Warren Keith Sinclair FREE

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Richard Lewis Arnowitt

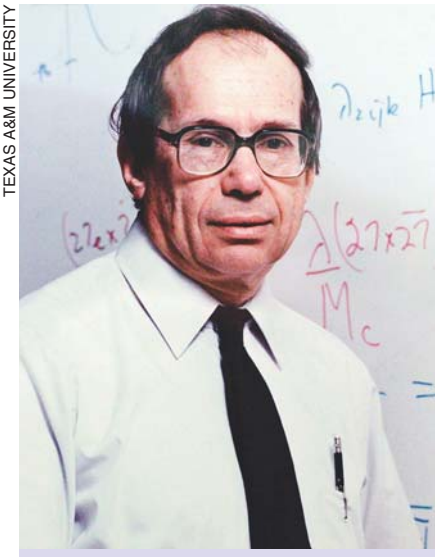
Richard Lewis Arnowitt, distinguished professor emeritus at Texas A&M University (TAMU) and an internationally renowned figure in general relativity (GR) and high-energy physics, died on 12 June 2014 after a gallant struggle with cancer. His older brother, Edwin, has begun an endowment in Dick's name for graduate student support at TAMU.

In GR, Dick is best known for the Arnowitt-Deser-Misner (ADM) formulation, which expresses GR as a modern field theory. His major work in high-energy physics was with Ali Chamseddine and one of us (Nath) on the development of supergravity grand unification, specifically the minimal SUGRA model, a tool commonly used in the search for new physics beyond the standard model.

Dick was born in New York City on 3 May 1928 and grew up there when it was the center of production of future physicists. A science prodigy, he finished high school early and went to Rensselaer Polytechnic Institute (RPI), where he obtained simultaneous bachelor's and master's degrees at 20. The oldest technical institute in the US, RPI was a mecca for young scientists during the postwar years, in part due to the proximity of General Electric's renowned Schenectady research laboratory.

Dick then went to Harvard University with his fellow RPI graduate George Benedek. Benedek remembers his RPI and Harvard years with Dick with pleasure, as does another of us (Deser), who shared classes, projects, and desks with him all four years. Dick's thesis with Julian Schwinger, on radiative corrections to hydrogen's hyperfine structure, was one of the last of the postwar quantum electrodynamics loop calculations. Schwinger mentioned to one of us (Scully) that he always appreciated Dick and regarded him very warmly. Given Schwinger's elevated standards, that is high praise indeed!

After postdoc stints at the Berkeley Radiation Laboratory in 1952–54 and the Institute for Advanced Study in 1954–56, Dick joined Syracuse University's faculty in 1956. He moved to Northeastern University in 1959 and in 1986 was called to TAMU, where he founded its Center for Theoretical Physics.



TEXAS A&M UNIVERSITY

Richard Lewis Arnowitt

Dick's physics career was illustrious and prolific, with more than 330 publications on a wide range of topics. His Syracuse years included the work, with his student Marvin Girardeau, on the highly cited pair theory for many-boson systems. The Girardeau–Arnowitt formalism is particle-number conserving and thus avoids subtle pitfalls associated with, for example, a perturbative analysis of the *S*-matrix.

The ADM formulation, published in a series of some 15 papers in 1958–62, garnered its authors the American Physical Society's 1994 Dannie Heineman Prize for Mathematical Physics. The ADM definition of GR energy is one of the formulation's best-known consequences. More generally, ADM remains a standard tool in GR—for example, in numerical methods to compute nonlinear gravitational radiation from black hole mergers.

With Chamseddine and Nath, Dick coauthored a highly cited paper on supergravity grand unification in 1982. Their mSUGRA model is part of the theoretical arsenal in the search for new physics at CERN's Large Hadron Collider. With Marvin Friedman and Nath, Dick developed an effective Lagrangian method for current-algebra analyses, and, with Nath, he provided a solution to the so-called $U(1)$ problem of why the ninth pseudoscalar meson, η', is so much heavier than the octet pseudoscalars. He was a coauthor with Nath and Bruno Zumino of the first local supersymmetry via a superspace formulation, a precursor of supergravity.

While he was at TAMU, Dick's other contributions—some in collaboration with Bhaskar Dutta, Teruki Kamon, and other colleagues—ranged from future accelerator designs to topics in *CP* violation, dark matter, and cosmology.

Dick's distinguished teaching career included mentoring a number of PhD students; publishing many review papers; and presenting a vast array of courses, plenary talks at international conferences, and summer school lectures. In recent years he was a frequent invited lecturer at the Erice International School of Subnuclear Physics in Sicily. Dick was an exemplary citizen as well and contributed to the building up and the welfare of his physics departments, as the undersigned can attest. Dick's more than six decades in physics, as well as his personal qualities, will long be remembered by the many students, colleagues, and friends he attracted worldwide.

Stanley Deser
Brandeis University
Waltham, Massachusetts
California Institute of Technology
Pasadena
Charles Misner
University of Maryland
College Park
Pran Nath
Northeastern University
Boston, Massachusetts
Marlan Scully
Texas A&M University
College Station
Princeton University
Princeton, New Jersey

Warren Keith Sinclair

Warren Keith Sinclair celebrated his 90th birthday amid family shortly before his death on 14 May 2014 in Escondido, California. We personally have lost a dear friend, and the radiation science community has lost a most respected colleague. His career, which spanned three continents and almost 50 years, can be divided into three phases: medical physics, radiobiology, and radiation protection. He excelled in all.

A native of New Zealand, born in Dunedin on 9 March 1924, Warren attended the University of Otago and received a BSc in 1944 and an MSc in physics in 1945. In 1944 he wrote a government report about uranium in New Zealand rocks, before the element's potential for nuclear weaponry was widely known. His interest in the use of radiation in medicine began when he was appointed hospital physicist at Dunedin Hospital, the first such position in New Zealand. Given the paucity of educational opportunity at home, he was advised by Ernest Marsden to obtain a doctorate in medical physics with W. V. Mayneord in London. The 1947 voyage to England held a surprise that would enhance his whole life—he met Joy, his future wife.

The timing of Warren's arrival in England was propitious; radioisotopes were becoming available from the UK Atomic Energy Research Establishment and Oak Ridge National Laboratory, and clinicians were initiating plans for their use. Mayneord's medical physics group at the Royal Cancer Hospital was ideal for Warren's professional development. Physics colleagues and academic clinicians at the hospital, where Warren was appointed an assistant physicist, along with numerous visitors to Mayneord's department, added to the fertile environment. Warren was instrumental in expanding the clinical uses of radioisotopes and in developing techniques for their measurement and handling. Those included brachytherapy, or internal radiotherapy, with tantalum-182 in wires and the treatment of bladder cancer with balloons filled with radioactive solutions. His work attracted medical scientists eager to learn about the use of radioactive sources for therapy.

While completing requirements to earn a PhD in physics at the University of London in 1953, Warren was appointed a lecturer in radiological physics and biophysics. He also took night courses in physiology, biochemistry, zoology, and botany. His zest for knowledge and the breadth of his interests helped make him an exemplary interdisciplinary investigator and science administrator.

In 1954 Warren accepted the invitation of Gilbert Fletcher to head the physics group at the MD Anderson Hospital for Cancer Research and to be a professor in physics at the University of Texas Postgraduate School of Medicine in Houston. Fletcher's radiotherapy department had recently installed a cobalt-60 gamma-ray unit and a betatron that emitted high-energy x rays. If the effectiveness of the two beams and similar ones in other centers were to be compared, standardized and accurate calibration techniques would be essential.

COURTESY OF NCRP

Warren Keith Sinclair

Warren measured the relative effects of the two sources on various biological targets and thus determined their relative biological effects (RBE) with considerably more precision than had previously been done. His RBE studies heightened his interest in cell responses to radiation *in vitro*. Although he had fine collaborators at Anderson, Warren was anxious to have his own laboratory. So in 1960 he became senior biophysicist at Argonne National Laboratory (ANL), and in 1964, a professor in the department of radiology at the University of Chicago.

In his studies at ANL, Warren examined the effects of radiation on cells exposed in different stages of the cell cycle. The cyclic variations observed *in vitro* to ionizing and UV radiation and drugs were a significant addition to our understanding of radiation effects. In 1970 he became director of ANL's division of biological and medical research, and four years later he was associate laboratory director for biomedical and environmental research.

Concerned over the professional development of physicists in medicine, Warren, John Laughlin, and Gail Adams helped found the American Association of Physicists in Medicine in 1958.

In 1977 Warren was elected president of the National Council on Radiation Protection and Measurements (NCRP) and had the difficult task of succeeding its founder, Lauriston Taylor. Again the timing was propitious, as the NCRP's influence was waning. Warren succeeded in restoring its influence, expanding the council to include experts in relevant fields, and publishing reports that were welcomed by both scientists and government agencies. For example, after the Three Mile Island reactor accident in 1979, controversy arose about the planned venting of the remaining krypton-85 into the atmosphere. At the request of Pennsylvania governor Dick Thornburgh, within three weeks the NCRP delivered a report on the safety of venting.

Warren played key roles in the NCRP, the International Commission on Radiological Protection, and the United Nations Scientific Committee on the Effects of Atomic Radiation in developing radiation protection standards. He also made important contributions to the support of radiation science in his positions as president of the Radiation Research Society and chairman of the National Research Council's Board on Radiation Effects Research.

Warren was reserved in composure but had a twinkling mien. He stood by his convictions with unflinching integrity. He will be remembered as much for his trustworthy character as for his solid contributions to radiation research and policy.

R. J. Michael Fry
Indianapolis, Indiana
S. James Adelstein
Boston, Massachusetts ■

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