Rufus Ritchie: A gentleman, scholar and “father of the surface plasmon”

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Carolyn Krause provides insights into the life of Rufus Ritchie, a corporate fellow at the Oak Ridge National Laboratory and a Ford Foundation Professor of Physics at the University of Tennessee at Knoxville.

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On the surface Rufus Ritchie was a happy, smiling, friendly, caring, modest man who showed interest in what others think and do. The discoverer of the surface plasmon, which has useful applications for therapeutic drug development, food analysis and nanoscience research, Ritchie was also a man of considerable depth. Because of his ground-breaking discovery, he was nominated for a Nobel Prize in physics and was honored with numerous awards.

A corporate fellow at Oak Ridge National Laboratory and a Ford Foundation Professor of Physics at the University of Tennessee at Knoxville, “he was the very definition of a gentleman and a scholar,” according to his obituary in the April issue of Physics Today. Ritchie died peacefully on July 29, 2017, in Gilbert, Ariz, at the home of his daughter, Susan Ritchie Snowden. He had two children and 15 grandchildren, great-grandchildren and great-great-grandchildren.

Ritchie – as many folks including his wife of 62 years, Dorothy, called him – was born on Sept. 24, 1924, in the coal-mining camp of Blue Diamond, Ky. His father was a coal mine supervisor and his mother an elementary school teacher; she impressed on him the importance of getting a good education.

“He told me once that his high school did not offer any advanced math,” said Larry Dipboye, pastor at Grace Covenant Church in Oak Ridge, which Ritchie attended (previously he was a member and deacon at First Baptist Church in Oak Ridge, where Dipboye had been preacher). “Rufus entered the University of Kentucky with an academic handicap but managed to catch up.”

Later he leaped far ahead. Ritchie “was universally respected and admired as a great theoretical physicist” who “could provide in a day or two a model and an elaborate calculation of an idea that had just been discussed,” according to the Physics Today obituary.

In 1947 Ritchie earned a B.S. degree in electrical engineering from the University of Kentucky. During World War II, he served in the U.S. Army Air Corps and attended military scientific education programs at Harvard and Yale universities and MIT. In 1949 he joined the Health Physics Division at ORNL, where he spent his entire career, except for sabbaticals at Cambridge University’s Cavendish Laboratory and two universities in Denmark.

Ritchie and Sam Hurst, who later pioneered the touch screen as an entrepreneur, became close friends at ORNL. Hurst asked Ritchie to help him gather radioactive materials from an atomic bomb site in Japan. According to Dipboye, Ritchie said while reminiscing about this experience, “We wore moon suits for protection. I have never moved so fast.” Ritchie lived to be almost 93.

The Physics Today obituary states that Ritchie “is regarded as one of the founders of modern radiation dosimetry.” His innovative contributions were essential for creating a program to determine radiation exposure of the atomic bomb survivors of Hiroshima and Nagasaki in Japan.

While at ORNL, Ritchie pursued a Ph.D. in physics at UTK, receiving it in 1959. During his pursuit he published a landmark paper, which has had more than 2,000 citations. Here is a description of his work in the Physics Today obituary to which former ORNL physicists and current UT professors Bob Compton and Tom Ferrell contributed:

“Early on, close collaborations between experimentalists and theorists were strongly encouraged, and they became a hallmark of Ritchie’s work. In the early 1950s, while analyzing experimental data with

Robert Birkhoff, Ritchie became interested in the way energy losses are distributed when a fast electron passes through a thin metal foil. In working out the spectrum to describe how the metal should respond, he discovered the surface-localized collective electronic oscillation now known as the surface plasmon or surface plasmon polariton.

“The discovery met fierce resistance from those who doubted that the surface plasmon could exist, and initially Ritchie was hesitant to move forward with his work. However, encouraged by his ORNL colleagues and mentors, he published his prediction in a 1957 paper in *Physical Review*. Three years later a series of electron-scattering experiments at the National Bureau of Standards (now NIST) confirmed surface-plasmon losses.

“The full effect of Ritchie’s discovery became clear only years later with the advent of nanotechnology in the late 1990s. The surface plasmon polariton can now be used to confine and manipulate light at the nanoscale, far below the diffraction limit of light. It provides large field enhancements for biosensors, surface-enhanced Raman scattering, diode lasers, and other physical effects. Ritchie’s 1957 paper opened up the new fields of nanoplasmonics and nanophotonics to various uses and has inspired many practical applications in such areas as optoelectronics, photovoltaics, solar energy conversion, and biomedicine.”

In the 1960s Ritchie had a joint UT-ORNL faculty appointment in the UTK Physics and Astronomy Department. At ORNL he was recognized in 1989 “for fundamental studies in radiation physics, radiation dosimetry, and surface physics and for pioneering theoretical work on collective electron modes, surface electromagnetic waves in solids, and elucidation of the interaction of charged particles with matter.”

So, what is a surface plasmon? First, think about plasma – a superhot gas in which free electrons move rapidly amid a background of positive charges. Plasmas are present in experimental fusion reactors and the sun’s atmosphere. Free electrons can also be accelerated or slowed at and just below the surface of a thin, electrically conductive metal foil. As a result of the excitement of the free electrons by laser light, electromagnetic waves of infrared or visible light are generated that can travel along the boundary between the foil and air or an insulator.

In an interview, Ferrell, who worked closely with Ritchie, described an experiment in which a thin layer of gold is evaporated on a microscope slide attached to a glass prism. A red light from a laser is aimed through the prism. The red light at many angles will be reflected. But at just the correct angle, the light energy penetrates the gold layer, creating surface plasmons on the layer that decay within microseconds, emitting light waves.

“The electric field of the light must oscillate in one direction to drive the electrons,” Ferrell said. “If you introduced blue laser light, it has to come in at a different precise angle to excite surface plasmons. If the angle is shifted by a tiny fraction of a degree, the light is reflected.

“Now, if you place a thin film of DNA or protein on the gold layer, that changes the angle at which the red and blue lights must come in so they are not reflected. By carefully measuring how much you have to shift the laser angle so that its light is not reflected, you can distinguish the bases of DNA or the amino acids of the protein you want to identify.”

Ferrell said that Erwin Kretschmann, while in Germany, originated the idea of the excitation of surface plasmons in the optical configuration, described above. To implement his idea, he came to ORNL and worked with Ritchie, who did the calculations, and Ed Arakawa, who conducted many experiments.

“Pharmacia Biosensor AB in Sweden (owned by Pfizer since 2003) funded University of Uppsala scientists for nine years to turn the Kretschmann configuration into a commercial device, called Biacore,” Ferrell said. “It is widely used as an analytical device for drug discovery and food and biochemical research.”

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Dipboye recalled that "Rufus had a great sense of humor and loved 'Car Talk' on NPR radio. In the late 1990s he and Sam Hurst initiated the Oak Ridge Forum on Religion and Science. Rufus once called Louie Armstrong's 'What a Wonderful World' 'the most beautiful song I've ever heard!' " And that was the song performed at Ritchie's memorial service in Oak Ridge.

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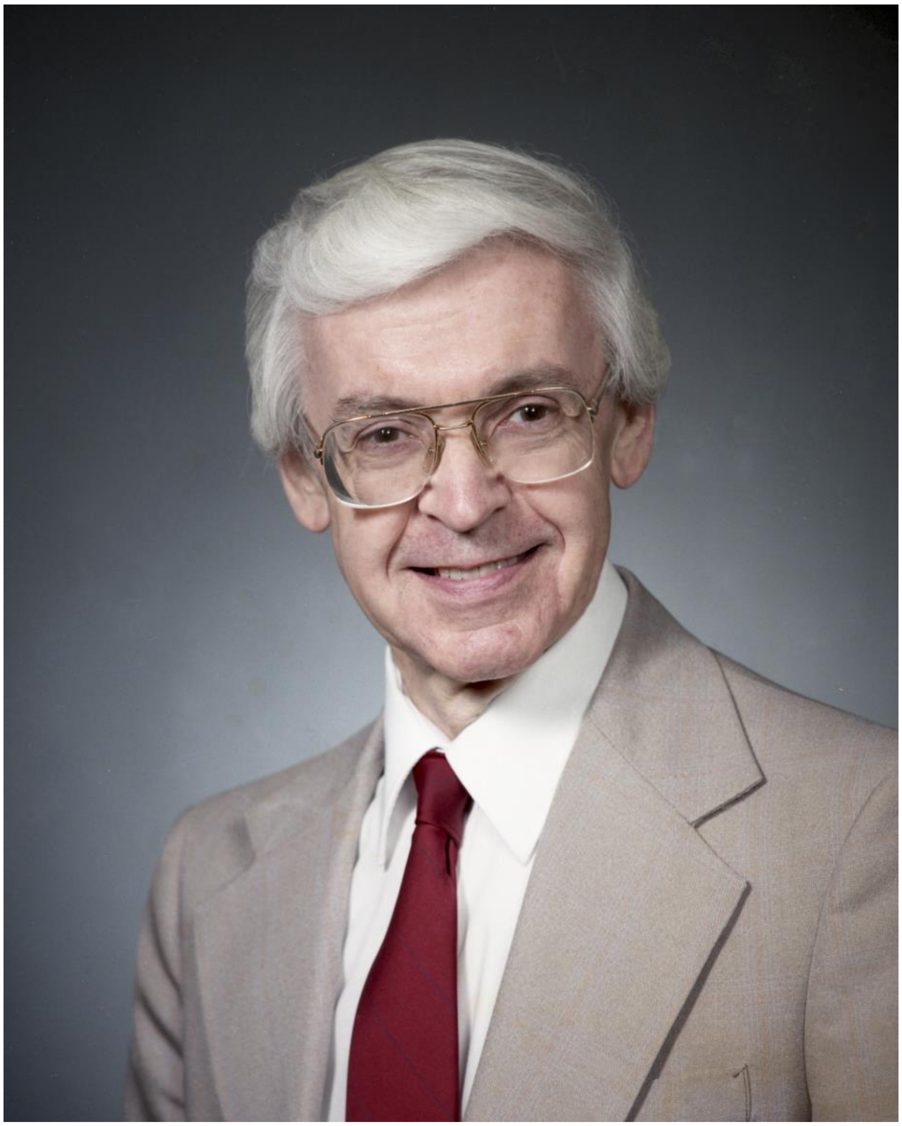
Thank you, Carolyn.



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