



## Biography of the Distinguished Professor Alexander Obiefoka E nukora Animalu



### Background, Personal Life and Discoveries

Alexander Animalu was born into the family of Mr Michael Nwakudu Animalu and Mrs Nkenwa Animalu. It was a large family with Alexander being his parents' fifth child. His research over the years has made remarkable contributions in the area of solid state and elementary particle physics. Animalu is an author of 28 books in science and humanity, including the famous *Intermediate Quantum Theory of Crystalline Solids*. Some of his discoveries and fundamental results include but not limited to:

- Modeling a potential for 25 elements
- Formulating the lattice dynamics of the transition metals in the framework transition-metal model-potential (TMMP) method
- Reformulation of the tight-binding theory of band offset at semiconductor heterojunction
- Generalizing one-electron theory of the optical absorption of solid and liquid alkali metals to include many-body effects
- His theory of high-temperature superconductivity based on the novelty of the pairing mechanism for electrons was published in the 'Hadronic Journal' in 1991.

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### 1. Education

His primary school education started at St Paul's Church Mission Society Church School, Isu-Oba from 1943 to 1944. In 1944 he recommenced his primary school education at the St. Thomas's Church Mission Society Church School, Okuzu, this change was due to distance from his place of residence. After completing infant II in 1945, he was sent to Church Mission Society Central School, Isu-Oba and in 1951 he took his First School Leaving Certificate Examination where he finished on top of his class. He proceeded to the Dennis Memorial Grammar School, Onitsha from 1952 to 1958, earning grade 1 in the West African School Certificate in 1956 and Cambridge Higher School Certificate in science subjects in 1958. He also earned the London Advanced Level Certificate in Arts subjects in January 1959 and in October of the same year, he proceeded to the prestigious University College, Ibadan (now the University of Ibadan) on Shell-BP scholarship, where he bagged a B.Sc. in Mathematics (Second Class Upper Division) at the top of his class in June 1962.

He won the Faculty of Science Prize for best performance for two consecutive years (parts I and II), as well as the College Postgraduate Scholarship that saw him through the University of Cambridge, United Kingdom from 1962

to 1965 where he obtained Master's degree in Applied Mathematics and PhD in Theoretical Solid State Physics. He was awarded a PhD in 1965 for his thesis, "*Model Potential in Solids*, which contained the screening theory published in his single-authored 1965 paper and used to great effect in his joint paper (1965) with Volker Heine and also in his 1966 paper. His PhD research work, subsequently published in the Philosophical Magazine, became a citation classic by 1983, having been cited more than 670 times between 1965 and 1983.

## 2. Administrative Life

Professor Animalu rose in academic positions; he became the Head of Department of Physics, University of Nigeria, Nsukka, from 1981 to 1994, and Dean of the Faculty of the Physical Sciences, University of Nigeria, Nsukka from 1987 to 1988.

Professor Animalu was appointed Director and Chief Executive of the National Mathematical Center, Abuja, holding the position from April 1999 to January 2001. He retired in June 2001 and was made Emeritus Professor of Physics. He chose to retire at this time in order to become the founding Chairman/CEO of the International Center for Basic Research.

## 3. Academic Career

While still at the Cavendish Laboratory in Cambridge, he had been given leave of absence to visit Bologna in Italy where he worked with F. Bonsignori and V. Bortolani and co-authored two joint publications with them. After this he spent several years in the United States; from January 1966 to December 1967 as a Research Associate in the Division of Applied Physics at the W. W. Hansen Laboratories of Stanford University; from January 1968 to August 1968 at the Department of Physics of the University of North Carolina at Chapel Hill where he was a visiting scientist; from September 1968 to 1970 as an Assistant Professor of Physics at the University of Missouri at Rolla, Missouri; from 1970 to April 1972 as an Associate Professor of Physics at Drexel University in Philadelphia, Pennsylvania; and from April 1972 to 1976 as a Research Physicist at the Lincoln Laboratory of the Massachusetts Institute of Technology.

In 1976 he left the United States and returned to Nigeria when he was appointed as Professor of Theoretical Solid State Physics at the University of Nigeria, Nsukka, in 1976.

## 4. Teaching and Mentorship

He has trained many Nigerians in the field of theoretical physics and solar energy and established two youth organizations, the Society for Promotion of Indigenous Inventions and Creativity and the Century-21 Club.

## 5. Research Interests and Contributions

Prof. Animalu has published many significant papers, almost all of which are single-authored papers. He has a Google scholar citation index of 3199 and h-index of 19 and i10-index of 27. In July 1965, Animalu and his thesis advisor Professor Volker Heine submitted a joint paper; "The screened model potential for 25 elements" to the Philosophical Magazine. It was published in 1965 and has proved so influential as to be rated as one of the most cited papers published by Cambridge scientists with 908 citations. This article was cited 729 times between 1965 and 2001. He is the only African in Physics to have earned such a record citation to a single paper, his paper is among the best twelve cited papers from the University of Cambridge in fifty years (1930-1980). It is of interest to note here that four out of these twelve most cited works have subsequently won the Nobel Prize in Physics.

In the article, the Fourier transform of the self-consistent screened model potential was calculated for 25 elements. The results presented in a form applicable to the potential in the solid or liquid metal or semiconductor, or to the electron-phonon interaction. They are reliable to about 0.01 ryd. The calculation was a continuation of the work by Heine and Abarenkov (1964), using the screening theory of Animalu (Non-local dielectric screening in metals). The article gave a crystal-clear explanation of the behaviour at high wavenumbers and other points of detail which was first of its kind and some average band effective masses were also calculated.

Some of his popular publications are: The spin-orbit interaction in metals and semiconductors (1966); (with F. Bonsignori and V. Bortolani), Electron-phonon contribution to the specific heat of alkalines (1966); (with F. Bonsignori and V. Bortolani) The phonon spectra of alkali metals and aluminium (1966); Optical conductivity of simple metals (1967); Self-consistent theory of optical transitions in simple metals (1967); The pressure dependence of the electrical resistivity thermopower and phonon dispersion in liquid mercury (1967); (with B. Vasvari and V. Heine) Electronic structure of Ca, Sr, and Ba under pressure (1967) [Note: Vasvari was a Hungarian who worked at Cambridge, England, while in receipt of a scholarship. Animalu writes, "This work was completed, supported in part by the Advanced Research Projects Agency through the Center for Materials Research, Stanford University, Stanford, California; Many-electron effects in the optical conductivity of simple metals by Kubo formula (1970); General theory of magnetic-field-induced surface states (1970); Mass ratio of quarks (1971); Charge spectrum of four-component fields with  $O(4, 2)$  symmetry (1971); Bound states and mass spectra of hadrons in the quark model (1971); Scale symmetry (1972); Lepton and hadron currents in  $O(4, 2)$  current algebra (1972); High-field magnetoresistance of metals by Kubo-Mott formula (1972); Pseudopotential approach to magnetic energy bandstructure and magnetic breakdown in metals (1972); Josephson current in tunneling between coupled superconductors (1973); A relativistic model of quark-quark strong interactions (1973); Electronic structure of transition metals. I. Quantum defects and model potential (1973); Electronic structure of transition metals. II. Phonon spectra (1973); Electronic structure of transition metals. III. d-band resonance and Regge-pole theory (1974); and Lattice dynamics of transition metals in the resonance model (1976).

In 1977, Animalu published the book *Intermediate Quantum Theory of Crystalline Solids*. It was reviewed by Timothy Sluckin. Among numerous textbooks of solid-state physics, this was well received by the community of solid-state physicists. An Indian edition was published in 1978; it was translated into Russian in 1981, reprinted in the United States in 1994 and is still readily available.

On his 70th birthday in 2008, a conference was organized in honour of him and it is now being hosted annually- the International Seminar on Theoretical Physics and National Development - in partnership with the National Mathematical Centre, Abuja and the International Centre for Basic Research, Abuja. Professor Animalu is author of numerous scientific articles in refereed journals and more than 30 books in both the sciences and the humanities, including the biographies of the Rt Hon Dr Nnamdi Azikiwe, Professor Chike Obi, Professor Kenneth Dike, Professor Samuel Okoye, Professor James Ezeilo, Professor Chukwuedu Nwokolo and Professor Agodi Onwumechili among others.

## **6. Honours, Distinctions and Memberships in Learned Societies**

He is a member of the Nigerian Institute of Physics, a Fellow of the Nigerian Institute Physics, member of the Nigerian Mathematical Society, and the American Physical Society. For his contributions to national development, Professor Animalu received the Nigerian National Order of Merit Award in 2000. This distinguished award is Nigeria's highest award for intellectual and academic achievement in Nigeria. He was elected President of the Nigerian Academy of Science (leading scientific organization in Nigeria) in 2001 where he served in this capacity till 2002.

## **7. Scholarships, Grants and Prizes**

He was awarded a University of Nigeria Senate Research Grant Award for the Energy and Materials Science Laboratory Project from 1976 to 1977.

Professor Animalu was the 1990 Ahiajoku lecturer, the highest Igbo academic forum.

## **8. Position Held**

In 2001, he was appointed a member of the Honorary Presidential Advisory Council on Science and Technology in Nigeria. He is the only African member up to the present date of the Advisory Board of the 'Euro-Journal Physica (B)' and the only African member of the Editorial Board of the USA-based international 'Hadronic Journal' and 'Hadronic Journal Supplement'. He is also the founding editor of the 'Nigerian Journal of Solar Energy' and one of the pioneering editors of the 'Bulletin' of the Nigerian Institute of Physics. He was the Foundation President of the Solar Energy Society of Nigeria, and the foundation editor of the 'Nigerian Journal of Solar Energy.