spectra taken with the powerful 200-inch, Kraft was able to state by 1962 that all known dwarf novae were consistent with binary status. He then extended the model to classical novae and, in so doing, explained the known relation between the orbital period and the absolute magnitude of the redder star. His Warner Prize lecture at the American Astronomical Society in 1963 summarized these results. His papers on dwarf novae[4] and on classical novae[5] are the seminal papers on the binary nature of cataclysmic variables, with roughly 200 citations each.

One object stood out, WZ Sge, with an orbital period of only 82 minutes. A typical exposure using photographic plates of that era would be of a similar length and would therefore obscure the orbital motion. By sheer luck, however, Kraft took two 40-minute exposures at the 200-inch at just the right orbital phase and saw a velocity difference of

1300 km/s! The resulting paper was entitled "Nova WZ Sagittae: A Possible Radiator of Gravitational Waves."[6] A second paper showed that the invisible component must be an M dwarf with mass <0.08 M⊙.[7] Now, stars of such low mass evolve only slowly and would not expand fast enough to provide the observed rate of mass transfer through their Roche lobe. Such a rate could only be explained, the authors said, if the system was being slowly "ground down" by gravitational radiation. These were the first two papers in astronomy to suggest that binary stars might radiate gravitational waves. Such waves from merging stellar-mass black holes and neutron stars have now been detected by the Laser Interferometer Gravitational-Wave Observatory (LIGO). Unfortunately, these recent works rarely cite the papers by Kraft and colleagues that founded the field, and these two seminal papers deserve to be better known.

The third milestone of Kraft's years at Mount Wilson was a large survey of stellar rotation speeds in field and cluster stars, leading to a deeper understanding of stellar winds and angular momenta. It was known that rotation velocities drop precipitously from about 25 km s^{-1} at 1.3 M⊙ (spectral type F5) to just a few km s^{-1} at the Sun (spectral type G0). The picture was emerging that cool stars below the break have deep convection zones, which drive hot stellar winds that pull magnetic field lines out of the star, exerting a magnetic torque and slowing the star down. Field stars alone cannot test the theory, being mostly too old. With heroic half-night exposures on the 200-inch telescope, Kraft was able to find fast-rotating F-G stars in the youthful Pleiades cluster and thereby show that the older slowly-rotating stars in the field must have slowed down with time. The resulting paper is his most cited (588 citations),[8] and the drop in rotation speeds near F5-G0 is often dubbed the "Kraft break."

University of California

Despite these scientific achievements, circumstances were brewing that made continuing at Mount Wilson increasingly difficult. The first was smog in southern California, which Kraft felt was impairing his sons' health. The second was a poor fit between his older son's free-wheeling lifestyle and the conservative southern California political climate. The third was growing tension with fellow Mount Wilson staff member Allan Sandage over Kraft's nascent Cepheid program. The era's cosmological Holy Grail was an accurate measurement of the Hubble constant, for which the Cepheid luminosity calibration was central. Though Kraft had not clashed with Sandage directly, he had questioned a Sandage associate's photometric measurements in print. Brief statements in Kraft's memoirs suggest that he no longer felt free to pursue the Cepheid calibration problem at Mount Wilson.

These facts were in Kraft's mind when good friend George Preston called from Lick Observatory, suggesting a job there. Kraft had previously declined a similar overture, thinking that his family (including his two teen-age sons) would not be happy living on the remote Lick mountaintop. But that roadblock was disappearing—Lick astronomers had lost their long-running battle to retain separate-campus status within the UC system and were moving down to UC's new campus in Santa Cruz, where they were charged to found a new astronomy department as well as manage Lick. This changed Kraft's thinking entirely. Beautifully situated on the coast of Monterey Bay and smog-free, Santa Cruz was not only a good match for the Kraft family's liberal politics, it was also a vibrant rock music scene, just the place, he felt, where his sons' budding musical careers might thrive. And so they moved again, to Santa Cruz in 1967.

Walking in the door at Lick, Kraft encountered turmoil. Long-time Lick observational astronomers were not happy about having to teach classes and run a graduate program. They were also not happy about losing their priority claim on Lick observing time and having to share with other UC campuses. The faculty was highly skewed towards observers and lacked the theoretical expertise needed to mount a balanced graduate program. The UCSC administration saw Lick as a rapid boost to the new campus's credentials, but Lick's traditionally minded research astronomers fit poorly with the rest of UCSC's avant-garde teaching ethos—Lick was a fish out of water. Lastly, under all these pressures, Lick astronomers lacked confidence in their director, Albert Whitford, who had done a superb job getting the 120-inch Shane telescope online in the early 1960s but whose political skills were not up to the new era.

As the new kid on the block and driven by his own high sense of duty, Kraft allowed himself to be coaxed into the job of acting observatory director, partnering with friend Preston, who took the helm of department chair. As fellow Berkeley alums and admirers of Otto Struve, they sought to institute the "Yerkes model" at Santa Cruz by adding a cadre of theorists to complement the observers. An all-important NSF departmental improvement grant funded five new theoretical faculty positions, and courses and graduate degree requirements were formulated. To accommodate the other campuses, Kraft designed a Lick telescope time-allocation process and instituted a UC-wide council to advise the Lick director. Finally, he oversaw the search for a permanent director. Five years later, he was finally able to step down as "acting" director when Donald Osterbrock arrived from the University of Wisconsin in 1973.

These achievements not only averted disaster, they laid the foundation for the success of the UCSC Astronomy Department, a famously harmonious institution that went on to become world-leading. Indeed, for me, a new faculty member in 1972, these former crises were invisible—a functioning department and observatory were in place, and it seemed that things had always been that way. Altogether, Kraft's leadership during this critical period was remarkable, all the more so for the fact that in a later memoir he confessed to "hating" this service.

With Osterbrock now leading, Kraft was free to forge a new scientific program optimized for Lick and UCSC. The new image-dissector scanner, invented at Lick by Joe Wampler and Lloyd Robinson in 1971, was astronomy's first high-efficiency panchromatic photon-counting spectroscopic detector, which for a time made Lick's 120-inch Shane reflector the most powerful spectroscopic telescope in the world. Kraft seized this opportunity to pursue an old interest, the elemental chemical compositions of metal-poor stars in the Galactic halo. This decades-long program began by discovering unexpected compositional anomalies in stars along the giant branch of globular clusters, which are caused by deep convective mixing that brings newly synthesized elements to the surface.[9]

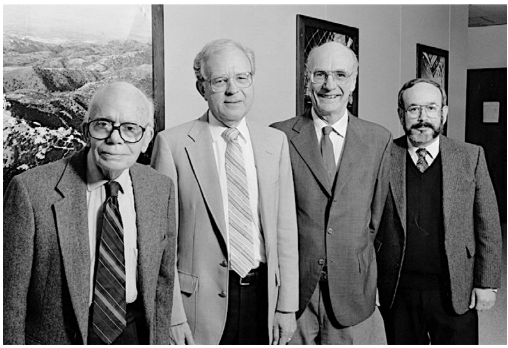
The Keck Telescopes and After

During the 1970s, while Kraft was focused on this new research direction, energies were building among UC astronomers to rebuild or relocate Lick Observatory to a dark-sky site. A solution had to be found to the San Jose and the Santa Clara Valley light pollution, which was increasingly affecting the Lick telescopes. The crisis was an opportunity not only to catch up to Palomar, then the world's largest telescope at 200 inches (5 meters), but to surpass it. Two groups developed plans for a new telescope in the 7-10–meter class. A UCSC group headed by Joe Wampler espoused a single monolithic mirror design, whereas a Berkeley/Lawrence Berkeley National Laboratory group headed by Jerry Nelson proposed a design with thirty-six hexagonal mirror segments. The inter-campus competition could have been politically fatal to Lick leadership, but the delicate situation was artfully handled by director Osterbrock, who created a "graybeards" committee of senior astronomers from around UC to review the two proposals and recommend a choice. The graybeards chose the segmented design for its lower risk of catastrophic breakage, amenability to prototyping, and ability to reach the 10-meter diameter goal with acceptable risk. Osterbrock embraced the recommendation and threw his weight behind the Nelson effort at UC Berkeley. Osterbrock also saw the successful negotiation of this delicate transition as an opportunity to return to full-time research and teaching, leaving the Lick directorship open at a critical time. Kraft decided to apply and was selected, taking the reins in September 1981. As stated in his memoirs, the post he had hated ten years earlier he now embraced.

Enormous challenges lay ahead. How should Lick support Jerry Nelson? Where would the telescope be sited? What would it cost, and where would the money, several tens of millions of dollars, be found? The project had momentum, and hopes were high. But Kraft knew that success was ultimately up to Lick, and Lick leadership of UC astronomy was on the line.

He proceeded by putting the full weight of the Lick Instrument Lab facilities at the disposal of the Nelson group, who were building a segment prototype at Lawrence Berkeley National Laboratory. He created a new and weightier UC-wide advisory committee to advise the director on running Lick and building the new telescope. He negotiated permission from the University of Hawaii to site the telescope on Mauna Kea, the premiere observatory site in the northern hemisphere. Finally, after fundraising efforts by the UC Office of the President had come to naught, Kraft's own assistant director, Joe Calmes, nearly secured a $50 million gift to build the telescope. The donor died unexpectedly just a few hours before the final papers could be signed, but the near-miss attracted interest from Caltech, and Kraft represented UC astronomy in negotiations that led ultimately to not one but two 10-meter telescopes, Keck I and Keck II. Finally, with a firm vision in mind for how UC astronomy should operate in the Keck era, Kraft wrote a new UC-wide management plan, opened up telescope access to all UC campuses, blessed a new IR instrument laboratory at UCLA, and birthed a new unit, the University of California Observatories (UCO), comprised of Lick Observatory plus UC's share in Keck.

Retiring as UCO director in 1991, Kraft returned again to studying the compositions of old Galactic stars. Not only did this work shed important light on sites of element nucleosynthesis at the time, it provided the foundational results that ultimately led to a new view of globular clusters as complex stellar systems with



The four Lick/UCO directors from 1958 to 1994, left to right: Albert Whitford, Robert Kraft, Donald Osterbrock, Joseph Miller, 1994. (Credit: UC Regents/Lick Observatory (Don Harris).)

multiple stellar populations. We still do not understand what drives the compositional differences observed among the stellar populations in globular clusters, but Kraft's initial explorations defined the issues,[10] and his papers with University of Texas collaborators established the framework in which we think about the problem to this day. In retrospect, the many stellar composition papers by Kraft and colleagues were instrumental in establishing the field of "Galactic archaeology," a now-thriving discipline that attempts to deduce the assembly of the Milky Way from the motions and compositions of long-lived stellar groups within it.

Students and Collaborators

Kraft left an indelible mark on the next generation of young spectroscopists. Advisees and close collaborators included Dennis Butler, Donald Fernie, Eileen Friel, Jon Fulbright, Lee McDonald, Matt Shetrone, Nicholas Suntzeff, Kurt Anderson, Beatriz Barbuy, Duane Carbon, Ed Langer, Katy Pilachowski, and Chris Sneden. All recall Kraft's humility, integrity, and concern for others, even during times of heavy administrative burdens. He encouraged his students to publish alone without him. He encouraged them to branch out in new directions. "He treated me and my wife to the opera; he went out of his way to be kind to the cooks at Mt. Hamilton," recalls Matt Shetrone. "He insisted that, having taken NSF funds, I had a social obligation to publish my results," says Eileen Friel, who also remembers Kraft's recipe for doing "real" science:

> *You formulate a problem. You go to the telescope and take a series of spectrographic plates. You sit down and look at each spectrum one after the other. Upon examining each spectrum, you put it either in pile A or in pile B. When you have looked at them all, you count up the numbers in piles A and B. You now write your paper. Anything more complicated is a waste of time.*

Beyond Astronomy

Kraft had many interests beyond astronomy and shared them constantly. Coming from a blue-collar family, he was ardently pro-worker and pro-union. His Nixon impression was devastating. He was a lifelong student of Beethoven and Mozart and taught university courses on them and on oenology. These interests graced his life naturally, and dinner at his house, co-hosted with Rosalie, was a cultural experience.

I arrived at Lick Observatory in 1972, fresh out of graduate school in the last year of Kraft's first, reluctant Lick directorship. He was my first boss and left an unforgettable impression. He was passionate about everything: Lick, politics, wine, opera ("Wagner is much better than it seems."), and even the Beatles ("Abbey Road is the Beethoven's 9th of pop-rock!"). He loved stars but hated galaxies because "their edges are blurry." He walked too fast—you had to run to keep up. He challenged your vote in the last election, whatever it was. But as director, he won your loyalty through the quality of his ideas, selfless ambition for the institution, and consummate personal integrity.

Two Bruce Medalists: RPK and Sandra Faber at her award ceremony, UCSC, 2012. (Credit: Mike Bolte.)

Modest to a fault, Kraft received many honors, but they were always in the background. They include the Warner Prize from the American Astronomical Society (1962) and the Catherine Wolfe Bruce Gold Medal from the Astronomical Society of the Pacific (2005). In 1995, he was awarded the Henry Norris Russell Lectureship from the American Astronomical Society. He was a member of the National Academy of Sciences and the American Academy of Arts and Sciences and served as president of the International Astronomical Union from 1997-2000.

Kraft with good friend George Preston, at the "Galaxy-Globular Connection" conference honoring Kraft in 2011. (Credit: Mike Bolte).

His memoir for the *Annual Review of Astronomy and Astrophysics*, entitled "An Astronomical Life Salted by Pure Chance,"[11] mentions others much more than himself. For Kraft, it was cosmic luck and the people around him who had carried him through. As one who witnessed his leadership and impact close at hand, I can attest otherwise.

Note

This biography draws heavily on Kraft's memoir in the *Annual Review of Astronomy and Astrophysics* and on the interview by Patrick McCray at the American Institute of Physics.[12] I especially thank George Preston for his recollections of Kraft's arrival at Lick Observatory and perspectives on his early work. Joseph Wampler recalled the challenges of Cepheid photometry and memories of working under Kraft. John Faulkner reviewed the text for accuracy and contributed much background. Eileen Friel and Matt Shetrone provided anecdotes and commentary. Kevin Kraft reviewed the piece for the Kraft family. The colorful remembrance by Virginia Trimble provides additional information.[13] Photo credits: Kevin Kraft, Mike Bolte, UCO, and UCSC.

REFERENCES

1. Kraft, R. P., and J. A. Crawford. 1956. An interpretation of AE Aqr. *Astrophys. J.* 123:44–52.

2. Kraft, R. P. 1961. Color excesses for supergiants and classical cepheids. V. The period-color and period-luminosity relations: a revision. *Astrophys. J.* 134:616–632.

3. Kraft, R. P. 1959. The binary system nova DQ Herculis. II. An interpretation of the spectrum during the eclipse cycle. *Astrophys. J.* 130:110–122.

4. Kraft, R. P. 1962. The binary stars among cataclysmic variables. I. U Geminorum stars (dwarf novae). *Astrophys. J.* 135:408–426.

5. Kraft, R. P. 1964. Binary stars among cataclysmic variables. III. Ten old novae. *Astrophys. J.* 139:457–475.

6. Kraft, R. P., J. Mathews, and J. L. Greenstein. 1962. The binary stars among cataclysmic variables. II. Nova WZ Sagittae: A possible radiator of gravitational waves. *Astrophys. J.* 136:312–315.

7. Kraft, R. P., and W. Krzeminski. 1964. Binary stars among cataclysmic variables. V. Photoelectric and spectroscopic observations of the ultra-short binary nova WZ Sagittae. *Astrophys. J.* 140:921–935.

8. Kraft, R. P. 1967. Studies of stellar rotation. V. The dependence of rotation on age among solar-type stars. *Astrophys. J.* 150:551–569.

9. Carbon, D. A., et al. 1982. Carbon and nitrogen abundances in giant stars of the metal-poor globular cluster M 92. *Astrophys. J.* Suppl. 49:207–258.

10. Kraft, R. P. 1994. Abundance differences among globular cluster giants: Primordial vs. evolutionary scenarios. *Pub. Astron. Soc. Pac.* 106:553–565.

11. Kraft, R. P. 2009. An astronomical life salted by pure chance. *Ann. Rev. Astron. Astrophys.* 47:1–26.

12. McCray, P. 2002. Robert Kraft. American Institute of Physics, Oral History Interviews, https://www.aip.org/history-programs/niels-bohr-library/oral-histories/25490.

13. Trimble, V. Robert P. Kraft (1927–2015). *Bull. Am. Astron. Soc.* 41(1), https://baas.aas.org/pub/robert-p-kraft-1927-2015/release/1?readingCollection=c3fb2819.

SELECTED BIBLIOGRAPHY

1956 With J. A. Crawford. An interpretation of AE Aqr. *Astrophys. J*. 123:44–52.

1957 Calcium II emission in classical Cepheid variables. *Astrophys. J*. 125:336–358.

1958 The binary system nova T Coronae Borealis. *Astrophys. J*. 127:625–641.

1959 With J. L. Greenstein. The binary system nova DQ Herculis. I. The spectrum and radial velocity during the eclipse cycle. *Astrophys. J*. 130:99–109.

The binary system nova DQ Herculis. II. An interpretation of the spectrum during the eclipse cycle. *Astrophys. J*. 130:110–122.

1961 Color excesses for supergiants and classical cepheids. V. The period-color and period-luminosity relations: a revision. *Astrophys. J*. 134:616–632.

1962 The binary stars among cataclysmic variables. I. U Geminorum stars (dwarf novae). *Astrophys. J*. 135:408–426.

With J. Mathews and J. L. Greenstein. The binary stars among cataclysmic variables. II. Nova WZ Sagittae: a possible radiator of gravitational waves. *Astrophys. J*. 136:312–315.

1963 With M. Schmidt. Galactic structure and Galactic rotation from Cepheids. *Astrophys. J*. 137:249–267.

1964 Binary stars among cataclysmic variables. III. Ten Old Novae. *Astrophys. J*. 139:457–475.

With W. Krzeminski. Binary stars among cataclysmic variables. V. Photoelectric and spectroscopic observations of the ultra-short binary nova WZ Sagittae. *Astrophys. J*. 140:921–935.

1965 Studies of stellar rotation. I. Comparison of rotational velocities in the Hyades and Coma clusters. *Astrophys. J*. 142:681–702.

1967 Studies of stellar rotation. V. The dependence of rotation on age among solar-type stars. *Astrophys. J*. 150:551–569.

1974 With G. E. Langer and K. S. Anderson. FG Sagittae: The s-process episode. *Astrophys. J*. 189:509–521.

1977 On the nonhomogeneity of metal abundances in stars of globular clusters and satellite subsystems of the Galaxy. *Ann. Rev. Astron. Astrophys*. 17:309–343.

1982 With D. A. Carbon et al. Carbon and nitrogen abundances in giant stars of the metal-poor globular cluster M 92. *Astrophys. J. Suppl.* 49:207–258.

1994 Abundance differences among globular cluster giants: Primordial vs. evolutionary scenarios. *Pub. Astron. Soc. Pac.* 106:553–565.

2004 With C. Sneden, P. Guhathakurta, R. C. Peterson, and J. P. Fulbright. The chemical composition contrast between M3 and M13 revisited: New abundances for 28 giant stars in M3. *Astron. J.* 127:2162–2184.

2009 An astronomical life salted by pure chance. *Ann. Rev. Astron. Astrophys.* 47:1–26.

2013 With A. F. Marino et al. The double sub-giant branch of NGC 6656 (M 22): a chemical characterization. *Astron. Astrophys.* 541:15–33.