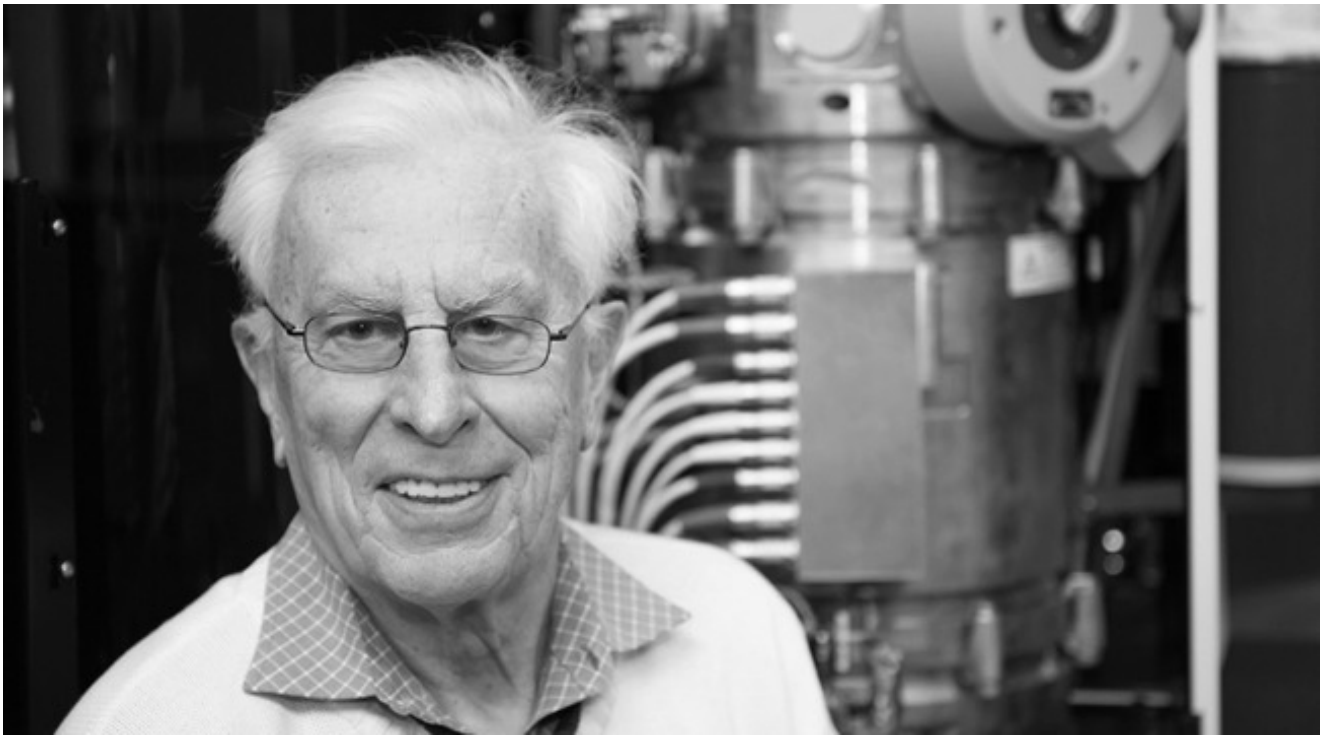
In Memory of Harald Rose

14 February 1935 – 27 July 2026



Harald Rose at Ulm University.

It is with deep sadness that the European Microscopy Society records the passing of Professor Harald Rose on 27 July 2026. With him, the microscopy community has lost one of the great architects of modern electron optics, whose theoretical work opened entirely new possibilities for imaging and analysing matter at the atomic scale.

Born in Bremen in 1935, Harald Rose studied physics and mathematics at the Technische Hochschule Darmstadt. Influenced by his teacher Otto Scherzer, he devoted much of his scientific career to one of the central limitations of electron microscopy: the spherical and chromatic aberrations inherent in rotationally symmetric electron lenses. From his doctoral and habilitation work onwards, Harald Rose developed increasingly sophisticated multipole concepts for overcoming these limitations, culminating in the sextupole-corrector design closely associated with his name.

For many years, practical aberration correction was regarded as extraordinarily difficult, if not beyond reach. Harald Rose, however, was convinced that the obstacle was technological rather than fundamental. Together with Maximilian Haider and Knut Urban, his theoretical concepts were eventually brought to experimental success. The 1997 demonstration that aberration correction could substantially improve TEM resolution was a decisive milestone and helped initiate a new era in electron microscopy. Aberration-corrected instruments are now standard in laboratories worldwide and enable structural, chemical and electronic information to be obtained with unprecedented spatial resolution.

Rose's contributions were by no means limited to aberration correction. He advanced the theory of image formation in both TEM and STEM, developed important descriptions of imaging with inelastically scattered electrons, and proposed imaging concepts such as differential phase contrast. His work on curved optical axes and on Omega and Mandoline energy filters further illustrates the remarkable range of his interests. His

monograph *Geometrical Charged-Particle Optics* became an important reference for researchers and students in electron and charged-particle optics.

His influence was equally visible in the scientists he trained. Several of his students later played leading roles in the development of electron optics in academia and industry, not least at CEOS, where fundamental ideas in aberration correction were developed into instrumentation that has had a worldwide impact.

Following his retirement from TU Darmstadt in 2000, Rose remained scientifically highly active. He held research appointments at Oak Ridge National Laboratory, Argonne National Laboratory and Lawrence Berkeley National Laboratory and contributed to advanced electron-optical concepts associated with the TEAM and PICO instruments.

A further important chapter began at Ulm University. In 2007, after one of the first commercial aberration-corrected transmission electron microscopes had been installed there, Ute Kaiser invited Harald Rose to introduce her group to the theoretical foundations of aberration correction. The initial lecture series grew into a close scientific collaboration lasting nearly two decades. As Senior Professor at Ulm University, Harald Rose continued to teach electron optics and Fourier optics, took part regularly in group seminars, and contributed his expertise to the SALVE project and to discussions of atomic-resolution imaging and beam-sensitive materials. For the Ulm group, discussions with him were both intellectually demanding and a constant source of stimulation and enjoyment; for Harald Rose, Ulm provided the opportunity to remain deeply engaged in science, teaching and research well into advanced age.

His intellectual curiosity never diminished. For about two decades, Harald Rose pursued a highly original theoretical approach to one of the most fundamental questions in physics: the internal structure of elementary particles and the origin of their mass. He developed a Lorentz-invariant four-dimensional model in which massive particles are described as bound systems of massless elementary constituents, with mass emerging from the four-dimensional rotational motion of the compound system. He succeeded in publishing this work in 2022. Its future scientific assessment remains open, but this late work illustrates something deeply characteristic of Harald Rose: even after his major achievements in electron optics, he continued to challenge established concepts and search for a deeper physical understanding of nature.

Harald Rose received many of the highest honours in his field, including the German Federal Cross of Merit. Together with Maximilian Haider and Knut Urban, he was awarded the Wolf Prize in Physics in 2011 and the BBVA Foundation Frontiers of Knowledge Award in 2013. In 2020, he shared the Kavli Prize in Nanoscience with Maximilian Haider, Knut Urban and Ondrej Krivanek. These awards recognised contributions that profoundly reshaped modern electron microscopy.

Those who worked with Harald Rose will also remember the character behind the science: his intellectual independence, his insistence on physical understanding, and his directness in discussion. Titles and formal authority carried little weight with him; a convincing physical argument carried a great deal. Conversations with him could be challenging, but they were invariably thought-provoking, and his enthusiasm for a good scientific idea remained infectious.

Harald Rose spent his scientific life pushing beyond accepted limits in electron optics and microscopy. His legacy is present not only in the instruments used today, but also in the scientific questions they allow us to ask and in the many researchers whose way of thinking he influenced.

The European Microscopy Society extends its deepest sympathy to his family, friends, colleagues and students.

Written by Prof. Dr. Ute Kaiser, Ulm University. Originally published by the European Microscopy Society (EMS) on 2 August 2026: www.eurmicsoc.org/in-memory-of-harald-rose-1935-†-27-07-2026/