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(*b*. Calcutta. India. I January 1894; *d*. Calcutta, 4 February 1974)

physics.

Bose was the son of Surendranath Bose, an accountant in the executive engineering department of the East India Railways, who later was a founder of the Indian Chemical and Pharmaceutical Works. His mother was Amodini Raichaudhuri. The family were members of the Kayastha caste. Bose began his primary education in the local English-language schools. The upsurge of Bengali nationalism that followed Lord Curzon's decision to divide the province of Bengal into two administrative units, however, convinced his father to send him to a Bengali-language secondary school in 1907. Two years later Bose enrolled as an undergraduate in Presidency College, Calcutta, where his teachers included Jagadischandra Bose in physics and mathematics, and Prafullachandra Ray in chemistry. Meghnad Saha, Jranchandra Ghosh, and Jnanendranath Mukherjee were among his classmates. He received the M.Sc. in mathematics in 1915, ranking first in his class.

Sir Asutosh Mookerjee, vice-chancellor of Calcutta University, had inaugurated the University College of Science in 1914. This institution, funded largely through the endowments of Sir Taraknath Palit and Dr. Rashbehari Ghose, was the first college in India to offer advanced studies in science. In 1915 Bose and Saha, among others, suggested that Mookerjee build upon the existing postgraduate chemistry curriculum at the college by instituting courses in mathematics and physics. Mookerjee agreed to their request and also obtained for them stipendiary scholarships and funds for procuring scientific journals and laboratory apparatus. When the physics department was organized in 1917. they were appointed lecturers. A year later Chandrasekhara V. Raman. then a civil servant in the Indian Finance Department, joined the department as Palit Professor of Physics.

Bose left Calcutta in 1921 to become Reader in Physics at the newly established University of Dacca in East Bengal. In July 1924 he sent a short manuscript entitled "Plancks Gesetz und Lichtquantenhypothese" to Albert Einstein for criticism and possible publication. Einstein himself translated the paper into German and had it published in the *Zeitschrift für Physik* later that year. He added a note that stated: "In my opinion Boses derivation of the Planck formula signifies an important advance. The method used also yields the quantum theory of the ideal gas as I will work out in detail elsewhere."

Einstein's enthusiastic endorsement of his work enabled Bose to obtain a two-year paid study leave from Dacca University. which he spent in France and Germany. During his year in France he was guided in his studies by Paul Langevin and was in close contact with Maurice and Louis de Brogue. Late in 1925 he had a brief but reportedly cordial meeting in Berlin with Einstein, and in the early summer of 1926 he heard Max Born's lectures at Göttingen on the new matrix mechanics of Werner Heisenberg. Later that summer Bose returned to Dacca as professor and head of the physics department. He held these posts until 1945, when he returned to Calcutta University as Khaira professor of physics and. from 1952 to 1956. as dean of the Faculty of Sciences. Following his retirement from Calcutta, he served for three years as vice-chancellor of Visva-Bharati University, an institution in West Bengal that had been established by Rabindranath Tagore. He relinquished that position in 1959 upon his appointment as a national professor by the government of India. Bose was president of the National Institute of Sciences of India in 1949- 1950, and from 1952 to 1958 served in the upper house of the Indian parliament. He was awarded the Padma Vibhushan by the government of India in 9154 and was elected fellow of the Royal Society in 1958. Bose married Ushabala Ghosh in 1914. and was the father of two sons and five daughters.

Bose's twenty-six original scientific papers. published between 1918 and 1956, include contributions to statistical mechanics, the electromagnetic properties of the ionosphere, the theories of X-ray crystallography and thermoluminescence, and unified field theory. Two of his first four papers were investigations of the equation of state for gases. written with Saha. In 1919 the Calcutta University Press published a two-volume editions of Einstein's collected papers on the special and on the general theories of relativity, translated into English by Saha and Bose, respectively. Bose's first paper on quantum theory (1920) demonstrated that the empirical formulas for the line spectra of' the alkali atoms are derivable from the Bohr-Sommerfeld quantization rules, and included the assumption that the effective potential in which the valence electrons of these atoms move can be expressed as the superposition of potentials due to a point charge and an electric dipole.

Bose is known outside India primarily for his first paper in the *Zeitschrift für Pkysik* (1924) in which he succeeded in deriving the Planck blackbody radiation law without reference to classical electrodynamics. Einstein's generalization of Bose's method led to the first of two systems of quantum statistical mechanics, known as the Bose-Einstein statistics. Paul Dirac later coined the term "boson" for particles that obey these statistics.

Planck's radiation law, derived in 1900, relates the electromagnetic energy density in equilibrium with a blackbody. or ideal radiator, at an absolute temperature. T, to the radiation frequency, v. Using modern notation:

where V is the volume of the radiator. c the speed of light, k the Boltzmann constant, and Ii Planck's constant. Planck based his derivation on a model in which the radiation emitted and absorbed by the blackbody is in equilibrium with a set of charged oscillators. He took the laws of classical electrodynamics as valid but assumed in addition that each oscillator could emit and absorb only in quanta proportional to its frequency of oscillation. That is, E = $nh\nu$, where n is any integer.

Planck regarded his quantum hypothesis as an ad hoc assumption to be grafted onto the inviolable body of classical electrodynamics. In contrast, Einstein. in his "photoelectric effect" paper of 1905, used general thermodynamic arguments to show that electromagnetic radiation could be regarded as having an atomic or quantum structure. Thus, he argued in effect that electromagnetic radiation in equilibrium with matter could be regarded as a gas similar in some respects to an ordinary gas the quanta of which are atoms or molecules. The zero-rest-mass quanta of the electromagnetic field are now called photons, a term introduced in 1926.

Bose's 1924 paper showed that the Planck law was completely consistent with Einstein's quantum gas model. His derivation followed a general procedure introduced by Boltzmann for determining the equilibrium energy distribution of the microscopic entities that constitute a macrosystem. The procedure begins by enumerating all the possible, distinguishable microstates of the entities, where each such state is defined by a set of coordinates and momenta. That is, each possible state of a single entity is specified by a point in six-dimensional phase space the axes of which correspond to the three spatial coordinates and the three components of momentum. Each possible state of the system is specified by a distribution of such phase points. Bose's innovation was to assume that two or more such distributions that differ only in the permutation of phase points within a subregion of phase space of volume h^3 (where h is Planck's constant) are to be regarded as identical. Thus, in effect he asserted that two truly identical photons cannot be distinguished even in principle. This method of counting has the effect of enhancing the populations of lower-energy photon states at the expense of those of higher energy, and leads to the correct Planck distribution law.

The assumption that the region h^3 sets a limit on the distinguishability of two photons appears to have been completely ad hoc and was arrived at, according to Bose's later recollection, in the course of preparing a lecture on the Planck law for a postgraduate physics class at Dacca. It can easily he shown to be consistent with the uncertainty principle of Werner Heisenberg, announced in 1927, and. more fundamentally, with either the matrix mechanics of Heisenberg (1925) or the wave mechanics of Schrodinger. In July 1924 Einstein had already generalized Bose's results to particles of nonzero rest mass the total number of which is conserved: and in January 1925 he showed that such a gas would, under conditions of extreme temperature and pressure, exhibit marked deviations in behavior from that of a classical ideal Maxwell-Boltzmann gas. The latter paper also showed that Bose's assumption is consistent with the relationship between the wavelength and momentum of a particle, λ h/p, which Louis de Broglie had hypothesized in 1923. Thus, by generalizing Bose's theory, Einstein completed the formulation of the first of two types of quantum statistics. In 1926 Enrico Fermi derived a second System of quantum statistics, now called the Fermi-Dirac statistics, in which it is assumed that each subvolume h^3 in phase space can be occupied by no more than one point, consistent with the exclusion principle enunciated by Wolfgang Pauli in 1925.

Bose's first paper in *Zeitschrift für Physik* was followed by another that was also translated by Einstein and published during 1924. In it Bose provided a general statistical treatment of emission and absorption processes for electromagnetic radiation in equilibrium with matter. This paper was accompanied by a note by Einstein expressing serious doubts about the method. In January 1925 Bose wrote to Einstein from Paris that he was working on a paper he felt would remove these doubts. But it seems never to have been completed.

Bose's next published scientific contribution consisted of two papers on mathematical statistics (1936). Two works on the electromagnetic properties of the ionosphere were published in 1937 and 1938, respectively. A paper on the mathematical properties of the Lorentz group appeared in 1939. Two more mathematical works, one on the inhomogeneous Klein-Gordon equation and one on an integral equation for the hydrogen atom. were published in 1941. Most of his published theoretical work between 1943 and 1950 was on X-ray crystallography and thermoluminescence, both areas in which experimental groups were active at Dacca. Bose's last six scientific papers, published between 1953 and 1955, were on unified field theory, a topic on which he and Einstein exchanged at least one letter in 1953.

Bose is reputed to have been a devoted and inspiring teacher. His ability to deliver polished lectures without notes was legendary and considered phenomenal even in India, where professors take considerable pride in that accomplishment. This skill was aided by a remarkable memory which he developed as a schoolboy, partly because of his exceedingly weak vision.

Born and educated in an era when Rabindranath Tagore was presiding over the Bengali cultural renaissance, Bose remained devoted to that movement throughout his life. In 1948 he founded the Bangiya Bijnam Parishad, or Science Association of Bengali, as a means of popularizing science in his native language. Like Tagore, he loved poetry. which he read and quoted not only in Bengali and Sanskrit, but also in English and French, both of which he spoke fluently.

BIBLIOGRAPHY

I. Original Works. Bose's papers include "On the Influence of the Finite Volume of Molecules on the Equation of Slate," in *Pilosophical Magazine*. 6th ser.. **36** (1918). 199–202. written with M.N. Saha; "On the Equation of State/' ibid., 39 (1920), 456. written with M. N. Saha; "On the Deduction of Rydberg's Law From the Quantum Theory of Spectral Emission" *ibid,***40**

(1920). 6 19–627; “Plancks Gesetz und Lichtquanten-hypothese” in *Zeitschnft fur Physik,***26** (1924). 178–181; “Warmegleichgewicht im Strahlungsfeld bei Anwesenheit von Materie” *ibid.,***27** (1924). 384–390: “Anomalous Dielectric Constant of Artificial Ionosphere” in *Science and Culture,***3** (1937), 335–351. written with S. R. Khastgir; “On the Total Reflection of Electromagnetic Waves in the Ionosphere” in *Indian Journal of Physics,***12** (1938). 121–144; “On an Integral Equation Associated With the Equation for Hydrogen Atom“in *Bulletin of the Calcutta Mathematical Society,***37** (1945), 51–61; and “Solution d’une équation tensorielle intervenant dans la théorie du champ unitaire” in *Bulletin de la Société mathématique di France,***83** (1955). 81–88.

Five letters from Bose to Einstein (1924- 1926) and a copy of a 1953 letter from Einstein to Bose are among the Einstein papers at the Institute for Advanced Study. Princeton. New Jersey.

II. Secondary Literture. See William A. Blan-pied. “Natvendrana!h Bose: Co-Founder of Quantum Statistics.” *in American Journal of Physics,***40** (1972). 1212- 1220: Nirendranath Roy. “Professor Satyendranath Bose” in A. K. Datta and Asima Chatterjee, eds.. *Satyendranath Bose 70th Birthday Commemoration Volume*(Calcutta. 1964). 6–12; and Jagadish Sharma. “Satyendra Nath Bose” in *Physics Today*.**27** . no. 4 (Apr. 1974). 129–131.

William A. Blanpied