Santa Fe Institute

MAY 4, 2018

David Pines, a central figure in understanding the elemental properties of condensed matter and who played a major role in birthing complexity science and founding the Santa Fe Institute, passed away May 3, 2018, in Urbana, Illinois after a battle with pancreatic cancer.

At the time of his passing Pines, 93, was co-founder in residence at SFI, founding co-director of the Institute for Complex Adaptive Matter (a multi-campus research program of the University of California) and its international component I2CAM, and founding director and professor emeritus of physics and electrical and computer engineering in the Center for Advanced Study at the University of Illinois at Urbana-Champaign (UIUC).

"David was one of the pioneering members of the SFI community who brought a true breadth of interest together with a devotion to education and a fascination with emergence. Rather than seek to reduce complex phenomena to those of physics and chemistry, David was willing to search for new formalisms in an entirely new environment, one in his terms, 'without fiefdoms,'" says SFI President David Krakauer. "To this day we strive to remain true to David's objectives."

Pines was a longtime advocate for describing the properties of systems that arise from the behaviors of their underlying components in terms of "emergence."

He is best known for his contributions to understanding the phenomena that emerge from the complex interactions of the elementary constituents of matter.

Pines' scientific career began at Princeton in the mid-1940s when he was a postdoc working with famed theoretical physicist David Bohm. Their work focused on the behavior of electrons in a dense gas, research that continued into the early 1950s and resulted in a series of influential papers even as Bohm was forced to leave the United States due to his investigation by the House Un-American Activities Committee. (Bohm was later acquitted.)

Kevin Bedell of Boston College, who knew and collaborated with Pines for decades, says one of Pines' earliest and most significant contributions to physics was a 1950 paper with Bohm that outlined a theoretical technique called the random phase approximation, or RPA.

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¨It doesn't sound like much, but it has impacted almost every field of physics,¨ Bedell says. ¨When somebody introduces a new method, they have to show they can reproduce RPA. Nobody really knows who initiated RPA. I always tell students the P in RPA stands for Pines."

Pines received his Ph.D. from Princeton in 1950 and in 1952 joined the physics department at UIUC, working as a postdoc with physicist John Bardeen, co-inventor of the transistor. Physicists had been working on a theory of superconductivity since the phenomenon's discovery in 1911, but a satisfying theory had yet to be developed.

Pines and Bardeen dug in on a then-controversial idea that superconductivity might arise from an attractive force between electrons resulting from phonons, or packets of vibrational energy in a crystal lattice. In late 1954 they showed that, despite the strong repulsion between like-charged electrons called the Coulomb repulsion, it is possible for phonons to generate an attractive force for some electrons in these materials.

Months later, in 1955, Pines accepted a coveted assistant professorship at Princeton. Tenure-track positions in physics were rare then due to the post-war migration of Manhattan Project physicists into key slots, and the opportunity seemed to Pines to be a fortuitous one.

In hindsight, the career move might have been a costly one. When Pines left Bardeen's group, his replacement Leon Cooper, graduate student Bob Schrieffer, and Bardeen went on to develop the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity that earned them the 1972 Nobel Prize in Physics.

"He did deserve some fraction of that Nobel Prize," says physicist and Nobel laureate Phil Anderson of Princeton, an SFI Science Board Emeritus member. "It was the Bardeen-Pines interaction that made the Cooper pairing mechanism. If they had allowed four people [on the Nobel Prize team], he would have been on it."

It wasn't the only Nobel near miss. Anderson says that at least two other times, Pines was the fourth (or an early) collaborator on work that later was awarded the top prize. Pines seemed to have a knack for collaborating with the most important people in physics on the most important questions, he says.

After a short stint at Princeton, Pines returned to Urbana-Champaign as a professor in 1958 and spent most of the remainder of his career with UIUC as his academic home base.

A 1958 paper by French physicist Philippe Nozières and Pines "was one of the important papers about electron-electron interactions," says Anderson. "It was the first work that really implied that modern quantum mechanics could apply to a solid state problem."

A 1999 volume co-edited with Nozières, "Theory of Quantum Liquids," is considered a classic text describing the unifying aspects of the extremely broad field and remains Pines' most persistently cited work.

In research that began in the late 1960s and continued into the 1990s, Pines joined a chorus of scientists studying superfluidity in neutron stars, in particular, the mysterious, sudden observed increases in the rotational speed of pulsars, termed "glitches."

After high-temperature superconductivity was verified in 1986, scientists rushed to define a theoretical framework for the phenomenon. Two leading theories emerged: Anderson's "resonating-valence-bond theory" proposed in 1987, and the "spin fluctuation theory" proposed in 1991 by Alexander Balatsky, Philippe Monthoux, and Pines. Neither approach is today considered satisfactory, but the early formulations helped define later thinking.

Beginning in the early 1980s, Pines played a critical role in the Santa Fe Institute's founding and growth. As an advisor at Los Alamos National Lab, he was among a group of senior scientists convened by George Cowan, who later became SFI's founding president, to brainstorm the recipe for a new and unconventional interdisciplinary institute.

During SFI's formation, Pines recruited many of the top scientists whose involvement bolstered the Institute's credibility, including Anderson and Murray Gell-Mann (Pines' longtime close friend). Pines also called on his connections in academia and government to attract some of the Institute's earliest funding. At various times he served as SFI's vice president, chair of the board of trustees, and co-chair of the science board.

And in 1984, Pines co-organized tandem SFI founding workshops attended by top scientists from around the world. Memorialized today in a printed volume titled "Emerging Syntheses in Science," with a forward by Pines, the workshops set the Institute on its successful research trajectory and defined its initial scientific community.

In terms of supporting SFI's founding president George Cowan and "putting it all together, it was David Pines and Mike Simmons [former SFI vice president]," says Anderson. "His relationship with Murray was very important. He brought me in. He knew a lot of influential people."

With Anderson and economics Nobel laureate Kenneth Arrow, Pines co-edited the volume "The Economy as a Complex Evolving System" summarizing a series of meetings in Santa Fe on complexity economics, which became SFI's first funded research program.

He remained an SFI ally and contributor for 34 years.

In recent decades, Pines spent much of his time in Urbana, Illinois, Santa Fe, New Mexico, and Aspen, Colorado where he was a member of a group of physicists nucleated around the Aspen Center for Physics. He was at various times affiliated with a least a dozen universities in a number of countries including Australia, China, France, Hungary, Russia, Sweden, Turkey, and the U.K. He also had long-term collaborations with the Neils Bohr Institute

collections of the most important papers at the frontiers of physics in the 1960s and ‘70s — was ¨enormously influential," says Anderson.

His research contributions were recognized by two Guggenheim Fellowships; the Feenberg Medal; the Friemann, Dirac, and Drucker Prizes; and by his election to the National Academy of Sciences, American Philosophical Society, American Academy of Arts and Sciences, Russian Academy of Sciences, and Hungarian Academy of Sciences.

Throughout his career, Pines devoted much of his time to improving the state of science education and its delivery. He delighted in teaching younger scientists during his professorship at the University of California, Davis. In 2011, he developed an online course, "Emergent Behavior in Quantum Matter," part of an 11-unit multimedia curriculum exploring the current frontiers of physics called Physics for the 21st Century.

Motivated by scientific curiosity, Pines was among the first to "reach across the antisemitism divide" following Stalinist Russia's post-war persecution of prominent Jewish scientists in the 1940s and '50s, says Campbell. He was the driving force behind a series of US-USSR scientific fellowship exchanges from the 1960s into the '80s that led to improved international relations, at least in the physics community. What he found, says Campbell, was "a lot of crossover and parallelism" among the work of the Russians and the Americans.

His passionate and persistent advocacy of a number of ideas in science sometimes chafed his colleagues. But it was that same conviction that led to the founding of several institutions that remain today, including SFI and the Institute for Complex Adaptive Matter, says Bedell.

"David [was] very influential in terms of getting people together and getting ideas together," he says. "He knows how to talk to people— not too forceful, but persistent, a good salesman."

"David had boundless energy, boundless ambition, and good sense of humor," says Elihu Abrahams of UCLA, who knew Pines from the early 1950s. "He's certainly the most energetic scientist I have ever met."

In the years preceding his death, Pines had become the chief promoter and architect of the international Think Like a Scientist (TLS) initiative. Its goals are to create a science literacy movement, build resources and technologies for science education, and teach young learners the tenets of scientific and critical thinking.

Pines is survived by his children Catherine Pines and Jonathan Pines, his three grandchildren Josie, Tillie, and Maisie Pines, and his sister Judith Fried. He was preceded in death by his wife Suzy Pines (1925-2015).

"He does bring enthusiasm to physics ideas," said Sebastian Doniach of Stanford, who knew Pines through the Aspen Physics Center and Los Alamos. "He carried a lot of good ideas from physics to a larger audience."

At an 80th birthday party for Pines, Bedell says he adapted a poem, "Charge of the Light Brigade," reading a version he calls "Charge of the Pines Brigade."

"That's the way I think about him," Bedell says. "In the course of any idea there are ups and downs. He's a guy who believes in the power of bringing people together from many perspectives and something good is going to come from it. If he believes in it — ICAM, SFI, TLS, high-temperature superconductivity — he doesn't waver. He believes in it to the core."

In honor of David Pines, the SFI Press is reprinting 'Emerging Syntheses in Science' with a new forward by Pines. The publication date will be announced on santafe.edu.

The Santa Fe Institute invites friends and colleagues of David Pines to share memories of his life and career on our Facebook page.

Read the obituary in *The New York Times* (May 11, 2018)

Read the obituary in *The Daily Californian* (May 15, 2018)

Read the obituary in the *Santa Fe New Mexican* (June 3, 2018)

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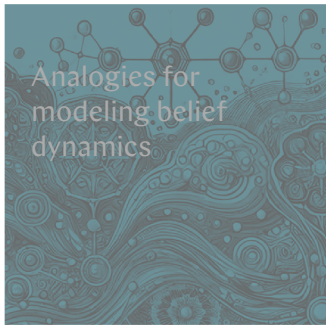

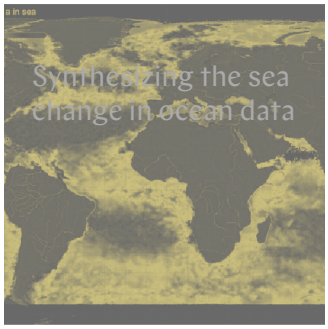

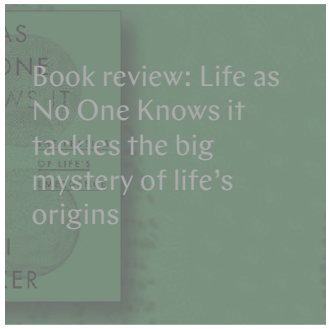

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