feature article

# The man behind Bose statistics

Kameshwar Wali

**A rich Bengali cultural tradition, British–Indian politics, and a two-year stint in Europe all helped Satyendra Nath Bose become a renaissance man as well as the originator of quantum statistics.**

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**On 4 June 1924,** a relatively unknown Satyendra Nath Bose from Dacca University in East Bengal, India, sent a short article to Albert Einstein with an accompanying letter (see figure 1), which begins[1]

> 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 the classical electrodynamics only assuming 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 its publication in *Zeitscrift für Physik*.

Bose goes on:

> 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. . . .
>
> Yours faithfully,
>
> S. N. Bose

Einstein's reply came in a postcard dated 2 July 1924 (figure 2) on which he wrote, "I have translated your paper and given it to *Zeitscrift für Physik* for publication. It signifies an important step forward and pleases me very much." In a note appended to his translation and published with the paper,[2] Einstein says that Bose's derivation "appears to me an important step forward. The method used here also yields the quantum theory of an ideal gas, as I shall show elsewhere." In fact, Bose's concern was radiation, for which the number of photons was not conserved; Einstein's generalization was to massive particles whose numbers were fixed.

On 10 July 1924, within a week or so after receiving Bose's paper, Einstein presented his own paper to the Prussian Academy of Sciences. Titled "On the Quantum Theory of the Monoatomic Gas," it was an extension of Bose's work. Einstein followed up that paper with two more in 1925, the second of which is well known for its prediction of a possible new state of matter whose existence took 70 additional years to demonstrate—the Bose–Einstein condensate.

According to Abraham Pais, Bose's derivation of Planck's law was the fourth and last of the revolutionary papers of the old quantum theory, the other three being by Max Planck, Einstein, and Niels Bohr.[3] Indeed, Bose's derivation of Planck's law was simple and straightforward, but it implied three novel and radical features. First, blackbody radiation consisted of zero-mass, particle-like light quanta of momentum $h\nu/c$ and energy $h\nu$. Second, Bose made no reference to classical theory. Independent stationary vibrations were replaced by the number of cells in one-particle phase space. Third, the probability law Bose used in distributing the number of quanta in the frequency range from $\nu$ to $\nu + d\nu$ among cells implied a new kind of statistical dependence or interaction between light quanta and, in Einstein's extension, between material particles. That feature is often called indistinguishability.[4]

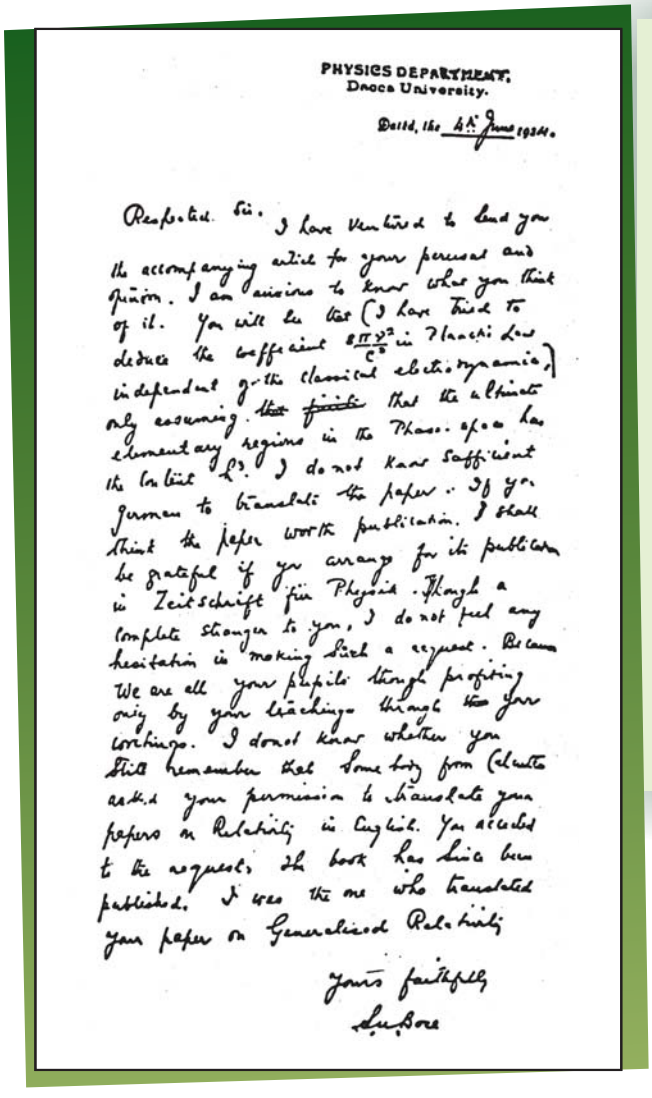
## Another Laplace or Cauchy

Thanks to his remarkable discovery, and with his name associated with Einstein, Bose became a legendary figure in the 20th-century science of India. Outside India, however, little is known about him. Even in India, his name is often confused with that of Jagdish Chandra Bose, the 19th-century Indian scientist who received wide international recognition for his experiments with wireless transmission and with plants.

Born on 1 January 1894 in Calcutta (now Kolkata), the capital of British India and the largest city in the state of Bengal, S. N. Bose, as he is often called, was the only son and the eldest of seven children of Surendra Nath and Amodini Bose. Bose's family, with two generations of English education, belonged originally to the Bara Jagulia village in the district of Nadia, known for its traditional learning of Sanskrit scriptures and its scholars. According to family records, the family lived in the village for more than three centuries. With the advent of the British Raj, Nadia lost its importance and the family moved to Calcutta.

Bose's father was an accountant with the East India Railway. Although working in the British civil service, he was a part of the rising English-educated middle class—a group that was deeply influenced by mid-19th-century European rationalism and individualism, yet was developing a rising nationalism opposed to British colonization. His son would inherit his wide range of interests, including mathematics, science, and philosophy.

Bose grew up in a normal extended family, with a loving mother, younger sisters, uncles and aunts, and a strict father who, as was customary in families of India, commanded



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 the classical electrodynamics) only assuming that the ultimate element any region 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 some boy 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

**Figure 1.** Satyendra Nath Bose in Paris in 1925. It was from Dacca in 1924 that Bose sent Einstein this letter accompanying his manuscript on Planck's blackbody radiation law. (Photo courtesy of Falguni Sarkar; letter from ref. 10.)

more respect than overt love. Bose's formal education began at the age of five in a school near the family's home, but he switched a few years later to the Hindu School, an institution of great tradition and distinction. From all accounts, Bose's teachers recognized him as a gifted child. Despite his weak eyesight, he was a voracious reader of Bengali, Sanskrit, and English literature, well versed in the poetry of Rabindranath Tagore, Kálidása, and Alfred Lord Tennyson. His mathematics teacher in the Hindu School recognized him as a genius in mathematics and proclaimed that he would one day be known as another Pierre Simon Laplace or Augustin Louis Cauchy.

By the time he joined Presidency College in Calcutta in 1909, Bose, despite his natural aptitude for languages and humanities, had decided to pursue science. That choice was partly motivated by the prevailing nationalistic sentiment ignited by the partition of Bengal in 1905. By partitioning Bengal, Lord Curzon, one of the most imperialistic, reactionary viceroys of British India, had intended to curb Bengal's influence on the rising national struggle for independence. Instead his action created a furor against the Raj and initiated a strong "swadeshi" movement of self-sufficiency. Swadeshi was characterized by a boycott of foreign goods, a public burning of British mill textiles, reliance on homespun industries, and street gatherings of people singing patriotic songs. Rakhi-bandhan, a popular festival in North India in which a sister ties a colored thread (rakhi) around a brother's wrist as a mark of protection, was converted into a solidarity pledge between all peoples, with Hindus and Muslims exchanging rakhis. Among the young, swadeshi generated a strong national awareness and dedication to national service. Talented students like Bose thought science, engineering, and technology were the ways to lead the country to progress and prosperity.

The year 1909 was remarkable in the history of Presidency College and in the scientific history of Bengal. The college's entering class included a group of extremely talented students who would make their mark in original research and play a dominant role in the scientific and economic development of free India. The brightest among them was Bose. Meghnad Saha, who was to become Bose's close friend and research collaborator,[5] joined Presidency College two years later.

United in their nationalistic ideals, the Presidency group was a part of both overt and clandestine activities in the swadeshi movement. Some of the students risked their careers. Some became members of the National Revolutionary Movement—one of several independence-minded groups in British colonial India—based in the state of Bengal. Upon the outbreak of World War I, its members began to organize an armed rebellion. In that politically charged atmosphere, several people, notably Manabendranath Roy (1887–1954) and Abani Mukherjee (1891–1937), left the country to secure arms from Germany. Bose was in contact with Mukherjee and helped him in many ways. Roy and Mukherjee went on to help start the Communist Party of India in 1920.

Bose, however, was under strict orders from his father not to get involved in any activities that might spell the end of his potentially brilliant career. As the eldest and only son, he was made aware of his responsibilities to the family. Bose obeyed his father, but he remained a strong supporter of those who participated in the swadeshi movement, helping

in whatever way he could, sometimes acting as a courier, sometimes providing shelter to fugitives from police pursuit, and sometimes helping out with money. And through his college years, he took part in running the night schools for working-class children; those schools came to be known as the Working Men's Institute. He strongly believed that enlightenment and self-awareness through the education of the masses was vital to independence.

Though Bose obeyed his father's political injunction, he rebelled against the paternal wish for him to avoid wasting his time on music. Not a respectable occupation, music nevertheless ran in Bose's veins, and he became an accomplished musician (see figure 3).

## Postgraduate ups and downs

Bose completed his BSc degree in 1913 and his MSc in 1915, and he secured first place in both examinations; Saha took second place. Both Bose and Saha, however, faced a grim situation, with no opportunities for further study or research or for any jobs. In the meantime, when he was only 20 years old and still a student in his MSc classes, Bose and Ushabati Ghosh were married. Ushabati was the only daughter of a renowned and rich doctor, Jogindranath Ghosh. Bose was not keen to get married so early, but he could not go against his mother's wishes. Marriage in India at an early age, when still in college, was very common then and remains common today. Bose was exceptional in neither accepting a dowry nor seeking monetary help from his wife's family when he faced difficult financial situations. If he wanted, he could very well have received support from his father-in-law for a trip abroad for higher studies, a prevalent practice. The couple's first child was born soon after Bose received his MSc degree.

Unemployed, both Bose and Saha spent a year earning what they could from private tutoring. Bose tried to work toward a doctorate degree in mathematics under Ganesh Prasad, who had just joined the University of Calcutta. Coming from Banaras, where he used to set up hard questions for MSc examinations, Prasad had a reputation for his scholarship. "The young students who flocked to him for research guidance, but had not fared so well in his exams, had to stomach adverse comments about their former teachers, too scared to answer back," recalled Bose. "After my MSc I too presented myself before Ganesh Prasad who was also my examiner though I had not fared as badly as the others [on Prasad's exam questions]. Dr. Prasad was kind to me at first but I was notorious for plain speaking. I found it difficult to bear his tirade against my teachers. I had dared to counter his adverse criticisms. This infuriated him. He said, 'You may have done well in the examination but that does not mean you are cut for research.' Disappointed, I came away. I decided to work on my own."[6]

He also decided to apply for a teaching position advertised by the government of Bihar—a state neighboring Bengal—but was turned down because he was overqualified. His attempt to get a job at a meteorological office met the same fate. Just as the situation looked most bleak, a splendid opportunity presented itself. It came from Asutosh Mookerjee, the vice chancellor of the University of Calcutta, who was a distinguished mathematician with a strong interest in physics. But Mookerjee had had no opportunities for continuing his mathematical research and advanced studies, so he had opted for law and rose to eminence as a judge of the Calcutta high court.

With generous financial help from two other lawyers, Taraknath Palit and Rashbehari Ghosh, Mookerjee established the University College of Science as part of the University of Calcutta. The college, which started functioning in 1916, emphasized advanced courses and basic research. As Bose writes,

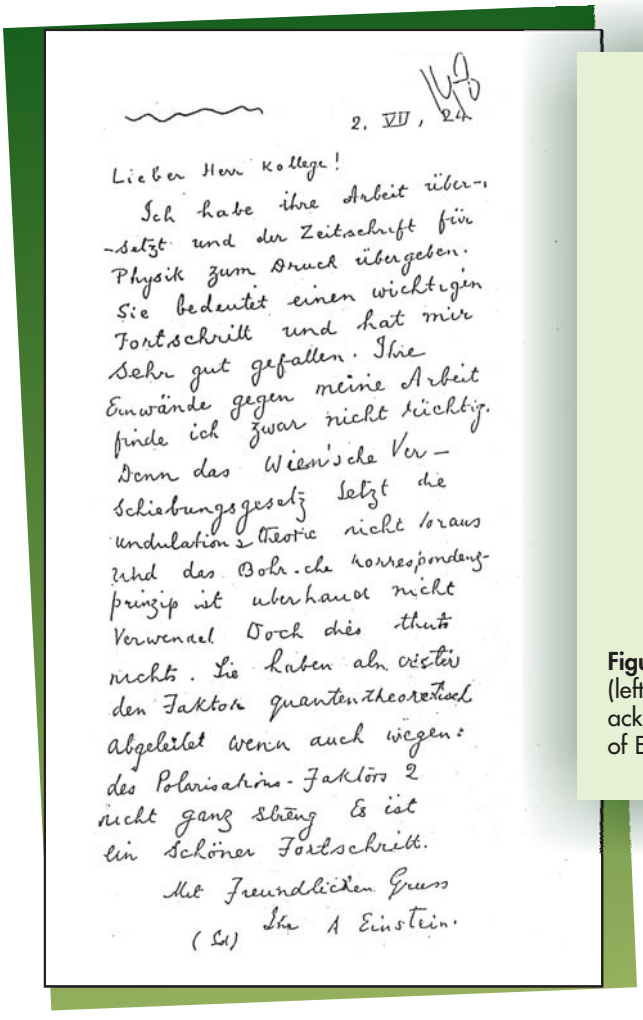
> One day we were called up by Sir Asutosh.
>
> Meghnad, Sailen [Ghosh] and I went up the steep stairs to the library, to the special chamber where Sir Asutosh sat. We were naturally meek and submissive and overawed by his august presence. He had heard that the younger generation wanted more modern subjects to be introduced in the University curriculum. He asked, "What subjects are you competent to teach, boys?"
>
> "Sir, we will try our best to teach whatever you want us to." He smiled. We had only heard of the many new discoveries in physics, most of them made in Germany—new developments and new discoveries. Planck, Einstein, Bohr—we Bengalis had only heard of them. To know more about them one had to read books in German or research journals in other languages. During the war most of these journals did not come to India.
>
> At long last, as the first step to a new career, we were given a special allowance of 125 rupees per month. Meghnad was assigned to study quantum theory and I had to learn Einstein's relativity theory. We came away committing ourselves to being prepared to teach within a year. But where were we to get the books from? There were some books in English on relativity; we got hold of them. But where could we get hold of the writings of Boltzmann, Kirchhoff, Planck?[6]

Help again came from an unexpected source. Bose knew a P. J. Bruhl, who was teaching engineering physics in the Bengal Engineering College at Sibpur. Bruhl, who had a doctorate in botany, had come to Calcutta from Germany on a scholarship to study flora in India. However, tuberculosis compelled him to avoid outdoor activities, so he had switched to physics, an indoor subject.

Bruhl had an excellent collection of German-language science books, advanced texts, and physics journals. Bose and Saha could not have asked for more. They borrowed whatever books they could lay their hands on—books by Planck, Ludwig Boltzmann, Wilhelm Wien, and others. Saha had taken pains to learn German; Bose knew French and was taking lessons in German. Together they prepared themselves to teach advanced modern physics and forged a collaboration in research.

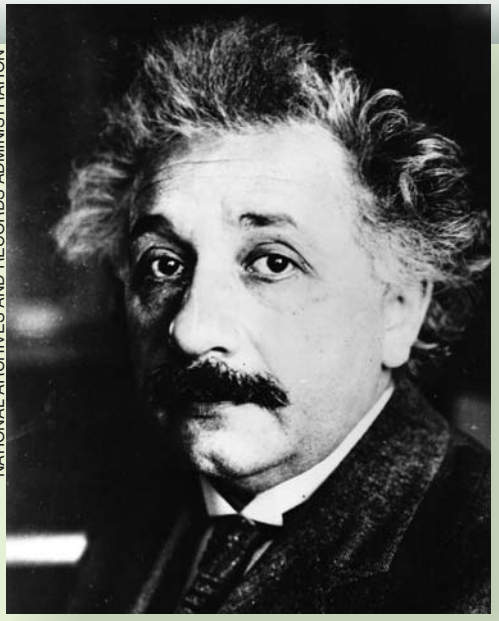
In 1919, Einstein's theory of general relativity received worldwide acclaim due to the confirmation of its predictions that a gravitational field would bend light. Immediately, the young self-taught stalwarts took it on themselves to translate the original papers on special and general relativity.[7] Bose and Saha's book of the translations was the first such collection in English.

Two years later, Bose got an offer of a readership at a higher salary from the newly established university in Dacca in East Bengal. (Presently called Dhaka University, it is now in Bangladesh.) The school's vice chancellor, P. J. Hartog, was a visionary committed to excellence. He handpicked Bose, who soon found himself with the task of building a new department—including setting up laboratories—to teach advanced courses for BSc honors and MSc students. Bose taught thermodynamics and Maxwell's theory of electromagnetism. The library was being replenished with books and journals. And just as his first group of students was graduating in 1923,



2. VII, 24

Lieber Herr Kollege!
Ich habe ihre Arbeit über-
-setzt und der Zeitschrift für
Physik zum Druck übergeben.
Sie bedeutet einen wichtigen
Fortschritt und hat mir
sehr gut gefallen. Ihre
Einwände gegen meine Arbeit
finde ich zwar nicht stichhg.
Denn das Wien'sche Ver-
schiebungsgesetz setzt die
Undulationstheorie nicht voraus
und das Bohr-che Korrespondenz-
prinzip ist überhaupt nicht
Verwendet. Doch dies thut
nichts. Sie haben ab erster
den Faktor quantentheoretisch
abgeleitet wenn auch wegen
des Polarisations-Faktors 2
nicht ganz strèng. Es ist
ein schöner Fortschritt.
Mit Freundlichen Gruss
Ihr A Einstein.
(Ld)



NATIONAL ARCHIVES AND RECORDS ADMINISTRATION

**Figure 2.** In July 1924, Albert Einstein sent S. N. Bose a postcard (left) that accepted Bose's paper on radiation statistics and acknowledged its importance. (Card from ref. 1; 1920s photo of Einstein courtesy of AIP Emilio Segrè Visual Archives.)

Bose got a letter notifying him that his appointment would not be extended beyond a year. Conflict between the government of India and the provincial government of Bengal had resulted in the cutoff of funds for the university. Bose became involved in a long struggle to keep his appointment.

It was under such troubled circumstances that he wrote his famous paper[8] and sent it for publication late in 1923 or early in 1924 to *Philosophical Magazine*. Six months later, when the editors informed him that the referee's report was negative, he sent his rejected paper to Einstein. Meanwhile, during a friendly visit to Dacca in March 1924, Saha brought to Bose's attention new attempts by Wolfgang Pauli and by Einstein and Paul Ehrenfest to derive Planck's law. Saha's visit got Bose thinking about the interaction between radiation and matter and led to Bose writing a second paper that he sent to Einstein at around the same time he sent his first.

## Paris and Berlin

Einstein's 2 July postcard was influential enough for Bose to obtain a two-year study leave. He arrived in Paris in October 1924 and stayed in a pension that was the home of India Association, which helped visitors, students, and student activists involved in the anti-British national movement with accommodations and other needs. During his leave, Bose intended to learn something new in the great laboratories of Europe; the x-ray and crystallography laboratories of Maurice de Broglie and the institute where Marie Curie worked on radioactivity were the obvious choices. Bose came to know Paul Langevin and, with Langevin's letter of introduction, went to see Curie. "She greeted me affectionately," wrote Bose, "and said that there was no way she could disregard a recommendation from such a person. You will certainly get an opportunity to work in the laboratory, she said. But not right now, after three or four months. Get to know the language, otherwise you will find it difficult to work in the laboratory. She spoke in chaste English for about ten minutes. I had no opportunity to tell her that I knew a French of sorts. I had been at it for ten years."[9] Bose came away resigned to wait and chose to work in de Broglie's laboratory.

On 26 October, shortly after his arrival, he wrote to Einstein:

> 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 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 study 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 with you in Germany. I will be glad however if you grant me the permission to work under you, for it will mean for me the realisation 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,
>
> S N Bose (Prof.)

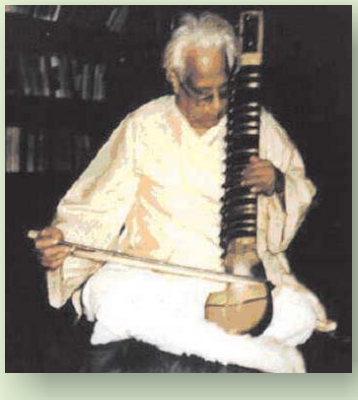


**Figure 3.** A renaissance man, S. N. Bose is seen here playing esraj. He also played flute, and even composed a raga. (Courtesy of Falguni Sarkar.)

Bose's second paper began with a critical review of the previous derivations of Planck's law (including those of Pauli and of Einstein and Ehrenfest) that, according to him, contained unnecessary assumptions. For Bose, the methods of statistical mechanics alone were sufficient to study the thermodynamic equilibrium of radiation and matter, independent of any specific mechanism of the elementary processes on which the energy exchange depended. Bose had obtained a general relation, which was valid for all special assumptions made by the previous authors about the elementary processes and their probabilities.

Einstein's reply came a week later, on 3 November:

> Most esteemed colleague!
>
> Friendly thanks for your letter of 26.10. I am happy to have the opportunity to meet you personally. Your papers have appeared already some time ago; unfortunately the offprints were sent to me instead of you. You can have them any time. I am not in agreement with your elementary law of probability for the interaction between radiation and matter, and have given the reason in a note that appeared together with your article. To wit, your law is not compatible with the following two conditions:
>
> 1. The coefficient of absorption is independent of the density of the radiation.
> 2. The behavior of an oscillator in a radiation field must result from the statistical laws as a limiting case.
>
> We can discuss this in more detail when you come here.
>
> With friendly greetings
>
> Yours

Bose took some time to reply to Einstein. He wrote on 27 January from his Paris residence that he saw a way around the difficulties pointed out by Einstein and that he had formulated his ideas in a third paper to be sent under separate cover. Bose said he had looked at the radiation field from a new standpoint by separating the propagation of the quantum of energy from any electromagnetic influence, and that he felt some such separation was necessary if quantum theory was to be brought in line with general relativity. Bose never published that third paper, and no trace of it exists in the Hebrew University's Albert Einstein Archives. It is regrettable that, either because of Einstein's critical remarks or because of the advent of new quantum mechanics, Bose's second paper also has received little attention.

Fortunately, Partha Ghose has provided an in-depth analysis of both the second and third papers.[10] Recalling a long conversation he had with Bose in December 1973 or January 1974, Ghose told me that Bose had his own approach to quantum theory based on his views about the interconnectedness of spontaneous and induced emissions, the subject matter of his second and third papers. Bose did not agree with Einstein's proposal to treat the two emissions as independent physical processes. Stationary states in atoms have zero widths in both the old and new quantum theories and therefore have infinite lifetimes. In reality, atoms decay and jump down to lower energy states with a finite lifetime.

What is the origin of the atomic widths? In Bose's view, they are a consequence of the interaction between atom and environment, as he attempted to show in his second and third papers. But Einstein did not agree and dismissed his views with the remark that in a world consisting of a single excited hydrogen atom and nothing else, the atom would obviously emit a photon and come down to its ground state. Bose, who found the remark to be sharp and cryptic, was disappointed by it simply because the world does not have only a single hydrogen atom and, inevitably, every atom does have an environment.

After spending a year in Paris, Bose went to Berlin in October 1925 and on his arrival wrote to Einstein requesting a visit. The two met, and Einstein introduced Bose to several prominent physicists, including Fritz Haber, Otto Hahn, Lise Meitner, and Walter Gordon. It was an exciting time in Berlin, the beginning of the new quantum mechanics. As Bose describes in a letter to Jacqueline Eisenmann, a young student he met while attending Langevin's lectures at the Collège de France and who became a lifelong friend,

> Everybody (every physicist) seems to be quite excited in Berlin the way things have been on with Physics. First, on the 28th October Heisenberg spoke in the colloquium about his theory, then, in the last colloquium, there was a long lecture on the recent hypothesis of the spinning electron (perhaps you have heard of it). Everybody is quite bewildered and there is going to be very soon a discussion of Schrödinger's papers. Einstein seems quite excited about it; the other day coming from the colloquium, we found him jumping, in the same compartment where we were, and forthwith he began to talk excitedly about the things we have just heard. He has to admit that it seems a tremendous thing, considering the lot of things which these new theories correlate and explain, but he is very much troubled by the unreasonableness of it all. We were all silent, but he talked almost all the time, unconscious of the interest and wonder that he is exciting in the mind of the passengers.

Einstein proposed two problems for Bose to work on: first, whether the new statistics implied a novel type of interaction between light quanta; and second, how the statistics of light quanta and transition probabilities would look in the new quantum mechanics. Apparently, Bose made no progress on either of the problems. Although he made frequent visits to the flat where Einstein lived, no record exists of their scientific conversations or of their differences concerning Bose's second and third papers. Bose never refers to those matters in his rare autobiographical sketches and articles on Einstein.

## Professor in India

Bose had to return to his university in Dacca after his two-year leave. While abroad, a professorship position had been

**Figure 4.** S. N. Bose in 1953. (Courtesy of Etienne Eisenmann.)

announced. He applied for the position with a letter of recommendation from Einstein that said

> The recent works of Mr S. N. Bose, especially his theory of radiation equilibrium, signify in my opinion an important and enduring progress of the physical theory. Also in personal discussion with Mr Bose, I have got the impression that he is a man of unusual gift and depth, from whom science has much to expect. He has also at his command an extensive knowledge and certain ability in our science. As university teacher he will certainly develop a successful and prosperous activity.

Einstein's letter and those of Langevin and de Broglie were not enough to make Bose the first choice for the position, since he had no formal doctorate degree. A year later, though, he was appointed to the professorship. Since his study leave was paid by the university, Bose felt an obligation to do something in return.

His two-year stay in Europe had been in many ways a turning point in his career as a teacher. He had realized the importance of experimental research in the advancement of science and had spent a year in France getting firsthand experience working in the laboratories of de Broglie and Curie. So, on his return he occupied himself with experimental work, designing and building his own equipment to set up an x-ray crystallography laboratory. He also became interested in chemistry; the first two papers he published after his return were in that field. Scientifically, he devoted himself almost exclusively to teaching and to guiding his students' research. He also held administrative positions as department head, dean of the Faculty of Science, and provost. He left Dacca in 1945 and returned to the University of Calcutta as the Khaira Professor of Physics. He published on a variety of subjects and disciplines. Then, in 1953–54, within a span of less than a year, he wrote some five papers, mostly mathematical in nature, on Einstein's unified theory. After retiring from active teaching in 1955, Bose continued to live in Calcutta. He was one of the last survivors among the brilliant young men who had entered the university some 40 years earlier.

Noted Einstein scholar John Stachel interviewed Eisenmann in 1994, and she gave him copies of some letters she had preserved. The last one Bose wrote was on 10 January 1974, just a month or so before his death:

> Dearest Jacqueline,
>
> Perhaps this letter will reach you after the rejoicings are over after your birthday anniversary. But you will excuse me this tardiness remembering my failings as an old man who has almost lost his eye sight—and has to depend upon others for almost every little thing. This year the university is sponsor to a conference on Statistical Physics, and they have graciously termed it a 50 yr anniversary of Bose-Statistics. I try to attend their Setting, and a few foreign scientists have chosen to come so far—
>
> Hope this finds you in the best of health, and may you be long with us and your dear ones.
>
> Love, Yours Bose

Throughout his life, Bose remained loyal and grateful to Einstein (figure 4) for his accepting Bose's short paper and making it known in the scientific world. He had unbounded admiration for Einstein's scientific achievements. Bose called Einstein the champion of the oppressed Jews and deplored the anti-Semitism that drove him from his native land. He wrote to Einstein on 9 December 1945,[11]

> As one who owes much to you and your guidance in life, I have always been anxious to have news about you, especially under the new conditions when you are in a new country. Some of my friends who are more lucky than me, had chances to visit the States recently, and had the good fortune of seeing you in your new house. I am glad to know that you are well, and still take a lot of interest in India and Indians.

In the 1950s, Bose tried unsuccessfully to obtain a visa to visit the US and particularly to meet with Einstein.

For most of his life, other than a few instances in informal discussions, he kept his disagreements with Einstein secret. But, according to Ghose, Bose did nurse a hurt feeling for not having had his "Master's" full blessings for some of his other ideas. In an April 2005 talk delivered at Dhaka University, Ghose reported that he was privy to some of those ideas.

> On one occasion he [Bose] told me he was going to confide something in me which I must never disclose. I admit I am therefore breaking his trust in making the story public, only because I think the story must be recorded for the sake of history. Moreover, I found later on that the essential idea was already in print as far back as 1931 in a paper of C. V. Raman and S. Bhagavantam.[12] I now wonder if Professor Bose knew about this paper at all, or had clean forgotten about it.
>
> Anyway, he got up and closed all the doors and windows so that nobody could hear what he was about to tell me. Then he started to explain to me in a low voice how in his derivation of Planck's formula he got the first factor $4\pi\nu^2/c^3$ instead of $8\pi\nu^2/c^3$ as required, and that he had proposed in his paper that this [additional] factor of 2 could come from the photon having a spin of one unit, which could be either parallel or antiparallel to its direction of propagation. But he said to me in Bengali with a sad smile, "The old man crossed it out!"
>
> Einstein apparently replaced it by the statement that this factor came from the two states of polar-

ization of light. There was no need to talk about the photon spin at that stage, was probably Einstein's stand. And then he went on to remark with a dismissive smile, "What on earth can the polarization of a particle mean?" I was shocked. I asked [Bose] why he had not pointed this out to Einstein when photon spin was eventually discovered. Einstein would have surely stood by your priority, I remonstrated with him. "How does it matter who discovered it? It's been found, hasn't it?" was his reply, again in Bengali, with a sense of satisfaction. That was Satyen Bose.

Bose's achievements in scientific research were not as sustained or as numerous as those of his contemporaries Saha, Raman, and Kariamanikkam Krishnan. After his great initial success, Bose fell into the trap of being a perfectionist; he published only worthwhile ideas, never kept notes, and lectured by memory. Many of his ideas ended up in students' theses.

He was, however, a towering figure in many other ways. With his love for stimulating conversations, his wide-ranging interests in all human endeavors, and his intellectual fervor, he was a source of inspiration for many who were outside physics. He was politically active throughout his life and served on many committees to further the scientific and industrial development of India after independence. Politically, the partition of India in 1947 had a profound effect on him. He felt disillusioned—India was free, but mutilated. He became a fervent Bengali nationalist and, following the lead of Tagore, he started a crusade of writing and teaching in Bengali. To summarize in the words of Ghose's Dhaka talk, "Bose was indeed a unique confluence of intellectual brilliance, encyclopedic knowledge, selfless dedication to the motherland, and unbounded compassion and love for fellow beings. He was a renaissance figure and a quintessential Bengali."

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