Kai M.B Siegbahn

Lund, Sweden, 20 Apr. 1918 - Ängelholm, Sweden, 20 July 2007

Nomination 14 Dec. 1985

Field Physics

Title Professor at the University of Uppsala

Commemoration – We remember with deepest respect the memory of a very distinguished scientist, who was our colleague, Prof. Kai M. Siegbahn. He was born on 20th April 1918 in Lund, Sweden. He passed away on 20th July, 2007 at the age of 89 at his summer home in Angelholm, in southern Sweden. He became a Member of our Academy on 14th December 1985. Kai Siegbahn was the son of another great Swedish physicist, Manne Siegbahn, who won the Nobel Prize in 1924. Kai Siegbahn himself won the Nobel Prize in 1981; he received half the prize for the new approach to chemical analysis based on photoelectron spectroscopy; the other half was shared by Arther Schalow and Nicolaas Bloembergen for their contributions to laser spectroscopy. Both these areas owe their origin to the conceptual discoveries of Einstein, earlier in the century, of the photoelectric effect and of coherence. Kai Siegbahn always acknowledged his father's influence on him; he remarked to the New York Times: 'Conversations in early life with the Nobelist at the breakfast table gave him an advantage unanticipated at that time'. By winning a Nobel Prize that his father had also won earlier, Kai M. Siegbahn joined several other families in this respect: the Thompsons (J.J. and G.P.); the Braggs (William and Lawrence); the Curie family (Marie and Pierre Curie, Irene and Fredrick Joliot Curie); the Bohrs (Neils and Aage); and most recently the Kornbergs (Arthur & Roger). Kai M. Siegbahn was a student at Uppsala University (1936-1942). From 1942-1951, he carried out research in Stockholm; he took his Ph.D. in Physics from the University of Stockholm in 1944. Kai Siegbahn's primary contribution was in the field of photo electron spectroscopy. He was the inventor of ESCA (Electron Spectroscopy for Chemical Analysis). This was essentially based on the bombardment of any given material with a beam of X-rays as a result of which electrons would be released. The energies of these electrons could be measured with a spectrometer and was characteristic of the electronic binding energies in the atoms from which they came; this was to some extent dependent on the chemical environment of the atom. As a result, one could reliably tell the composition of the material being tested. The photoelectric effect, which relates to the emission of electrons from a metal surface irradiated by photons had been explained by Einstein in 1905; and X-rays were used for such experiments in the second decade of the last century. But it was through the work of Kai Siegbahn and his collaborators, who developed sophisticated instruments for studying the energy spectrum of the emitted electrons, that it became the method it is today, for widest application for chemical analysis. ESCA was based on Kai Siegbahn's deep understanding of nuclear spectroscopy. One should recall the classic works edited by him 'Beta- and Gamma-Ray Spectroscopy' (1955) and 'Alpha-, Beta- and Gamma-Ray Spectroscopy' (1965). Throughout the 1970s there were innumerable surveys on ESCA. They had their roots in his books 'ESCA: Atomic, Molecular and Solid- State Structure Studied by Means of Electron Spectroscopy' (1967) and 'ESCA applied to Free Molecules' (1969). He was editor for the journal 'Nuclear Instruments and Methods in Physics Research' since it started in 1957. The Nobel lecture that Kai M. Siegbahn gave on 8th December 1981, when he received the Nobel Prize, was on 'Electron Spectroscopy for Atoms, Molecules and Condensed Matter'. ESCA is now used routinely for studies of surface reactions such as those that occur in corrosion and catalytic reactions; for testing the surfaces of semi conductors etc. These are vital in many process industries. Later Nobel Prizes have been awarded for a deep understanding of processes at surfaces. ESCA is an extremely sensitive technique, and particularly with the rapid development of computers, become fairly all-pervasive. Kai Siegbahn was deeply committed to science and its applications. He was a simple person and a good friend.

M.G.K. Menon

Most important awards, prizes and academies

Academies: Royal Swedish Academy of Science; Royal Swedish Academy of Engineering Sciences; Royal Society of Science; Royal Academy of Arts and Sciences of Uppsala; Royal Physiographical Society of Lund; Norwegian Academy of Science; Royal Norwegian Society of Sciences and Letters; National Academy of Sciences; Honorary Member of the American Academy of Arts and Sciences; Honorary Member of Societas Scientiarum Fennica; Comite# International des Poids et Mesures, Paris; President of the International Union of Pure and Applied Physics, IUPAP (1981-84); Pontifical Academy of Sciences; European Academy of Arts, Sciences and Humanities; Academia Europaea; Member of the Board of the Ioffe Institute, St Petersburg (1999). *Awards*: The Lindblom Prize (1945); Bjo#rke#n Prize (1955, 1977); Celsius Medal (1962); Sixten Heyman Award, University of Gothenburg (1971); Harrison Howe Award, Rochester (1973); Maurice F. Hasler Award, Cleveland (1975); Charles Frederick Chandler Medal, Columbia University, New York (1976); Torbern Bergman Medal (1979); Nobel Prize in Physics (1981); Pittsburgh Award of Spectroscopy (1982); Ro#ntgen Medal (1985). Honorary Degrees: University of Durham (1972); University of Basel (1980); University of Lie#ge (1980); Uppsala College, East Orange, NJ (1982); University of Sussex (1983); Universite# de la Me#diterrane#e, Aix-Marseille (1998); St Petersburg State Technical University (1999); Honorary Professor at the University of Hefei, China (1991). Founder: International Journal of Nuclear Instruments and Methods in Physics Research and editor (1957-); International Centre for Physics at the University of Uppsala for Countries under Development (1961); University for Science in Nairobi (1966); Member of the Scientific Advisory Board and cofounder of the World Laboratory.

Summary of scientific research

The main fields of research cover nuclear physics, atomic and molecular physics, electron spectroscopy and surface science. The early part of the production concerned nuclear physics, mainly $\alpha-$ $\beta-$ and $\gamma-$ray spectroscopy of radioactive nuclei. This activity is summarized in the book with the same title. With this background the field of electron spectroscopy for atoms, molecules and condensed matter was developed, beginning during the early fifties. These researches gradually developed in various directions with applications in physics, chemistry and industrial technology, in particular related to surface technology. Photoelectron spectroscopy under the acronym ESCA (Electron Spectroscopy for Chemical Analysis) was described in two books, published in 1967 and 1969 with titles given above. This new spectroscopy can be applied to all states of aggregation of matter and yields detailed information on the atomic and molecular orbitals in chemical compounds in gases, solids or liquids. From a technological point of view, its high surface sensitivity is being utilized in fields like corrosion, surface reactions, catalysis, polymers and solid state electronics. The main emphasis from an instrumental point of view is in particular put on increased spectral resolution and intensity and extension of monochromatic x-ray and UV sources, complemented by synchrotron radiation.

Main publications

Beta- and Gamma-Ray Spectroscopy (1955); *Alpha-, Beta- and Gamma-Ray Spectroscopy* (1965); *Atomic, Molecular and Solid State Structure Studied by Means of Electron Spectroscopy*, ESCA (Uppsala, 1967); *Applied to Free Molecular*, ESCA (Uppsala, 1969); ‘Electron Spectroscopy for Chemical Analysis’, *Phil. Trans. Roy. Soc. London A*, pp. 33-57 (1970); ‘Perspectives and Problems in Electron Spectroscopy’, *Proc. Asilomar Conference* (1971), (D.A. Shirley, ed.)(North Holland, 1972); ‘Electron Spectroscopy – A New Way of Looking into Matter’, *Endeavor*, 32 (1973); ‘Electron Spectroscopy for Chemical Analysis’, *Proc. of Conf. on Atomic Physics 3*, Boulder (1972), (S.J. Smith and G.K. Walters, eds.)(Plenum, 1973); ‘Electron Spectroscopy for Chemical Analysis’ (with Allan, C.J.), *MTP Int. Rev. of Science*, vol. 12, Analytical Chemistry, Part 1, Butterworths (1973); ‘Electron Spectroscopy – An Outlook’, *Proc. Namur Conference 1974* (Elsevier, 1974); ‘Electron Spectroscopy and Molecular Structure’, *Pure and Appl. Chem*., 48, (Pergamon, 1976); ‘Electron Spectroscopy for Solids, Surfaces, Liquids and Free Molecules’, *Molecular Spectroscopy*, Ch. 15 (Heyden, 1977); ‘Electron Spectroscopy for Atoms, Molecules and Condensed Matter’, *Les Prix Nobel en 1981*, The Nobel Foundation (1982); *Some Current Problems in Electron Spectroscopy* (Plenum, 1983); ‘Photoelectron Spectroscopy: Retrospects and Prospects’, *UUIP-1136* (April 1985); ‘Electron Spectroscopy for Atoms, Molecules and Condensed Matter – An Overview’, *Journ. Electron Spectrosc*., 36, p. 113 (1985); ‘From X-Ray to Electron Spectroscopy and New Trend’, *Journ. of Electron Spectroscopy*, 51 (1990); Charged Particle Spectrometer. *Encyclopedia of Physical Science and Technology*, Academic Press 1992 (Also editor of this encyclopedia); High Resolution Electron Spectroscopy, *UPTEC 96* (1996); A Study of High Resolution Valence Electron Spectroscopy by Means of Laser Excitation, *UPTEC 96* (1996); A High Resolution and Large Trasmission Electron Spectrometer, *NIM* (1997); The Medical X-Ray Imaging Project at the ESCA-LASER laboratory, *UPTEC* (1999); Development of Laser Technology Applied to Electronic Structure of Matter in Symbiosis with Electron Spectroscopy, *UPTEC* (2000); Symmetry Analysis of the ZnSe (100)/Air Interface by Second Harmonic Generation, *UPTEC* (March 2000); Hyper-Rayleigh Scattering in Solution of

Organic Nonlinear Optical Molecules and Measurement of the Hyperpolarisability, *UPTEC* (March 2000); Dot Pattern from Second Harmonic and Some Sum Frequency Generation in Polycrystallic ZnSe. An extensive monography exists on: 'Electron Spectroscopy and Laser Spectroscopy for Analysis of Solids, Surface, Interfaces and Free Molecules'.