Observations

In Memoriam: Jerry Nelson, Legendary Telescope Designer

His brilliant insights helped pave the way for an astronomical revolution

By Hilton Lewis on June 16, 2017

Nelson with a model of the Keck telescope. *Credit: W. M. Keck Observatory*

I met Jerry Nelson for the first time 31 years ago. He was the project scientist for the Keck Telescope, but no one warned me that he also was the smartest guy in the room. But it didn't take long to find out—and it never changed in the many decades since.

My recollections of Jerry are a tangle of awe, friendship, fun and the hardest work of my life.

Jerry, a pioneering astronomer at the University of California, Santa Cruz, and the "father" of the twin Keck telescopes, died Saturday, June 10, at age 73. He first started serious work on a proposal for a large segmented primary mirror in 1977. At that time the biggest successful telescope was the 200-inch Hale telescope on top of Mount Palomar near San Diego. A storied machine responsible for some of the greatest advances in modern astronomy, its 200-inch primary mirror set the size limit for five decades.

The diameter of the primary mirror is a critical parameter of a telescope, defining its light-collecting power as well as its ability to discriminate fine detail. For decades people had sought a path to making larger primaries, but the challenge had proved insurmountable. To maintain the precision surface, the mirror had to be thick enough to support its own weight without deflecting. But that enormously increased the mass, which caused the mirror to change shape constantly as the temperature varied throughout the night—ruining the very shape that was so important to making perfect images.

Jerry's singular innovation—the killer app that underpins the extraordinary scientific success of the Keck telescopes—was to make small, thin, lightweight segments and tile them together to make a single large mirror. It sounds easy, but turned out to be fiendishly difficult in practice. Jerry worked closely with fellow physicist Terry Mast to figure out how to polish the individual segments to the precise shape needed (there are 36 interlocking segments of six different shapes in each of the Keck telescopes' 10-meter primary mirrors); how to support them mechanically to avoid distortions; and, most critically, how to position them individually so that they maintain their relative positions as the telescope moves and temperatures fluctuate throughout the night.

The twin Keck Telescopes, Mauna Kea, Hawaii. Credit: NASA, JPL

There is no doubt that the design pioneered by Jerry with the help of Mast and their colleague Gary Chanan is a tour de force. Many once doubted it would ever work; now proved beyond doubt on the Keck telescopes, it is the basis of the next generation of extremely large ground-based telescopes as well as space-based ones such as the James Webb Space Telescope, successor to the storied Hubble Space Telescope.

Jerry was the driving force behind the concept of the segmented mirror telescope. Yet he was much more than just a thinker. To me, he was always "an engineer's engineer," even though he had degrees in physics from California Institute of Technology and U.C. Berkeley, and was a practicing astrophysicist long before he became a legendary telescope designer. He loved nothing more than to think things through from first principles. His tool of choice was the Excel spreadsheet on his beloved Mac—he recognized Excel's power for engineering computation while the rest of us were writing dedicated FORTRAN and C programs (and getting them wrong some of the time).

Jerry taught me the power of thinking of the general case before trying to solve the specific one. He and Terry, derided by one of their famous colleagues as "the goes-as boys," made extraordinarily powerful use of scaling laws—of one quantity "going as" some power of another. Jerry had a deep grasp of how physics underpinned all engineering problems, a superpower that the rest of us "regular" engineers and physicists could only strive to emulate. A friend once had him come over to stabilize a home-built swing set—and marveled at how Jerry immediately pointed out a few strategically placed additions, transforming it from a rickety death trap to a structurally sturdy, engineered solution.

Credit: UC Santa Cruz

Jerry was never dismissive of anyone. He had endless patience in explaining things although he was often frustrated at how long it took to make things work. "We can walk and chew gum at the same time," he would declare—overlooking that we were on a balance ball, juggling six other tasks and solving problems no one had even considered before. In the technical arena he never met a challenge he didn't want to conquer, a problem he didn't think had a solution. I have never had a mentor like Jerry: a teachable moment always started with "It's probably just me, but I don't understand…" or "I'm no expert, but…" It

signaled your arguments were tenuous, built on a foundation of sand and liable—no, destined—to crumble. Those of us who worked with him learned to think clearly and defend our proposals well. Never did we feel belittled or condescended to. His gift was to teach without pedantry; to ask that one crucial question that illuminated the way out of the most difficult problem.

Jerry loved people regardless of station—or especially if they had no station. He was as much at ease with a junior engineer as with a leading astrophysicist. He enjoyed the company of everyone with whom he came into contact, finding value in every human interaction. But he was no pushover. Jerry fought for the scientific promise of the Keck telescopes. Whereas others worried about budgets and schedules, Jerry demanded only the best. He didn't win every battle—thankfully, or we might still be building the observatory—but he won the war. Nor was he always right; when you could prove there was a better way, he gracefully accepted it, and fought to implement your idea as if it were his own.

Conceiving, designing and building the Keck telescopes was the most significant part of Jerry's career, but it was by no means the only part. Jerry went on to play an important role in the development of adaptive optics for large telescopes as the founding director of the Center for Adaptive Optics at U.C. Santa Cruz. Adaptive optics is a technique for compensating for the blurring effect of Earth's atmosphere, allowing a telescope to resolve the highest level of detail possible for a given mirror size. It is now central to the performance of all the large telescopes, and has given the Keck telescopes an unsurpassed ability to resolve the finest details of the most distant objects. Not content with this, Jerry for the last two decades led the charge for a next-generation extremely large telescope, serving as the project scientist for the proposed Thirty Meter Telescope (TMT), a massive segmented-mirror, adaptive optics–enabled telescope now under design.

Innovator, independent, dedicated, relentless—these words describe Jerry Nelson, the visionary creator of the Keck telescopes, which are often described as the "jewel in the crown" of the Caltech and University of California astronomy research facilities. But I also remember another Jerry: a loving father and devoted husband, a friend, a wonderful teacher and an inspiration to all. A man as much at home sharing a few

beers, surfing or going for a swim with friends as with discussing the most difficult intellectual concepts. A man who had known sorrow, but was the more human for it.

Nelson on receiving the Benjamin Franklin medal in electrical engineering in 2012. Credit: UC Santa Cruz

In the last years of his life, disabled by a stroke, Jerry nonetheless continued to make significant contributions to the design of the TMT and a complex optical system scheduled to be delivered to the Keck Observatory in just a few more months—his most recent technical communication coming only a day before he died. One of my colleagues recounts watching Jerry struggle to make it into his office on campus day after day following his stroke. Jerry could easily have given up and stayed home. He had earned more glories and prizes than anyone could wish for, and the respect of all who knew his work. But he persevered—not to prove anything but for the love of the field to which he had dedicated his life. He immeasurably enriched astronomy and the art of telescope-making. The instruments he built and the science they enable are testament to the man. Jerry showed us that together we could achieve more than we ever dreamed.

As we say in Hawaii, *A hui hou*—until we meet again. You are sorely missed, but your inspiration lives on.

ABOUT THE AUTHOR(S)

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Hilton Lewis is director of the W. M. Keck Observatory on the Island of Hawaii, home to the world's two largest optical/infrared telescopes. He worked with Jerry Nelson on the design and construction of the twin Keck telescopes.

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