

## Elias Burstein FREE

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achievement), and as president of the solar-system division of the International Astronomical Union.

Because of his leadership, scientific drive, and generosity, the University of Maryland became a center of the cometary universe. By many counts, he trained, collaborated with, and employed more than 80% of the pre-Rosetta generation of cometary astronomers. Mike's students remember him for encouraging them to try new projects and supporting them to actually see them through. His scientific lectures were always pan-disciplinary, well argued, and concise but also illuminating, even to experts in the field.

An avid sailor, celestial navigator, husband, and parent, Mike was well loved by his students and highly respected by the planetary-science community, who will miss his rapier wit and love of logical argument for all things cometary. But if they look up some night, they may see a piece of him in the sky: Asteroid 3192 was named A'Hearn in his honor.

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## Elias Burstein

Elias "Eli" Burstein, Mary Amanda Wood Professor emeritus in the physics department at the University of Pennsylvania, passed away peacefully on 17 June 2017 at his home in Bryn Mawr, Pennsylvania, three months before his 100th birthday.

Born in Brooklyn, New York, on 30 September 1917, Eli majored in chemistry at Brooklyn College and later obtained an MSc in chemistry from the University of Kansas in 1941. From 1941 to 1943, he was in the doctoral program at MIT, but his study was interrupted by World War II. He joined the US Naval Research Laboratory and worked in the physics section of the crystal branch. Within 10 years he was promoted to head of the semiconductor branch.

Eli never formally completed his PhD degree, partly because he did not have the time and partly because he did not need to. Widely recognized for his efforts

in solid-state physics, he received many honors, including the 1979 John Price Wetherill Medal from the Franklin Institute and the 1986 Frank Isakson Prize for Optical Effects in Solids from the American Physical Society (APS).

In 1958 Eli joined the University of Pennsylvania as a professor of physics. He was named the Mary Amanda Wood Professor of Physics in 1982 and held that chair until his retirement in 1988. Eli helped to build up the physics department into a leader in condensed-matter physics. He was one of the founders of the university's Laboratory for Research on the Structure of Matter.

Eli's main research interests focused on the properties of semiconductors, particularly on their optical properties. He broke ground on many of the techniques used for studying semiconductors, including optical spectroscopy of shallow impurities and inelastic light scattering, also known as Raman scattering.

Eli was among the first to use lasers to study the optical properties of solids. But his interest went well beyond his experimental work. One of his most cited papers, published in *Physical Review* in 1954, explained some anomalous effects due to impurities in the semiconductor indium antimonide. Workers at AT&T Bell Labs had discovered that the onset of absorption in InSb shifted to higher energy when the impurity concentration was increased. That effect was opposite to what had been observed in other semiconductors, such as silicon and germanium. Eli proposed an explanation in

terms of the unusually small effective masses of the electronic bands of InSb and the Pauli exclusion principle. The effect has become known as the Burstein shift and the Burstein-Moss shift, since it was also suggested independently by Trevor Moss in the UK.

In the field of Raman scattering, Eli's contributions were extensive and influential. Conventionally, Raman scattering was performed on transparent crystals, since the signal was much weaker than the elastically scattered light. Eli pioneered the use of double spectrometers to reject the strong elastic scattering so that weak inelastic-scattering signals from opaque semiconductors could be detected. He demonstrated theoretically that when a crystal strongly absorbs the incident light, the Raman process should be interpreted in terms of inelastic scattering of polaritons. Eli and his coworkers extended the study of Raman scattering to surface polaritons, interface phonons, and two-dimensional plasmons. He also was instrumental in understanding the mechanism for the phenomenon of surface-enhanced Raman scattering, or SERS.

In 1963 Eli became the founding editor of *Solid State Communications*, the first letter-type journal devoted to the field. He remained its editor-in-chief for nearly 30 years. He also was the founding editor of *Comments on Condensed Matter Physics* in 1986 and coeditor of the book series *Contemporary Concepts of Condensed Matter Science*. He worked tirelessly to help APS's division of condensed-matter physics emerge from the shadow of particle and high-energy physics to become the society's largest division.

A devoted family man, Eli will also be remembered by his 35 PhD students and the many researchers he mentored and treated like family members. He would encourage them to submit papers, including to the journals he edited, and to lecture at conferences, including the numerous ones he organized. Eli will be missed for his warmth as a human being and his deep insights as a physicist.

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