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George Wallerstein (1930–2021)

Lee Anne Willson¹, Chris Sneden², Caty Pilachowski³, Charli Sakari⁴

¹Iowa State University, ²UT Austin, ³Indiana University, ⁴San Francisco State University

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George Wallerstein died on Thursday, May 13th, 2021, at the age of 91.

George's father Leo Wallerstein was a chemist advising brewing companies. George was born on January 13, 1930. He attended Horace Mann School in the Bronx, where there is now a chemistry lab bearing the names of Leo and George Wallerstein. George went on to attend Brown University, where he graduated with a degree in Physics in 1951. From 1951–53 he served as a junior officer on a ship during the Korean War.

Photo provided by Julie Lutz.

After his navy service George went on to earn a PhD at Caltech in 1958, and joined the faculty at the University of California, Berkeley. In 1965 he was offered the position of chair of the new Department of Astronomy at the University of Washington (UW). There, he and Paul Hodge grew it into one of the top astronomy programs in the U.S., building on the observational program initiated by Theodor Jacobsen. While the appeal of the UW job undoubtedly included the proximity of the mountains, he was also enthusiastic about building the department. He created a graduate program, started teaching astronomy, and began recruiting faculty and postdocs. He was instrumental for developing the Manastash Ridge Observatory (MRO) and for procuring the 30" mirror. The Observatory will be celebrating its official 50-year anniversary in 2022. George served as the director of MRO from 1972 until 1990. UW also became a member of the Astrophysical Research Consortium (ARC), which built the 3.5 m telescope at Apache Point Observatory (APO). George was an active observer at APO, with observations scheduled well into 2020 to observe Type II Cepheids in the Galactic bulge.

Hardly an area of stellar astrophysics hasn't felt the Wallerstein thumbprint, from the metallicities of stars to the pulsations of red giants. His Ph.D. dissertation in 1958 focused on population II Cepheids (W Virginis stars), a first step in a lifelong effort to understand Population II stars. His interest in these objects continued for his whole

life. His 1959 paper [1] proposed the shock-wave model to explain Population II Cepheids, noting that an outward-moving shock wave was necessary to heat the expanding gas to temperatures high enough to ionize H and He, producing the observed emission lines.

Much of our modern perspective on the chemical analysis of stars can be traced to George Wallerstein, including his introduction of the bracket notation that is now so well embedded across astronomy [2]. His early work exploring the chemical abundances in G dwarfs provided the first comprehensive survey of the composition of the local solar neighborhood. His landmark 1962 paper [3] introduced and successfully attacked many chemical composition topics that we still are working on today: derivation of accurate $[\text{Fe}/\text{H}]$ metallicities, identification of alpha element overabundances and manganese deficiencies in metal-poor stars, and clear identification of metallicity-space velocity correlation. In an unfairly overlooked small contribution, Wallerstein & Carlson (1960, [4]) established the $\delta(\text{U-B})$ line blanketing index that enabled photometric determinations of overall metallicity in stars. UV stellar flux distributions continue to be studied in large-sample stellar surveys. In 1963 Wallerstein et al. [5] published the first chemical composition analyses of three now well-known red giants. One of them, HD 122563, is the only very metal-poor star in the Bright Star Catalog, and now has been cited in nearly 200 papers. Highlights from that paper include pushing the alpha and Mn anomalies to metallicities $[\text{Fe}/\text{H}] < -2.5$, and identification of an extreme barium deficiency. This was the first glimmer of what became a major research field of neutron-capture elements in low metallicity stars. Finally, Conti et al. (1967; [6]) conducted the first oxygen abundance survey in red giants, being thus the first to discover the $[\text{O}/\text{Fe}]$ excesses in low metallicity stars.

George's interest in the chemical compositions of stars led him to studies of open clusters and globular clusters (GCs). His early spectroscopic studies in the late 1950s and 60s investigated nearby open clusters like the Hyades and M67 and GCs like M13 and M92. In the late 1970s, George and his then-postdoc, Caty Pilachowski, conducted a series of spectroscopic observations of GC stars. At the time, the question of intra-cluster spreads within GCs was relatively new. Over the next forty years, George and his students, postdocs, and collaborators would investigate the photometric properties of various Milky Way GCs and spectroscopically determine detailed chemical abundances of ~ 250 stars in over 30 Milky Way clusters, including very distant GCs in the outer regions of the Milky Way and GCs that were connected with the Sagittarius dwarf galaxy. In the late 1990s and early 2000s, it became possible to observe stars in more distant systems, including satellite dwarf galaxies. George's postdocs and

collaborators led high profile papers about the field stars and GCs in several nearby galaxies, including Sagittarius, Sculptor, Fornax, and M31, with George often the second or third author.

Wallerstein's interest in chemical abundances, and specifically in nucleosynthesis, began in the 1950s. As a graduate student, he witnessed both the discovery of the first metal-poor stars [7] and the birth of our modern understanding of the origin of elements [8]. That interest culminated in the new classic *Synthesis of the elements in stars: forty years of progress* [9] in collaboration with numerous authors, summarizing decades of work on the subject. As with other topics, Wallerstein's interest in lithium abundances was sustained throughout his career. Wallerstein et al.'s (1965; [10]) study of lithium in the Hyades presaged Boesgaard et al.'s (2016; [11]) later discovery of the lithium dip among F main sequence stars.

George was very well aware of the power of abundance analyses to illuminate the history of stars, clusters, and populations. However, when it came to the very red, very luminous, variable stars near the upper right corner of the HR diagram — long period variables, Cepheids, and luminous giants and supergiants — the familiar methods ran into problems. The absorption lines are formed high in the atmosphere of some of these objects, where the passage of periodic shocks from pulsation can throw the chemistry out of equilibrium — as is evident from strong non-LTE fluorescent emission lines. He was drawn into considerations of the dynamics of both single stars and those with companions, leading to a lifelong interest in the unusual systems VY CMa and R Aqr as well as more typical pulsating variable star.

Although Tc was first discovered in S stars in 1952 by P. W. Merrill, new results appeared in 2007 correlating Li and Tc and supporting the idea that these elements are the result of recent internal nucleosynthesis and mixing [12]. Wallerstein et al. (2011; [13]) followed up this idea with sub-millimeter observations of CO in S stars, confirming a $^{12}\text{C}/^{13}\text{C}$ ratio intermediate between late M stars and carbon stars, again suggesting deep mixing plays a role in the evolution of late-stage red giants. Even more recently, Shetye, Wallerstein, et al. (2021; [14]) confirmed two groups of S stars, one resulting from intrinsic processes (active nucleosynthesis and mixing) and the other from extrinsic processes (binary mass transfer).

Among George's most cited works are two reviews on the subject of carbon stars prepared for the Annual Review of Astronomy and Astrophysics in 1973 [15] and in 1998 with G. Knapp [16]. George had a nearly unbroken record of publishing at least

one paper per year in PASP. He published 114 papers in that journal between 1957 and 2019, missing only a couple of years near the end.

A 1982 paper with collaborator Chris Sneden [17] reported the first lithium-rich red giant star. Puzzled about the origin of its high lithium abundance, they ascribed it either to convective dredge-up of fresh lithium during the red giant phase, or to swallowing an inner terrestrial planet as the red giant expanded into its own exoplanetary retinue. While they did not favor this hypothesis, they did argue that the star may be a viable candidate for searches for extraterrestrial life “because the inhabitants of their outer planets might be screaming for help as they watch their inner planets disappear into their central star.”

Wallerstein’s favorite star was probably VY Canis Majoris, long given the title as the Milky Way’s biggest, most luminous star (a title now claimed for UY Scuti). In 1958, Wallerstein discovered potassium emission lines in its spectrum [18]. Along with calcium and sodium emission lines, the potassium lines gave Wallerstein the tools to determine the physical conditions in the outer layers of VY CMa, the first quantitative analysis of this behemoth. At one point he explained observations of this object with a “rotating holey cloud” hypothesis. As he commented in a 2001 paper with G. Gonzalez [19], “With a (hopefully) long career ahead of him, the first author decided in the 1960s to monitor VY CMa until it either contracted to the main sequence or became a supernova.” While the object did neither, it can be said that the long career did materialize, with publications spanning 1956–2021.

George’s first paper on R Aqr, Jacobsen & Wallerstein (1975; [20]), argued that a previously asserted 26.7 year orbital period was not correct, and discussed evidence for mass loss. In 1980, Wallerstein and Greenstein suggested that the system was not binary, but the observed variability might be a magnetic field event [21]. By 1986 he was, however, looking at phenomena associated with a 44-year orbit, possibly eccentric, with an eclipse or periastron event centered around 1977–1978 [22], as proposed by Willson, Garnavich and Mattei in 1981 [23]. As the predicted event of 2021–2022 approached, George sprang into action: he began collecting spectra in 2016 and continued to do the observing himself until the end of 2018. When the eclipse arrived right on time, in early 2019, he recruited friends and colleagues to obtain observations of R Aqr, continuing this activity until a few weeks before his death.

George married fellow astronomer Julie Lutz in 1998, and the pair of them settled in Seattle, enjoying the outdoors, opera, and much more together. With this step, he acquired two daughters and three grandchildren, all of whom he enjoyed very much.

George enjoyed watching the Mariners and played baseball until age 75. He enjoyed classical music and opera, especially the Wagner Ring series produced in Seattle for many years. He devoured books, particularly on the subjects of history, mountaineering and polar exploration.

Throughout his life, George was an enthusiastic climber of mountains, with many first ascents of peaks in California, Alaska, the Yukon, and East Greenland to his credit, including a first ascent of Mount McArthur, a 14,400 foot peak in the St. Elias Range in the Yukon Territory, Canada, in 1961. George's expeditions to the Yukon lead to his being honored as a Pioneer of the St Elias. In 1986, George served as a "negatively paid Sherpa" on an expedition to climb K2, bringing along a satellite receiver to the Advanced Base Camp at 17,000 feet. George endeavored to re-measure the height of K2, and his result, widely reported in the press, [suggested that K2 might be higher than Everest](#). Once the height of Everest was remeasured with modern equipment, however it regained its title as the highest mountain on Earth.

Among his many enthusiasms, George also maintained a lifelong interest in glaciology and meteorology. His students and postdocs quickly learned not to ask about the weather in casual conversation, since he would invariably reply with a full analysis of atmospheric conditions. George's meteorological expertise led him occasionally to teach the basic meteorology course at the University of Washington. And much to the chagrin of the faculty of the Meteorology Department, he frequently won their annual weather prediction contest.

For many years, George owned and flew a small plane. He found it convenient for professional and mountaineering purposes. In 1980, when Mt. St. Helens erupted, George was fascinated. One of his friends in Geology wanted to see the devastation up close, and George offered to fly him around the volcano. After some delay in getting permission they set off, with a third passenger, Lee Anne Willson, in the back seat taking pictures. They had excellent views. The next day, Mt. St. Helens erupted again.

George became an Emeritus Professor in April 1998. During winter quarter of that year, he taught the graduate course in Stellar Evolution. When the time came to distribute teaching evaluation forms at the end of the quarter, George handed them out but commented that the forms didn't have much meaning because he was retiring. The eight students diligently filled out the forms anyway. When George got the evaluations back later, he found that all eight students had written the same thing under the item "How to Improve the Course": Tell more puns! Of course, George was

well known for his love of puns, and especially the long battles carried out with like-minded punsters (Howard, we're thinking of you!)

While George's record of philanthropy is not as well-known as his other exploits, his lifelong contributions to the cause of social justice have made an important difference in the world. George recognized early in his life that opportunity is not distributed equally in our society, and his selfless support of Historically Black Colleges and Universities, including Tougaloo College, Morehouse College, and Fisk University provided funds for research fellowships for faculty. Starting in the 1960's, George contributed to the NAACP Legal Defense Fund, and devoted significant effort to raising funds for that organization and others. He helped to establish the Thurgood Marshall Institute and supported its work on voting rights. Contributions to the Herbert Lehman Education Fund supported Black undergraduates and law students to complete their undergraduate studies to become judges, members of Congress, professors, and founders of community organizations to work for social justice. George also provided significant support to the ACLU, Planned Parenthood, and the Nature Conservancy.

In an obituary for his post-doc advisor, Jesse Greenstein, George wrote:

One of Jesse's finest characteristics as a thesis and general research adviser was his ability to imbue younger people with the self-confidence to become independent scientists. It is particularly important nowadays to recognize the value of such encouragement, especially when new postdocs join groups of 20 or 30 scientists on a single project, yet a postdoc's name likely will not be listed as first author unless it happens to begin with an A.

The same was true of George Wallerstein. Many of his papers were led by his students and postdocs, including many women. He is remembered especially for his unwavering and generous support for so many early career astronomers.

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