Bulletin of the AAS • Vol. 53, Issue 2

John I. Castor (1943–2021)

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Published on: Jun 28, 2021

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John Irvin Castor, whose work helped to shape both astrophysics and high energy density science, died suddenly on January 19, 2021.

John Castor was born in Fresno, California on January 5, 1943, the youngest child of Lyle Castor and Virginia (Bragg) Castor. At age 10, Castor was given a book on calculus by a perceptive teacher, which he promptly devoured. He subsequently became interested in astronomy and built a telescope, grinding his own lens. He was taken under the wing of the local

Photo credit: unknown.

club of amateur astronomers and went to their star parties in the mountains above Fresno. In his sophomore year at Clovis High School, he enrolled at Fresno State University, and at the age of 18, he graduated with a double major in Math and Physics in 1961. He was given an honorary high school diploma. From 1961 to 1967, he was a graduate student at the California Institute of Technology, and earned a Ph.D. in astronomy in 1967. His supervisor was [J. Beverley Oke](#), who studied the spectra of RR Lyrae variable stars. Castor's thesis was on the theoretical modeling of RR Lyrae pulsations, with additional supervision from [Robert Christy](#). From 1967 to 1969, he was a post-doctoral research associate at the University of Colorado, working in the Joint Institute for Laboratory Astrophysics (JILA) under the supervision of John Cox. Castor continued the RR Lyrae modeling, incorporating time-dependent convective energy transport, and extending to a treatment of the linear instability theory of non-adiabatic pulsations.

In 1969, he joined the University of Colorado faculty in the Department of Physics and Astrophysics, and subsequently became a Fellow of JILA and eventually a Professor of Astrogeophysics. He began to work on the modeling of the spectra of Wolf-Rayet stars, stimulated by others at JILA including David Hummer, [David Van Blerkom](#), Peter Conti and Katy Garmany. While at Colorado, Castor made an extremely important contribution to astrophysics by developing the theory of radiatively driven stellar winds. In the late 1960s and early 1970s, astronomical observations showed that hot (O and WR type) stars were blowing off large amounts of mass in stellar winds.

Existing theories could not explain these observations. His work that ultimately explained this phenomenon was laid out in several papers published between 1972 to 1983. The main results were presented in the *Astrophysical Journal* in 1975, coauthored with Castor's graduate student David Abbott and postdoc Richard Klein. This work became known as the CAK theory [1]. Before this, the radiative pressure driving force on gas in the outer atmospheres of hot stars was calculated to be too small to create the observed winds. The CAK paper showed two additional factors produced a radiative force about one hundred times that of the existing theories. The first was the inclusion of a large number of weak, but still optically thick, lines of the abundant light elements in the radiative force calculation. The second was an elegant and effective formulation of the influence of Doppler shifts on line opacity in an accelerating wind. These two additions enabled a much larger fraction of the stellar continuum radiation to contribute to the radiation pressure than previously believed, thereby producing a higher mass loss rate. The CAK theory explained the observed wind velocities and mass-loss rates and pointed out the consequence of such strong winds on stellar evolution. Subsequent work explained the observation of H and He in the winds and the presence of radiative-hydrodynamic instabilities that explained time-dependent variations and the production of x rays in these winds. Castor's work on stellar winds has been extensively cited, utilized and improved upon since its inception over 45 years ago, up to the present day.

In addition to the stellar wind theory, together with Richard McCray and Robert Weaver, Castor developed a theory for the production of "interstellar bubbles" through the interaction of a strong stellar wind with the surrounding interstellar medium. This work has been highly utilized in understanding observations in stellar, interstellar, and galactic astrophysics over the past 45 years.

In 1981 Castor left Colorado to join Lawrence Livermore National Laboratory in a group led by Carol Alonso. At LLNL, Castor contributed to many important aspects of both classified and unclassified weapons physics. He was a key contributor to experiments at the Nevada Test Site. His astrophysical work with Klein continued, and became a general theory of non-local thermodynamic equilibrium (non-LTE) spectral analysis, that is, modeling the spectrum when the atomic level populations must be found by solving kinetic equations rather than using the relations valid for thermal equilibrium. This was an area of very active development at LLNL in the 1980s, as a key component of the X-ray laser program. Castor also developed the ALTAIR code to solve the time-dependent non-LTE problem for a multilevel atom in two-dimensional axisymmetric geometry on a Lagrangian mesh of arbitrary complexity .

In the 1990s, Castor worked with Bruce Remington, Gail Glendinning, and others to develop the nascent field of laboratory astrophysics. The team performed the first experiments to study supernova-relevant hydrodynamic instability experiments on the Nova laser. This transformative work demonstrated the utility of laser-driven experiments in exploring astrophysical phenomena. Much of the work performed at the Nova laser, and in the early days at the National Ignition Facility, laid the basis for the field that is now broadly known as “High Energy Density Science.” It is difficult, and perhaps impossible, to find a current experiment that was not influenced in some way by this early work at Nova.

In the 2000s, Castor focused on improving radiation hydrodynamic modeling and simulation capabilities for these laboratory experiments. His book, “Radiation Hydrodynamics” [2], provides an accessible introduction to the theory, and the large-scale simulation methods used in the study of the dynamics of matter interacting with high intensity radiation. As a part of this work, Castor worked with Carlos Iglesias, Forrest Rogers, Brian Wilson, Mau Chen, and others, to develop a client-server database of tabular opacity models for use in simulations. This work provided a revolutionary way of dealing with essential physical inputs for modeling laboratory-scale experiments. Castor also continued his astrophysical work on radiation-hydrodynamic models of eclipsing low-mass X-ray binary stars.

During the last several years of his tenure at Livermore, Castor worked on experiments to measure the X-ray opacity of matter at high temperature and density. These experiments used high-power, short-pulse lasers to create the heated matter. He provided critical insights for motivating these experiments and on computational simulations to design and understand them. He also participated in the Cimarron Collaboration, led by Frank Graziani, to extend large-scale atomistic simulation capabilities to the study of plasmas.

In 2012, Castor was named a “Distinguished Member of the Technical Staff” at LLNL. This is the highest honor, bestowed by the Laboratory Director, for extraordinary scientific and technical contributions to the Laboratory and its missions, as acknowledged by Castor’s professional peers and the larger community.¹ Castor worked at LLNL until his retirement in 2017. A symposium in his honor featured talks about the context and impact of Castor’s work by several collaborators over the course of his career.²

John Castor (photo courtesy Melissa Reading)

Castor was a mentor to many over the course of his career, and he demonstrated day in and day out how to treat others. We never heard him raise his voice or say an unkind word, though he also had no tolerance for nonsense. We expect a high degree of precision and accuracy in our work, and Castor was one of the folks who truly set the bar for the physics community. He did not hesitate to point out when there was a problem with our work. That being said, he always did so in the most patient and constructive way, without making anyone feel innately less capable. He never turned anyone away when asked for help. There was a pretty constant stream of folks at Castor's door seeking advice. In every interaction, he demonstrated the caring of a most patient instructor, coupled with the intelligence of a great scientific mind.

John Castor and his wife, Melissa Reading, on one of many mountain treks. (Photo courtesy Melissa Reading)

Castor had a love of music and the outdoors. He enjoyed trips with his family to the mountains of Colorado, California and Europe. He also attended numerous classical music concerts and festivals. He is survived by his wife of 43 years, Melissa Reading, daughter Emily Warren and son-in-law Frankie Warren, sister Judy Butts and brother-in-law Alan Butts, and many loving nieces, nephews, cousins, and close family friends. He was preceded in death by his brother Paul Castor, in 1967 and son Ethan Castor, in 2017.

Footnotes

1. Castor authored more than 100 papers which have garnered more than 8200 citations. [↵](#)

2. A video archive of the Castor Symposium can be viewed online:

https://youtube.com/playlist?list=PLvGO_dWo8VfdmV7pSam62WZc7DBWgHIzL ↵

Citations

1. Castor, J. I., Abbott, D. C., & Klein, R. I. (1975). Radiation-driven winds in Of stars. *The Astrophysical Journal*, 195, 157–174. <https://doi.org/10.1086/153315> ↵
2. Castor, John I. (2004). *Radiation Hydrodynamics*. ↵