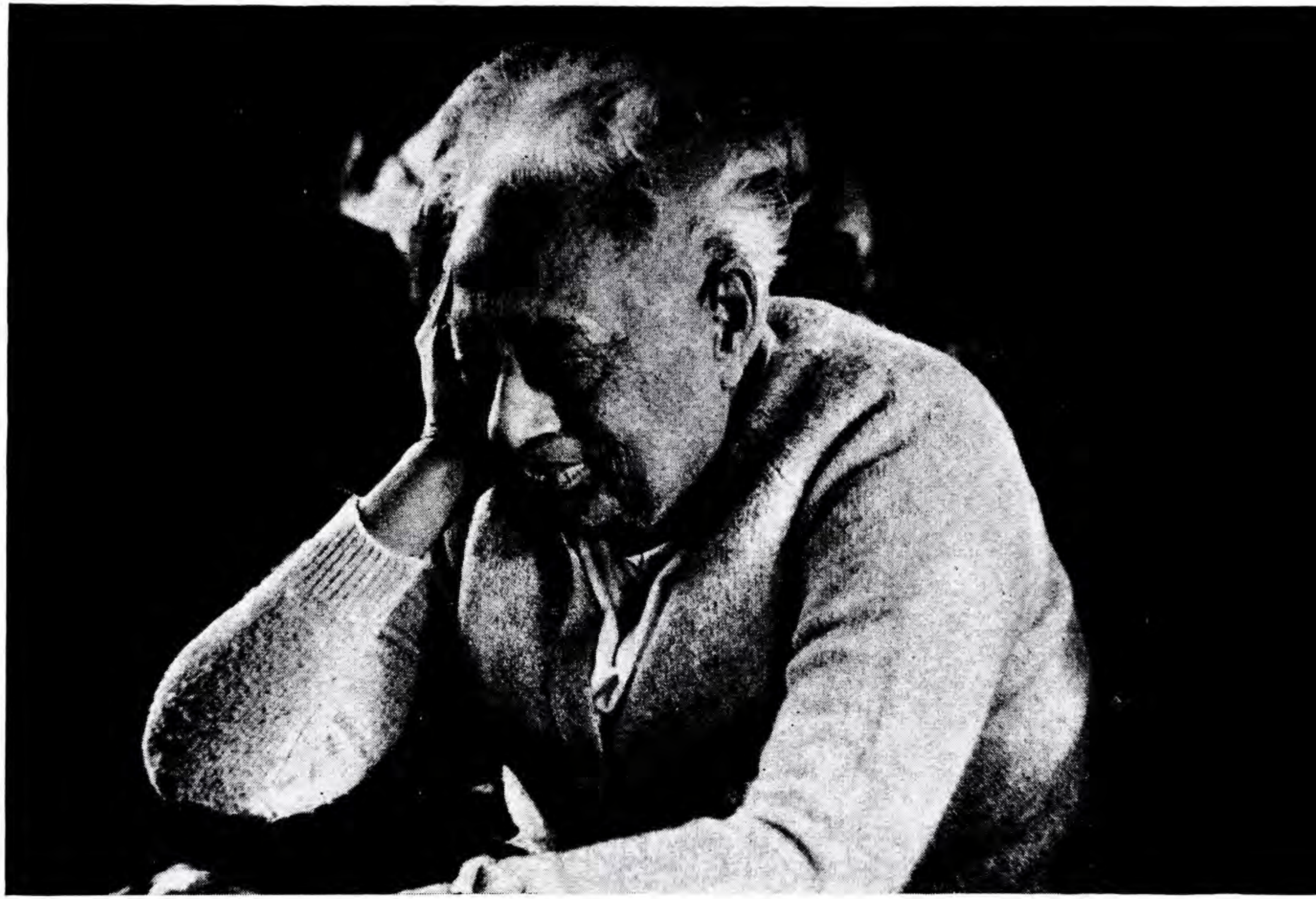

SATYENDRA NATH BOSE

(1894–1974)

Foundation Fellow 1935

Birth, Parentage and Childhood

Satyendra Nath Bose was born on the New Year's Day, January 1, 1894, in Calcutta. His ancestral home was located in the village Bara Jagulia, in the District of Nadia, about 48km from Calcutta.

Satyendra Nath's father, Surendra Nath Bose, had a keen fascination for mathematics. In his professional career, he became a qualified accountant and held responsible positions in the East Indian Railway. He lived upto the ripe old age of 96 years. He breathed his last on June 2, 1964, with his mental faculties fairly alert. Satyendra Nath's mother, Smt. Amodini Debi, had died earlier, in 1939. Her life was a ceaseless struggle against ill-health and inadequate income to maintain a middle class home. Satyendra Nath was her only son and she had after him six daughters in succession. The parents were proud of their son, and the son was no less devoted to his parents.

Formative Influences on the Young Scientist

During his boyhood, it was the spirit of the times that moved him most. The later years of the nineteenth century witnessed a new awakening in Bengal. Politically and socially, India was making its entrance into the modern age. He was a school boy when he came under the impact of what is now known as the Swadeshi Movement in Bengal. A significant feature of the Movement was the growth of a new spirit of self-help and emphasis on building up of Indian industries, and of art and culture. This became evident in the annual sessions of the Hindu Mela. The trend reached its peak during the Industrial Exhibition of 1896. Swadeshi stores were opened and a ceaseless campaign for Swadeshi goods was started. Satyendra Nath's father was one of the leaders of the Movement. He was a founder of the Indian Chemical and Pharmaceutical Works, which went into production about the same time as Sir P. C. Ray's Bengal Chemical and Pharmaceutical Works. Meanwhile the national movement of the Indian National Congress had started. It fired the younger generation with a spirit of intense nationalism. Imbued with this spirit, talented young men felt an inner urge to forge ahead and to excel in their respective fields of specialisation. Satyendra Nath belonged to this generation.

School and University Education

Satyendra Nath's schooling began at the age of five. At first he was put in the Normal School, which was close to their home. It was the same school where Rabindra Nath Tagore had been a student for a short period. Later on, when the family moved to their own house at Goabagan (22, Iswar Mill Lane, Calcutta), he was admitted to the neighbouring New Indian School. Satyendra Nath's father was anxious to put his son into an even better school where his talents would be sharpened by keener competition. And so, in the final year of school, he was admitted to the Hindu School which had a hoary tradition. Its mathematics teacher, Upendralal Bakshi, was a legendary figure. He was quick to recognise the signs of genius in the boy and found in him an ideal pupil. Once he gave him 110 marks out of 100 in a test examination. When taken to task by the Headmaster for his crazy behaviour, the teacher replied : "Satyen had succeeded in the allotted time in correctly solving all the questions without excluding any of the alternatives." His enthusiastic forecast about Satyen Bose's future career was that he would one day be as great a mathematician as "Laplace or Cauchy." Satyendra Nath was due to sit for his entrance examination in 1908 at the age of 14 years. But unfortunately, he was down with an attack of chicken pox just two days before the examination. As a result he had to remain in Hindu School for one more year. He used the opportunity to study advanced mathematics and sanskrit classics. In the next entrance examination of 1909, Satyen stood fifth in order of merit. He next joined the Intermediate Science course at the Presidency College, Calcutta, where he came under the tutelage of illustrious teachers like Jagadish Chandra Bose and Prafulla Chandra Ray. According to Sir P. C. Ray : "In that memorable year, some members of the brilliant group of students, who were afterwards destined to play a conspicuous part in notable scientific research took their admission in the Presidency College." The brightest among them was Satyendra Nath Bose. His fellow-students were Jnan Chandra Ghosh, Jnanendra Nath Mukherjee, Nikhil Ranjan Sen, Pulin Bihari Sarkar, Maniklal De, Sailendra Nath Ghose and Amaresh Chakrabarti. Meghnad Saha came from Dacca and joined the Presidency College two years later. Prasanta Chandra Mahalanobis, Nil Ratan Dhar and Sisir Kumar Mitra were a few years senior to this group.

In the Intermediate Science examination of the Calcutta University in 1911, the first five places (in order of merit) were occupied by Satyendra Nath Bose, Maniklal De, Meghnad Saha, Jnan Chandra Ghosh and Pranakrushna Parija respectively. Satyen had physiology as the fourth subject in his I. Sc. examination, in which he scored 100 marks out of 100.

In the B. Sc. class, Satyendra Nath Bose, Nikhil Ranjan Sen and Meghnad Saha opted for Mixed Mathematics, while Jnan Chandra Ghosh, Janendra Nath Mukherjee and Pulin Bihari Sarkar opted for Chemistry. Sailendra Nath Ghose, Amaresh Chakrabarti and Snehamoy Dutta studied Physics while Pranakrushna Parija took up Botany. It is interesting that five of the above group of fellow-students at the Calcutta University became, in quick succession, General Presidents of the Indian Science Congress Association.

Calcutta University

No. 1

CALCUTTA UNIVERSITY.

M. Sc. Marks.

The following are the marks obtained by Satyendranath Basu

No. 1 Presidency *College at the* **M. Sc. Examination 1915**

in Mixed Mathematics.

	Theoretical										
	First Paper.	Second Paper.	Third Paper.	Fourth Paper.	Fifth Paper.	Sixth Paper.	Seventh Paper.	Eighth Paper.	Total.	GRAND TOTAL.	Minimum for a First Class ... 480 Second " ... 360 Third " ... 264
	98	85	100	89	88	94	98	84	736		

SENATE HOUSE.

The 15-9-1915

P. Basak

Registrar.

C. U. Press—Reg. No. 163—11-9-11—500.

In the B. Sc. Honours examination in Mathematics in 1913, Satyendra Nath stood first, Meghnad second and Nikhil Ranjan third, all in first class. The same result was repeated in the M. Sc. Mixed Mathematics examination in 1915. Satyendra Nath stood first and Meghnad Saha stood second in first class. Nikhil Ranjan did not appear at the M.Sc. examination in 1915 due to illness. However, he topped the list of successful cadidates next year. It is said that the marks secured by Satyendra Nath Bose in his M.Sc. (Mixed Mathematics division) examination created a new record in the annals of the Calcutta University, yet to be surpassed. A photostat copy of the original marksheet is exhibited on the facing page.

PRIVATE LIFE AND REMINISCENCES

Marriage, Wife and Children

In 1914, at the age of 20, while still a student of the Post-graduate M.Sc. class, Satyendra Nath Bose was married to Ushabati Ghosh, the only daughter of Jogindranath Ghosh, a renowned medical practitioner of Calcutta. According to the social custom of those days, Bose had no say in the choice of the bride. It was left entirely to his mother to select her daughter-in-law. Young Bose, however, objected to the one social evil, viz., the acceptance of dowry. He agreed to marry the girl of his mother's choice only on condition that they would not demand any cash dowry from the girl's family. This was, of course, agreed to by both parties.

Ushabati was eleven when she was married. She had gone to school, first at the Nivedita School, then at the Mahakali Pathsala. The enthusiastic husband started giving her lessons in English.

They had nine children. Two of them (a boy and a girl) died in their infancy. Professor Bose left behind him his surviving widow, two sons and five daughters. The elder son Rathindra Nath Bose is an electrical engineer while the younger, Ramendra Nath Bose joined an electronics engineering firm. Bose took good care that most of his daughters had graduated before they were married.

Languages

That he should write English of real power may perhaps be deemed natural enough for a scientist of his varied interests and artistic bent of mind. His presidential address as General President of the Indian Science Congress in 1944 is a model of chaste scientific prose. But it is indeed remarkable that he should be equally at home since his student days, with French, German and Italian languages. It was perhaps Hugo, Goethe or the Sanskrit classics, which gave him inspiration and pleasure. In his youth he was associated with Pramatha Chaudhuri and Sudhindranath Dutta and regularly attended the "*Sabuj Patra*" conventions. Here he came under the influence of Rabindra Nath Tagore, whose writings cast a spell over him.

Bose had always been alive to the problem of propagation of science among the people. Soon it became clear to him that the reason why science in our country was not able to make progress was the barrier of a foreign language through which it was taught. In 1948, he founded the *Bangiya Bijnan Parishad* (Science Association of Bengal) for popularising science in Bengali. The *Parishad* has since been publishing

Jnan O Bijnan (Knowledge and Science), a popular monthly in Bengali on Science. It has now also a building of its own, named "Satyendra Bhavan" after his death. The *Parishad* publishes school and college text-books on science in Bengali, and also arranges popular lectures and seminars, conducted in Bengali. During his speeches at the *Parishad,* Bose could express himself in elegant Bengali without the intervention of a single foreign word. He had also started teaching post-graduate classes on Relativity at the Calcutta University in colloquial Bengali.

EARLY TEACHING AND RESEARCH (1915–20)

In 1915, a batch of brilliant and enthusiastic students, after completion of their M.Sc. course, approached Sir Asutosh Mookerjee, the then Vice-Chancellor of the Calcutta University, for advice regarding research and higher studies. He recognised their talents and engaged them to run the newly started post-graduate classes in Physics and Applied Mathematics in the University College of Science, Calcutta. Satyendra Nath joined the university as a research scholar in 1916 and started his studies in the theory of Relativity. Next year, both he and M. N. Saha were appointed lecturers in Physics and Applied Mathematics departments. In the words of Bose : "We took upon ourselves the teaching of post-graduate students. Saha taught Theory of Heat and Thermodynamics and Spectroscopy in the Physics Department and Hydrostatics in the Mathematics Department. I was more amphibious, teaching both Physics and Applied Mathematics quite regularly. On me fell the task of teaching General Physics and giving all entrants suitable introduction to Mathematical Physics, teaching them Differential equations, Harmonic analysis etc. I also taught Elasticity and Relativity in the Mathematics Department."

Both of them had accepted the challenging job of developing the University College of Science, Calcutta, into a centre of advanced learning of international standards. It was an exciting era in the history of scientific progress. The quantum theory had appeared and new significant results started pouring in. According to Oppenheimer : "For those who participated, it was a time of creation. There was terror as well as exaltation to their new insight." Bose's research work in Physics covers a wide range of problems, theoretical and experimental alike. His first important contribution in theoretical physics is a paper jointly with M. N. Saha on the equation of state. It was entitled : "On the influence of the finite volume of molecules on the equation of state." It was published in the *Philosophical Magazine* in 1918. The equation of state proposed in the paper is generally known as Saha-Bose equation of state. This was followed by two papers, one on "The Stress equations of Equilibrium" and the other "On the Horpolhode." They were published in the *Bulletin of the Calcutta Mathematical Society* in 1919. During the following year, he published two more papers in the *Philosophical Magazine,* viz., "On the equation of state" (jointly with Meghnad Saha) and "On the deduction of Rydberg's law from the quantum theory of spectral radiation." During this period, the Calcutta University also published a booklet entitled : "*The Principle of Relativity,*" which contained original papers by A. Einstein and H. Minkowski, translated by M. N. Saha and S. N. Bose, with a historical introduction by P. C. Mahalanobis.

PROFESSIONAL CAREER

Bose at Dacca and his First Visit to Europe (1921–26)

During 1920's, the situation in the Department of Physics of the Calcutta University was rather uncomfortable. Too many able scientists were crowded together and laboratory accommodation, technical resources and equipment were all inadequate. With the migration of some of the members of the teaching staff to other universities, there was some relief. The first physicist to migrate was Satyendra Nath Bose. He joined the Dacca University, which was founded in 1921, as Reader in Physics. While Bose did much teaching and guiding students in their practical classes, his main interest was theoretical physics. And so, most of his spare time was devoted to a critical study of original papers of Planck, Einstein, Böhr and Sommerfeld. This was a period of intense study and preparation for Bose, who used to impress upon his students : "*Never accept an idea as long as you, yourself, are not satisfied with its consistency and logical structure on which the concepts are based. Study the Masters. These are the people who had made significant contributions to the subject. Lesser authorities clearly bypass the difficult points.*"

Background of His Principal Work (1924)

S. N. Bose had carefully studied Max Planck's book entitled "*Thermodynamik und Wärmestrahlung*" a copy of which had been presented to him by Dr D. M. Bose. He knew about phase space and Boltzmann Statistics from Gibbs' book : "*Vorlesungen über Gastheorie.*" He also knew about Einstein's deduction of Planck's formula and how he had never been satisfied with the derivation of this quantum law: he always kept on coming back to it. Planck's condition ran counter to the classical ideas. Planck was aware of the difficulties, but he had never been able to resolve them. He wanted to reconcile his theory with the classical theory. He had the idea of having continuous absorption and discontinuous emission. In order to make these things clear to his students, Bose wanted to solve the difficulty in his own way. It was sometime around March 1924 that Saha happened to visit Dacca University, in connection with M.Sc. practical examination. He stayed with Bose who told him about the difficulties about the derivation of Planck's law, which he encountered while teaching his post-graduate students. He saw the need for a derivation without inner difficulties. Saha drew his attention to certain aspects of equilibrium between radiation and electron gas and to a paper by Einstein and Ehrenfest (1923) published in *Zeitschrift für Physik*. Saha also informed him that Pauli (1923) had utilised Einstein's (1917) idea. The difficulty in Pauli's work was that in order to apply the quantum condition, one had to know exactly what was going to happen afterwards. Saha pointed out these difficulties to Bose.

S. N. Bose was thus induced into a careful study of Einstein and Ehrenfest (1923), Compton (1923), Debye (1923) and Pauli (1923). From these studies, Bose learned about the existing status of Planck's radiation law. The themes of his following two papers on the statistics of radiation grew out of this inquiring study.

Bose's First Major Paper

Bose set about thinking deeply and "spending sleepless nights" about the radiation problem. Next he took the crucial step in the identification of blackbody radiation as a photongas. He showed that the photons had a startlingly "new" property of being strictly identical. This led to a new expression for the thermodynamic properties of an assembly of photons in contrast to what one would have calculated on the then accepted basis, the so-called Maxwell-Boltzmann statistics. But with the "revolution" that Bose introduced into the counting process one obtains the correct thermodynamics of the photon gas. And that one step was the basis of a new synthesis between the wave and particle properties of photons; and, with it, the foundation of quantum field theory.

Bose communicated this paper to the *Philosophical Magazine* in England. Unfortunately, no acceptance letter was received by him for a long time. And so, he sent a duplicate copy of the manuscript, which was entitled "Planck's law and light quantum hypothesis," to Einstein in Berlin, with a request to have it translated into German and published in the *Zeitschrift für Physik*. He wrote :

Physics Department
Dacca University

Dated, the 4th June 1924.

Respected Sir :

I have ventured to send you the accompanying article for your perusal and opinion. I am anxious to know what you think of it. You will see that I have tried to deduce the coefficient $8\pi\nu^2/c^3$ *in Planck's Law independent of classical electrodynamics, only assuming that the elementary regions in the phase-space has the content* h^3. *I do not know sufficient German to translate the paper. If you think the paper worth publication I shall be grateful if you arrange for its publication in* Zeitschrift für Physik. *Though a complete stranger to you, I do not feel any hesitation in making such a request. Because we are all your pupils though profiting only by your teachings through your writings. I do not know whether you still remember that somebody from Calcutta asked your permission to translate your papers on Relativity in English. You acceded to the request. The book has since been published. I was the one who translated your paper on Generalised Relativity.*

YOURS FAITHFULLY
Sd/- S. N. BOSE

(A facsimile of the above letter in Bose's own hand writing is shown in the plate on the facing page).

Einstein acknowledged Bose's letter and the manuscript in a hand-written post-card, stating that he regarded the paper as an important contribution and that he will have it published. As a matter of fact, Einstein immediately translated Bose's paper into German and added the following note at the end. ***Comment of the translator*** :

PHYSICS DEPARTMENT.
Dacca University.

Dated, the 4th June 1924.

Respected Sir. I have ventured to send you
the accompanying article for your perusal and
opinion. I am anxious to know what you think
of it. You will see that (I have tried to
deduce the coefficient $\frac{8\pi\nu^2}{c^3}$ in Planck's Law
independent of the classical electrodynamics,)
only assuming ~~that finite~~ that the ultimate
elementary regions in the Phase-space has
the content h^3. I do not know sufficient
German to translate the paper. If you
think the paper worth publication I shall
be grateful if you arrange for its publication
in Zeitschrift für Physik. Though a
complete stranger to you, I do not feel any
hesitation in making such a request. Because
We are all your pupils though profiting
only by your teachings through ~~the~~ your
writings. I do not know whether you
Still remember that somebody from Calcutta
asked your permission to translate your
papers on Relativity in English. You acceded
to the request. The book has since been
published. I was the one who translated
your paper on Generalised Relativity

Yours faithfully
S. N. Bose

"*Bose's derivation of Planck's formula appears to me to be an important step forward. The method used here gives also the quantum theory of an ideal gas, as I shall show elsewhere.*"—A. EINSTEIN

Bose's paper, translated by Einstein under the title, "Planck's Gesetz und Lichtquantenhypothese, was received by the *Zeitschrift für Physik* on July 2, 1924 and was published in its issue of August 1924. After Bose's paper came an avalanche of developments, the extension of Bose's theory to particles of arbitrary mass and non-zero chemical potential by Einstein (1924, 1925) : the Fermi(1926)-Dirac(1926) statistics for electrons; the quantization of the electromagnetic field by Heisenberg and Pauli (1929, 1930), and quantum electrodynamics by Dirac (1927, 1935).

Both Bose's theory, including Einstein's extension, and Fermi's theory were essentially statistical theories and dealt with complexions of the field. The actual construction of the wave functions which are symmetric and antisymmetric in the many particle labels was done by Dirac (1927). To find the relation between particle type and the statistics which it obeyed was left to Pauli (1936, 1940), who showed that integral spin particles obeyed Bose statistics and half integral spin particles obeyed Fermi statistics. In modern relativistic quantum field theory, the spin-statistics theorem involving Bosons and Fermions is one of the most fundamental of results.

The applicational possibilities of quantum statistics were clearly demonstrated by Sommerfeld (1928), by introducing Fermi-Dirac statistics to metal physics. In the case of an ideal Bose gas with non-zero chemical potential, there is a critical temperature, below which a finite fraction of gas condenses into a single quantum state. This condensed phase discovered by London (1938) should exhibit superfluid properties. London also suggested that superfluid Helium should be related to this Bose-Einstein condensation phenomenon. Indeed Bose's work stands out as one of the central columns supporting the edifice of modern physics.

Bose, however, did not realise the importance of the immediate impact of this paper. He said to Mehra (1975) later : "*I had no Idea that what I had done was really novel. I thought that perhaps it was the way of looking at the thing. I was not a statistician to the extent of really knowing that I was doing something which was really different fom what Boltzmann would have done from Boltzmann statistics. Instead of thinking of the light quantum just as a particle, I talked about these states. Somehow, this was the same question the at Einstein asked when I met him. How had I arrived at this method of deriving Planck's formula ? Well, I recognised the contradictions in the attempts of Planck and Einstein, and applied the statistics in my own way, but I did not think that it was different from Boltzmann statistics.*"

Bose's Second Principal Paper on Radiation Theory

Just eleven days after sending his first paper and letter to Einstein, Bose sent him another paper with a covering letter.

He wrote :

Physics Laboratoroy
Dacca University
Dacca, India,
15th June, 1924

Respected Master :

I send herewith another paper of mine for your kind perusal and opinion. I hope my first paper has reached your hands. The result to which I have arrived seems rather important (to me at any rate). You will see that I have dealt with the problem of thermal equilibrium between Radiation and Matter, in a different way, and have arrived at a different law for the probability for elementary particles, which seems to have simplicity in its favour. I have ventured to send you the type-written paper in English. It being beyond me to express myself in German (which will be intelligible to you). I shall be glad if its publication in Zeitschrift für Physik *or any other German journal can be managed. I myself know not how to manage it. In any case, I shall be grateful if you express your opinion on the papers and send it to me at the above address.*

YOURS TRULY
Sd/- S. N. BOSE

Einstein did not send any reply to Bose's second letter, but he had not forgotten his paper as will be seen later.

Meanwhile, early in 1924, Bose had applied to the Dacca University for a two-year leave for study abroad, but he had not received any definite reply. Fortunately, Einstein's first post-card letter gave Bose a sort of passport to study-leave. He got two years' leave on generous terms. In early September 1924, S. N. Bose sailed from Bombay aboard a steamer of the Lloyd Triestino line. After some stops for sight-seeing on the way, he arrived in Paris around mid-October 1924, and took lodgings at 17 Rue du Sommerard, Paris 5^{e}, a building which housed the Indian Students' Association. Soon after arrival in Paris, Bose addressed another letter to Einstein.

17 *Rue du Sommerard*
Paris Ve
26-10-1924

Dear Master :

My heartfelt gratitude for taking the trouble of translating the paper yourself and publishing it. I just saw it in print before I left India. I have also sent you about the middle of June a second paper entitled, "Thermal equilibrium in the Radiation Field in the presence of Matter."

I am rather anxious to know your opinion about it, as I think it to be rather important. I don't know whether it will be possible also to have this paper published in Zeit für Physik.

I have been granted leave by my university for 2 *years. I have arrived just a week ago in Paris. I don't know whether it will be possible for me to work under you in Germany. I shall be glad however if you will grant me the permission to work under you, for it will mean for me the realization of a long-cherished hope.*

I shall wait for your decision as well as your opinion of my second paper here in Paris.

If the second paper has not reached you by any chance, please let me know. I shall send you the copy I have with me.

With respects,

YOURS SINCERELY
Sd/- S. N. BOSE

Meanwhile, the paper referred to by Bose had been translated by Einstein and sent to *Zeitschrift für Physik*, where it was received on July 7 1924 and published in the August-September issue under the title, "Wärmgleichgewicht im Strahlungsfeld bei Anwesenheit von Materie."

Just as he had done at the end of Bose's earlier paper, Einstein added a note at the close of this paper also. He wrote:

"I hold that Bose's hypothesis regarding the probability of the elementary radiation process is not justified on the following grounds :

For the statistical equilibrium between Böhr's state with another, the relation,

$$\frac{n_r}{g_r} \quad \frac{N_\nu}{A_\nu+N_\nu} = \frac{n_s}{g_s}$$

is valid, as Bose has stated.

It follows from this that the probability for the transitions $r=s$ and $s=r$ must be pro portional to the left or the right sides, of this equation. The transition probability for a molecule must therefore be as $\frac{N_\nu}{A_\nu+N_\nu}$: 1 (if we put half of the statistical weights of both states equal to 1 for simplicity). From the knowledge of thermodynamic equilibrium nothing more can be extracted. From the hypothesis introduced by me these probabilities will be proportional to N_ν (i.e., density of radiation) and $(A_\nu+N_\nu)$ respectively, whereas from the hypothesis of Bose these will be $\frac{N_\nu}{A_\nu+N_\nu}$ and 1 respectively.

From the latter hypothesis, the external radiation can very well effect the transition of a state Z_r of lower energy to the state Z_s of higher energy, but not inversely the transition from Z_s to Z_r. But this again contradicts the validity of the well-known basic law that classical theory must represent quantum theory in the limiting case. According to the latter theory, for example, the radiation field can transmit positive as well as negative energies to a resonator (according to the phase) and indeed both are probable. The probability of both transitions must depend therefore, on the radiation-density, i.e., on N_ν, in contradiction to Bose's hypothesis. In the last edition of his book on Radiation theory, Planck has discussed in detail the question, namely to what extent, quantum theory embraces the classical theory as a limiting case.

"Secondly, according to Bose's hypothesis, a cold body must possess a capacity for absorption depending on the density of radiation (decreasing with it). In the domain where Wien's formula is valid, the bodies in cold state, must absorb 'non-Wien' type of radiation more weakly than the less intense radiation. This would have been already discovered in the case of infrared radiation of light sources, had it behaved in this way."

In his reply to Bose's letter from Paris, dated 26-10-24, Einstein wrote :

Berlin W. 30
3 *November* 1924

Dr S. Bose
17, *Rue du Sommerard*
Paris.

Dear Colleague :

Thank you sincerely for your letter of 26 *October. I am glad that I shall have the opportunity soon of making your personal acquaintance. Your papers have already appeared sometime ago. Unfortunately the reprints have been sent to me instead of you. You may have them at any time. I am not in agreement with your basic principle concerning the probability of interaction between radiation and matter, and have given the reasons in a remark which has appeared together with your paper. Your principle is not compatible with the following two conditions :*

(1) *The absorption coefficient is independent of the radiation density.*

(2) *The behaviour of a resonator in a radiation field should follow from the statistical laws as a limiting case.*

We may discuss this together in detail when you come here.

With kind regards,

YOURS
Sd/- A. EINSTEIN

Bose did not write to Einstein, in reply to the objections raised by him, for almost three months. In fact, he was sorely disappointed because his second paper, which he cherished most, did not get proper recognition from Einstein. He postponed his visit to Berlin for the time being and prolonged his stay in Paris. After deep thinking, he replied to Einstein's letter as follows :

17 *Rue du Sommerard*
Paris V_e
27th January 25

Revered Master :

I received your kind note of 3*rd November in which you mentioned your objections against the elementary law of probability. I have been thinking about your objections all along and so did not answer immediately. It seems to me there is a way out of this difficulty, and I have written down my ideas in the form of a paper which I send under a separate cover. It seems that the hypothesis of negative Einstrahlung stands, which as you have yourself expressed reflects the classical behaviour of a resonator in a fluctuating field. But the additional hypothesis of a spontaneous change, independent of the state of the field, seems to me not necessary. I have tried to look at the radiation field from a new standpoint and have sought to separate the propagation of quantum of energy from the propagation of electromagnetic influence. I seem to feel vaguely that some such separation is necessary if quantum theory is to be brought in line with Generalised Relativity Theory.*

The views about the radiation-field, which I have ventured to put forward, seem to be very much like to what Böhr has recently expressed in May Phil. Mag. 1924. *But it is only a guess, as I cannot say honestly to have exactly understood all he means to say, about virtual fields and virtual oscillators.*

I am rather anxious to know your opinion about it. I have shown it to Professor Langevin here and he seems to think it interesting and worth publishing.

I cannot exactly express how grateful I feel for your encouragement and the interest you have taken in my papers. Your first Post card came at a critical moment and it has more than any other made this sojourn to Europe possible for me. I am thinking of going to Berlin at the end of this Winter, where I hope to have your inestimable help and guidance.

YOURS SINCERELY
Sd/- S. N. BOSE

The aforesaid paper in which Bose had hoped to meet Einstein's objections, one which Langevin considered 'worth publishing,' was never published. No mention of it was made afterwards.

In the context of Einstein's critical comments on Bose's second paper, Sudarshan (1974) has made the following remarks : "This questione concerns the equilibrium of radiation when it is in interaction with matter and being continually emitted and absorbed. In 1915, for the special model of a Böhr atom coupled to radiation, Einstein (1917) had shown that we could get Planck's distribution provided the emission rate contained one term proportional to the number of photons in the phase cell times the spontaneous transition rate. This additional term is called stimulated or induced emission. This special model was extended to many-level systems by Einstein and Ehrenfest (1923). Pauli (1923) on the other hand, had studied the scattering of light by electrons and showed that if Compton effect was taken into account, the Planck distribution was steady. Bose (1924) proposed to take up the general case and showed that in his formulation, both the Pauli processes and the Einstein-Ehrenfest processes were included as special cases.

"This by itself should have met with general acceptance and acclaim. But Bose did point out that instead of Einstein's assumption of a stimulated and spontaneous transition rate for absorption, it is possible to consider only the spontaneous transition rate for emission provided the absorption rate is taken to be not proportioned to the number of quanta per phase cell but this number divided by this number plus one. Now as far as radiative equilibrium is concerned, this 'ansatz' is as good as the Einstein (1940) 'ansatz', since only these ratios do come in. So it would have been quite possible for Einstein to add such a foot-note to Bose's paper and call attention to the positive features of Bose's formulation. But he chose otherwise. Three years later, Dirac (1927) constructed his theory of emission and absorption of radiation and the Einstein 'ansatz' of stimulated and spontaneous emissions was seen to be a natural consequence of the matrix elements of creation and destruction operators. But then Bose did not write on radiation theory ever again."

Stay in Paris (1924–25)

Recalling the days, he had spent in Paris, Bose said to Mehra (1975) :

"I wanted to go abroad directly to Berlin but I didn't venture to go straight on, because I was not sure of my knowledge of German. I came out thinking that perhaps after a few weeks in Paris I should be able to go to Berlin to see Einstein. However, two things happened :

(*i*) Friends;

(*ii*) Letter of introduction to Langevin.

My friends who received me on arrival there, took me to their boarding house, where they were staying. Then they all insisted that I should stay there. WeL, I found it convenient to be among friends."

He was then introduced to Professor Sylvain Levi, the famous French Indologist by his friend, Prabodh Chandra Bagchi. Levi gave him a letter of introduction to Paul Langevin, Professor titulaire at the College de France.

As a teacher of Physics, Bose had been asked to familiarise himself with modern developments in the fields of both theoretical and experimental Physics. Bose's instinctive motivation goaded him to learn about experimental techniques—Radioactivity from Madame Curie and also something of X-ray spectroscopy from Maurice de Broglie. Langevin suggested that he should pursue the possibility of working in Madame Curie's laboratory,' perhaps with Mme Curie herself.' Langevin gave a note of introduction to her and Bose accordingly sought an interview. During their meeting, she carried on the conversation in English. Mme Curie believed that it was essential to know the language of a country really well in order to be able to participate effectively in its scientific and cultural life. Bose told her that he would remain in Paris for about six months and learn French well, but due to his inherent shyness, he wasn't able to tell her that he knew sufficient French already to enable him to work in her Laboratory. She preferred to have her own ideas and told Bose to be around for a longer time, not hurry but concentrate on the language. Thus Bose's desire for learning experimental techniques in Radioactivity under Mme Curie's guidance remained unfulfilled.

Since Bose had showed an interest in X-ray spectroscopy, Langevin gave him an introductory letter to Maurice de Broglie also. The latter apparently knew of Bose's theoretical work; and he readily allowed Bose to work with his chief assistant, Alexandre Dauvillier. There he learnt diverse techniques of X-ray crystallography. He also became deeply interested in theoretical aspects of crystal behaviour. These experiences stood him in goodstead when he had the opportunity to help K. S. Krishnan and his group of students, during their investigations on crystal magnetism at the Dacca University.

Sojourn to Berlin

After about a year's stay in Paris, Bose went to Berlin, and wrote to Einstein on October 8, 1925, seeking an appointment to meet him. Einstein was then on his annual visit to Leyden. The long-cherished meeting with him materialised several weeks later, when Einstein returned to Berlin. Meanwhile Einstein had already published three papers utilising Bose-statistics. His last decisive contribution to statistical thermodynamics had been published in January that year. He had now moved on to other things including the beginning of his search for a unified field theory. And so, Bose lost the chance of a life-time for a fruitful collaboration with Einstein. Nevertheless, their meeting was most interesting. Einstein wanted to know how he had hit upon the idea of deriving Planck's law in this particular way ! He also wanted to know whether Bose's kind of statistics did really mean something novel abut the interaction of quanta and whether Bose could work out its details. Bose hesitated because the duration of his study leave was limited and he was anxious to widen the range of his scientific knowledge during this brief period. And so, Einstein gave him a letter of introduction, which enabled him to attend the Physics colloquium and to borrow books from the university library. It also gave him the privilege of meeting and forging personal friendship with top-ranking German Scientists like Fritz Haber, Otto Hahn, Lise Meitner, Walther Bothe, Michael Polanyi, Von Laue, Walter Gordon, Eugene Wigner and others. He actively engaged himself in X-ray crystallography at Polanyi's laboratory, and in theoretical studies with Gordon (of Klein-Gordon equation fame). He visited the 'Radioactivity' laboratory of Hahn and Meitner quite often. Meanwhile Heisenberg's (1925) paper on quantum mechanics came out and Einstein became very excited about it. He wanted Bose to try to see what the statistics of light quanta and the transition probabilities of radiation would look like. Bose discussed the problem with Gordon and tried to understand the trend of the new theory. Meanwhile Einstein lost his interest in the problem, because he refused to believe that it was by any means the final theory. During this interlude, Bose held fruitful discussions with Einstein on Relativity theory, Unified field theory and Hilbert's (1924) theory.

Later, during the summer of 1926, Bose visited Göttingen and met Max Born and Erich Hückel. Thus Bose's first European visit was very profitable to him although he did not publish any scientific paper during this period. He returned to Dacca in 1926.

At Dacca (1926–44)

Before his return to Dacca, his friends had advised him to apply for a Professorship of Physics at Dacca University. Since he did not possess any doctorate degree, they suggested that he should obtain a letter of recommendation from Einstein. Einstein was surprised at the request because he thought that Bose's scientific work should entitle him to the position. Einstein's recommendation notwithstanding, the professorship at Dacca was offered to Dr D. M. Bose, who declined. S. N. Bose was then appointed Professor of Physics and Head of the Department in 1927.

This was the beginning of the second phase of his professional career which extended from 1926 to 1944 and was spent at Dacca University. He had just returned to a medieval university after a fairly long visit to some modern European universities and laboratories. And so, he strove to see how science could do more and more for his countrymen. The accent was not on the problem of science, but what science could do for the common man. He had embarked on a professional career during the sealing wax and string era. His conviction was that it was necessary to build one's own appratus in order to understand its performance fully. Equally competent as both a theoretician and an experimentalist, Bose would take nothing for granted with respect to mathematical formulations or laboratory procedures. Just as he insisted upon deriving mathematical equations himself, rather than relying upon the literature (indeed he disdained to "look things up"), he likewise insisted upon designing his own experimental equipment. Returning to Dacca, he launched a drive into experimental physics. He designed and constructed X-ray diffraction cameras for rotation and powder photography. When great interest developed later in the study of extra Laue reflections, known as thermal diffuse scattering, he designed a sensitive Bragg-type X-ray spectrometer. He also formulated an easy method for identifying the indices of the plane of reflection of Laue photographs recorded in a cylindrical camera. Under his leadership, studies in crystal structure were undertaken perhaps for the first time in India. It was also his quest to assemble around him an active, gifted and perceptive band of colleagues like K. S. Krishnan, S. R. Khastgir, K. Banerjee and others. He did not care to build up any school of experimental research of his own; rather, in his characteristic way, he tried with the limited resources of his department, to provide facilities for research to all his colleagues in their respective fields of specialisation.

He had a fascination for chemistry as well. Perhaps he imbibed it from Professor Herman Mark, whom he used to visit quite often in Berlin. At Dacca, he made a personal cell for research in organic chemistry. Assisted by P. K. Dutta, he studied the reactions of *p*-acetyl-amino-benzene-sulphonazide and *p*-toluene-sulphonazide with pyridine. He also worked on the synthesis of some *r*-pyrone derivatives related to Patulin, which is equally bacteriostatic to both gram-positive and gram-negative organisms. It has also a beneficial effect on the treatment of common cold.

When his experimental laboratories began running in full swing, Bose returned to Theoretical Physics, after about a decade.

In 1936–37, Bose published two papers on D^2-statistics, to which his attention had been drawn by Professor P. C. Mahalanobis, Founder-Director of Indian Statistical Institute. In these two papers, he found out recurrence, algebraic relations and differential equations, satisfied by the moments of this distribution. Both these papers exhibit his great skill in mathematical manipulation.

In 1938, he investigated the problem of total reflection of radio-waves in the ionosphere, by solving the classical Lorentz equation by the method of characteristics. From this general scheme, four different possible conditions for the total reflection of radio-waves can be obtained only under different sets of simplifying assumptions. It is said that he was drawn to the problem at the inducement of Professor M. N. Saha, during his lecture at the Dacca University.

In 1939, he published a paper on Lorentz group. In this paper, a four-dimensional transformation was decomposed into two factors which lead to the spinors from algebraic considerations.

In 1941 (jointly with S. C. Kar), he published a paper entitled—"The complete solution of the equation

$$\nabla^2\phi - \frac{\partial^2\phi}{c^2\partial t^2} = -4\pi\rho\,(x,y,z,t)."$$

Incidentally, a similar equation had been used rather empirically by H. J. Bhabha during the course of a lecture on cosmic rays at the Department of Mathematics, Calcutta University.

In 1943 (jointly with K. M. Bose), he published "A note on Dirac equations and the Zeeman effect." Here, the exact solution of the Dirac equation for hydrogenic atom in a magnetic field was obtained in terms of some polynomials.

In 1945, Bose deduced the integral equation in the momentum space for Schrödinger's wave-equation for the Hydrogen atom and discussed the physical problem from the integral equation.

It was no wonder Bose could manage to utilise his giant intellect successfully in so many diverse fields ! As a matter of fact, he was very sensitive, contemplative and retiring by nature. He always "needed someone to provoke him with some challenging problem in physics or mathematics." Once aroused, he could work ceaselessly on till the goal was achieved.

Bose lived in Dacca for about a quarter of a century. He was loved and respected by his colleagues and students alike. The general public of Dacca were also proud of him. But the political atmosphere of Dacca cast a shadow over the academic environment. The communal tension lurked beneath the festive board, which disturbed S. N. Bose intensely. At this moment, a vacancy of Khaira Professorship occurred at the Calcutta University, due to the sudden death of its previous incumbent Professor B. B. Roy. Piofessor S. N. Bose accepted the offer and left Dacca for good.

Back to Calcutta (1945–56)

Bose began the third phase of his professional career at the Calcutta University. During this period, he found a new way of work. He did not work in solitude as an individual, he worked in collaboration with others. When he was appointed Head of the Department of Physics and Dean of the Faculty of Science, he spread his wings over most of the departments of science. He accepted Böhr's aphorism : "*The main human lesson drawn from investigation of natural phenomena ever more remote from ordinary experience is the recognition of the inseparability of objective knowledge from our ability to put questions to nature by means of experiments suited to give unambiguous answers.*" And so, this incredibly versatile man delved deeply into the ocean of knowledge and attempted to familiarise himself with its unknown facets. A number of young, keen and serious research workers congregated around him and started colloquia on advanced topics of physics and mathematics. Once his interest in a challenging problem was aroused: he would not rest until it was solved. If somebody approached him with an original paper, he would first try to understand the motivation and main objective of the paper and what the author wanted to arrive at. Next he would formulate the paper in his own way with pencil and paper, and finally, would solve the problem. Quite a number of times, his methods and his results were much more general than those envisaged in the paper. "Always read the Masters," he would say—"These are people who made really significant contributions to the subject. Lesser authors cleverly bypass the difficult points."

After attendir g a seminar, and listening to the discussions on various aspects of Einstein's Unified Field Theory, Bose was drawn into its vortex, when he came to learn about the inability of experts to find exact solutions of the field equations. In the geometrical aspect of the theory, it is necessary to solve sixty-four equations with affine connections and the metric tensors and their derivatives. Professor Bose plunged into the problem with single-minded devotion and succeeded in finding an exact solution. The importance of Bose's work will be evident from the following remarks of Schrödinger : "In the general case, it is next to impossible to produce it in a serveable tensorial form. This is hard to believe, unless one tries." During 1953–55, Bose published five important papers related to Unified Field theory. These are believed to be a mathematical *tour de force,* even though they did not create as great a stir as his earlier ones of 1924. The solutions of the equations for the general case are given in the first two papers. In others, the complete development of the physical theory and relevant mathematical results are given. He sent these papers to Einstein, who wrote that he did not quite follow how precisely Bose's solution was to be used in physics and discussed it in detail in one of his own papers.

Bose wrote down his reply at length and wanted to meet Einstein personally at Bern, on the occasion of the celebration of the 50th anniversary of the discovery of the theory of relativity. Unfortunately fate intervened, and when the news of the death of his master came, Bose was so overwhelmed with grief that he tore and threw away the only copy of his important paper.

It is a paradox of Bose's career, that he made only two outstanding contributions to mathematical physics—the one on "Statistics," in the twenties and the other on "Unified Field Theory" during fifties with a gap of about thirty years between the two. The answer is that Bose was a rare combination of kaleidoscopic versatility and evergreen vitality which had made him fill the intervening gap of thirty years with studies of subjects as diverse as Experimental Physics, Chemistry, Mineralogy, Biology, Soil Sciences and Archaeology.

Since his predecessor in Khaira Laboratory happened to be an X-ray spectroscopist, Professor Bose guided his students in their original lines. An important project comprised the study of thermoluminescence. The rapid scanning spectrophotometer designed and fabricated under his guidance is a typical example of his interests and abilities in instrumentation work. In 1954, at the Crystallographic Conference in Paris, Bose presented the constructional details of his spectrophotometer, which was subsequently adopted in some well-known laboratories in Europe. He also encouraged the present writer to install the first indigenous Radio-carbon dating equipment in India in 1953. He sponsored measurement of radioactivity in thermal springs, which had far-reaching effects in balneology and balneotherapy. Indeed the renovation of Bakreswar thermal springs for the purpose of building a spa-sanatorium is mainly due to his initiative at the instance of the late Dr B. C. Roy. An extensive study of Indian clay minerals by X-rays, chemical analysis and cation exchange technique was also undertaken by his research scholars.

In the realm of Organic chemistry, he embarked on a laborious routine involving synthesis of Emetine and Quinine, but he was forestalled by foreign workers. Considering the importance of Germanium as a strategic material in electronic industry, he made a systematic search for Germanium in the sulphide minerals of India. In collaboration with his class-fellow, Professor P. B. Sarkar, of the Department of Inorganic Chemistry, he actually extracted Germanium from a sample of Sphalerite from Nepal.

From 1951, Bose had been visiting Europe almost every year. He visited Germany in 1951 and met Professor Walther Bothe, Otto Haxel, J. H. D Jenson and H. Maier-Leibnitz in Heidelberg. He also visited Göttingen to meet Professors Otto Hahn, Werner Heisenberg and Houtermans. In 1953, he was asked to attend the World Congress for General Disarmament and Peace at Budapest, Hungary. Invitations also came from Soviet Russia, Denmark and Czechoslovakia. Bose took this opportunity to visit Geneva, Paris, Copenhagen, Zürich and Prague. He met Professor Pauli in Zürich and Niels Böhr in Copenhagen.

Bose's next trip was to England in 1956 to attend the meeting of the British Association for the Cultivation of Science. Two years later he was back in London to attend the Royal Society meeting where he was elected a Fellow. In 1962, he went to Sweden and from there to Moscow to attend the Peace Conference. In August 1962, he was invited to Japan to attend a Seminar on Science and Philosophy.

In 1956, at the age of 62, Bose retired from the Calcutta University and became the Vice-Chancellor of Visvabharati.

Bose at Santiniketan (1956–58)

Bose lost no time in getting down to work. He drew up a Master Plan for reorganising the set-up at Visvabharati by introducing science courses. He wished to create facilities for advanced training and research in some familiar branches of science. It is a pity that his motive was misunderstood and some old-timers of Santiniketan thought that this move would go against the age-old tradition of Santiniketan. They opposed him vehemently. Thus ended the tragic episode about his efforts to upgrade the Science curriculum at Santiniketan. Actually, his affinity and good relations with Rabindranath Tagore were eminently suitable to launch such a drive. Incidentally, Tagore had dedicated his book entitled "*Visva-Parichay*" (Introduction to the World of Science) to Satyendra Nath Bose. However, his brief interlude at Visvabharati was soon over and Bose returned to Calcutta to the great delight of his students, friends and admirers.

Bestowal of Honours

He had all along been averse to publicity and self-aggrandizement. He remained satisfied with a mere M.Sc. degree appended to his name. Indeed, he had resolved to espouse obscurity as much as St. Francis of Assisi had espoused poverty. But towards the end of his career, honours and recognitions were showered upon him in abundance. These included the following :—

(1) Foundation fellowship of the Indian National Science Academy (1935).
(2) D.Sc. (*h.c.*), Calcutta University (1957).
(3) D.Sc. (*h.c.*), Jadavpur University (1957).
(4) D.Sc. (*h.c.*), Allahabad University (1957).
(5) F.R.S., Royal Society, London (1958).
(6) Deshikottama, Visvabharati University (1961).
(7) D.Sc. (*h.c.*) Indian Statistical Institute (1963).
(8) D.Sc. (*h.c.*) Delhi University (1964).

Among the many distinguished positions and offices he held were :—

(1) Sectional President, Physics and Mathematics at the Madras Session of the Indian Science Congress (1929).
(2) President, Indian Physical Society (1945–48).
(3) General President, Indian Science Congress, 31st Session at New Delhi (1944).
(4) President, National Institute of Sciences of India (1949–50).
(5) Member of the Rajya Sabha, Indian Parliament (1952–58).

National Professorship (1958–74)

We now reach the final phase of his professional career. It occupied three five-year terms as National Professor extending from 1958 till his death. He started in a new style, of a very special character, acting and talking as an equal in a group of young and enthusiastic scholars undergoing training in diverse branches of science. Tempered by the years, with his luxuriant crop of white hair, he came to be regarded as a sort of father confessor, giving counsel on any problem on which any one sought his guidance. To him may be applied what Francis Bacon said about himself, "*I have taken all knowledge to be my province.*"

His fortê was a profound and clear understanding of the fundamentals of sciences. However, he had now come to the conclusion that time had changed the basic character of physics. It had become a large enterprise extending beyond the ivory tower of the Universities and research Institutions. He scanned the horizon and set his intellectual eye on the workings of Nature. He persuaded the present writer to join him in an exploration of Helium, an ingredient for loss-free electrical power transmission of the future. Earlier, an indication of the presence of this gas in fair amount was detected as an important constituent of the natural gas emanating from Bakreswar thermal springs in West Bengal. Now he supervised the construction of a field laboratory at the site. The enthusiasm and ideas of other people would not have been enough, however, if a man of his stature had not supported it, and worked out every detail. After his demise, the project was taken over by the Department of Atomic Energy, Government of India.

Fine Arts and Music

His personality cast its spell of genius on the common people. They regarded him as a living myth or legend. Often in informal musical concerts, Bose, the connoisseur of classical music, would close his eyes and seem to fall asleep, to everybody's dismay. But at the end, he would open his eyes and put extremely pertinent questions to the performer. He was extremely fond of instrumental music and played on the "*Esraj*" like a master. People have seen him playing on his "*Esraj*" in a lonely corner of his home, with tears rolling down his eyes.

He also had an absorbing interest in fine arts, and would often discuss about the elegance of mural paintings with maestros like Jamini Roy. Seldom did he decline to attend any musical soiree, cultural function or art exhibition, when invited.

Reminiscences

The conscious and the unconscious appeared to have a strange deep unity in his restless brain. At different levels of perception the legend carved out a superb figure of a giant who was engagingly childlike and a man of supreme genius who was entirely human. Often he appeared to be immersed in laziness, but the somnolescence was full of alertness. Once presiding over a lecture of Professor Niels Böhr at the Saha Institute of Nuclear Physics, he had closed his tired eyes and it seemed that he was asleep. But when Professor Böhr hesitated before the blackboard and said "Perhaps Professor Bose can help me here," he at once opened his eyes, explained the mathematical point and seemed to revert to his unseeing meditation. On another occasion, at the same venue, he was presiding over a lecture by Professor Frederic Joliot-Curie. After introducing the speaker in English, he closed his eyes as usual. But when Professor Joliot asked for an interpreter to render his speech in French into English and none came forward, Professor Bose opened his eyes, stood up and translated Professor Joliot's speech into chaste English, sentence by sentence.

The most attractive feature in Professor Bose's outlook was the blend therein of the orient and occident. He combined in himself the temper of the visionary and that of the man of the world. He had witnessed life in its manifold phases—its brilliant sunshine, its weeping gloom. He had suffered and endured the buffets of life, staggered for a moment and then went on his way oblivious of the past and heedless of the future. Naught but a truly religious spirit could have given him the inward joy and sweet content which enabled him to laugh at the world's waywardness to scorn. His greatest conquest was the conquest of self.

His life resolved itself into a kind of perpetual giving. He was a tower of strength to his companions. His enduring love and sympathy lifted their spirits and cut paths through their sickness, loneliness, disappointment and despair. He awakened their awareness, strengthened their faith, deepened their love and steeled their courage to face life's grimmest challenges without fear. He had the free immolation of a being that could give all and receive nothing and above all the quality of a soul in which neither fame nor adversity could change the exceptional purity. He did know how to be famous. He had a life-long aversion for the lime-light. Natural kind--ness, strong nationalism, extraordinary intelligence and graceful sensitivity were the keynotes of his greatness.

Last Days

On the occasion of the attainment of his eightieth year on January 1, 1974, the Calcutta University arranged for an international seminar. It was specifically meant to celebrate the golden jubilee of "Bose Statistics." The invitations weie sent clear around the world. The great and the learned accepted. This meeting was to be a gathering of brains, a survey of the world's opinion on the impact of "Bose Statistics" on contemporary science. The men of science congregated from all parts of the world. The inaugural meeting was held in the lecture theatre of Bose Institute on January 8, 1974. The panel of speakers carried dazzling names. But they were all dwarfed by a man with his luxuriant crop of white hair as his trademark—Professor Satyendra Nath Bose. He tried to pull himself up from his seat. He was requested to speak while sitting. As he delivered his impromptu address, lights flashed and cine-cameras around, but the message and the genius and the role of his prose were there. He naively recounted nostalgic reminiscences of bygone days and speculated on the possible influence of heavenly planets, which had guided him to write a four page paper fifty years ago, and which had now acted as a spark to bring together so many distinguished scientists from the East and the West. He concluded prophetically with the following words : "*Well, after all, if one has lived through so many years of struggle, and if at the end he finds that his work has been appreciated, he feels that he does not need to live long. I think this is the faithful end to a long career.*"

During the following weeks, he carried himself through a hectic programme—attending seminars, inaugurating exhibitions, lecturing at social functions, all held in his honour. Perhaps the responsibility of excuting so many diverse programmes was too big and widespread for a man of his age to carry. He took on too much and exerted himself beyond the limits of his endurance. Worn out by his ceaseless activities, he was unable to withstand an attack of bronchial pneumonia that followed recurrent attacks of respiratory troubles. Knowing more about his disease than his attending physician, he realised it how it would end for him and faced death severely during morning hours of February 4, 1974. His mortal frame was consigned to flames at Keoratala Crematorium in the presence of his close relatives, friends, co-workers and students, who loved and respected him.

With Professor Satyen Bose's death an era ended—an era of great men who created Science in India. We are perhaps too close to him to judge his great, ness. Only from a distance can one see how much Mount Everest towers over the other peaks of the Himalayas. It was Bose himself who helped to create the continuation of his spirit into the future. It puts us under obligation to continue what he wanted to do.

S. D. CHATTERJEE

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