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ARTICLE

"Self-questioning": The scientific autobiography of Amal Kumar Raychaudhuri

Arnab Rai Choudhuri[1]

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Abstract
Amal Kumar Raychaudhuri formulated the Raychaudhuri equation (Phys Rev 98(4):1123–1126, 1955a), a landmark in general relativity and arguably the most impactful physics work done from India in the quarter century after Indian independence. His 1955 paper received 195 citations even during the recent five-year period, from 2020 to 2024. Raychaudhuri wrote a scientific autobiography in Bengali describing the very difficult circumstances under which he did his famous work. The purpose of this paper is to present an annotated translation of this autobiography (Sect. 2) and to put it in the proper historical context with an introduction and concluding remarks. Raychaudhuri obtained his famous result when working as a Research Officer at the Indian Association for the Cultivation of Science (IACS) in Calcutta in the 1950s. M.N. Saha, the Director of IACS, urged the young Raychaudhuri to align his research interests with those of some existing group and discouraged him from working on general relativity independently. Even Raychaudhuri's job confirmation letter stipulated the humiliating criterion that he was required to "work on problems to be suggested by the Director and the Head of the Department". Raychaudhuri accuses both M.N. Saha and S.N. Bose, the two towering figures in the physics world of Calcutta at that time, of failing to provide the right kind of leadership needed for the growth of physics in Calcutta.

Keywords Raychaudhuri equation · General relativity · Cosmology · Singularity theorems · Indian Association for the Cultivation of Science · M.N. Saha · S.N. Bose

1 Translator's introduction

The derivation by Amal Kumar Raychaudhuri[1](1923–2005, Fig. 1) of what is now known as the Raychaudhuri equation was a landmark in the development of general relativity. This work appeared in a paper titled "Relativistic cosmology I" (Raychaudhuri, 1955a) and became a part of Raychaudhuri's doctoral dissertation. The Raychaudhuri equation turned out to be the starting point for proving singularity theorems in general relativity by Hawking and Penrose a few years later. One of the examiners of Raychaudhuri's doctoral dissertation was John Wheeler, a professor at Princeton University, who was the supervisor of Richard Feynman. Wheeler wrote in his report on the dissertation: "He has given an answer to the most outstanding problem in relativistic cosmology." In a review of cosmological models, Ellis (1984, Sect. 2.2) has written: "The standard results rest on three pillars: the conservation equations, the Raychaudhuri equation, and the energy conditions." The Raychaudhuri equation was arguably the most significant contribution to physics made from India during the quarter-century after Indian independence in 1947.

Accounts of Raychaudhuri's life and science have been given by Narlikar (2006), Ehlers (2006) and Majumdar (2020). The physics behind the Raychaudhuri equation is discussed by Kar and Sengupta (2007), whereas Raychaudhuri (2007a) provides an account of the scientific questions that motivated him to undertake his famous work. *General Relativity and Gravitation*, the leading international journal in this field, has a series known as *Golden Oldies* in which historically important early papers on general relativity have been identified and reprinted. When Raychaudhuri's paper was reprinted in this series as Raychaudhuri (2000), Earman wrote an 'Editor's note' (Earman, 2000) discussing the significance of this work, with an Appendix by Raychaudhuri

[1] In some of his publications including his paper on the derivation of the Raychaudhuri equation, his name is given as 'Amalkumar Raychaudhuri'.

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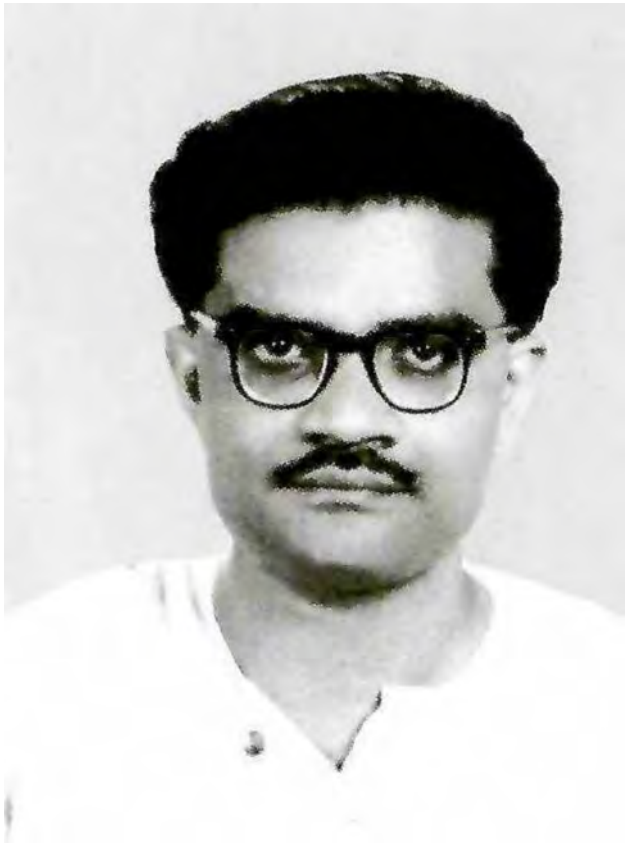


Fig. 1 The young A.K. Raychaudhuri, photographed around the time his famous paper was written

giving the publication history of the paper. Readers are also referred to the documentary on Raychaudhuri, produced by the Inter-University Centre for Astronomy and Astrophysics (IUCAA) in collaboration with Vigyan Prasar, based on a videographed interview of Raychaudhuri recorded just two months before his passing away.[2]

Raychaudhuri wrote a brief scientific autobiography in Bengali describing the very difficult circumstances under which his famous work was done (a representative manuscript page is shown in Fig. 2). This was published posthumously in a volume of Raychaudhuri's miscellaneous writings titled *Atmajijnasa O Anyanya Rachana* (Raychaudhuri, 2007b, pp. 1–29). A translation of Raychaudhuri's text is provided in Sect. 2, making it available to a wider circle of readers for the first time. An account of how one of the most important scientific works from post-Independence India was done is certainly of immense historical value. We now highlight a second reason for the importance of this unique document.

In the 1920s, when quantum theory was leading to quantum mechanics, three very important contributions to this new physics came from India: Saha ionization equation in 1920, Bose (-Einstein) statistics in 1924, and the Raman effect in 1928. The three discoverers, Meghnad Saha, Satyendra Nath Bose, and Chandrasekhar Venkata Raman, had all been faculty members in the Physics Department of Calcutta University, which was newly established in 1916. Given the fact that nearly all important works pertaining to the new physics in that era came from a limited region of Western Europe, it is truly exceptional that three such major discoveries were made in a distant, impoverished colony like India with no previous tradition of research in modern physics (Choudhuri, 2024a, 2024b). This brilliant era of Indian physics, however, did not last long. Raychaudhuri was an undergraduate student in Calcutta, the cradle of modern physics in India, barely a decade after the first Nobel Prize given for a scientific work done in Asia came to Calcutta (to Raman in 1930). In an unpublished manuscript (private communication: Subinay Dasgupta), Raychaudhuri wrote: "The present writer passed out of the University in 1944. I remember how those who were a few years senior discouraged me from taking up research. The feeling was that one should take up any job whatsoever that he may be able to get, rather than enter into a field where prospects were simply dismal. To make matters worse, an idea circulated that scientific research is the business of supermen like Bose and Saha, and an ordinary Indian should not be foolish enough to aspire to anything worthwhile. Strangely, neither Bose nor Saha did anything to counter such absurd ideas – I wonder whether they actually relished it!" How did the mood of the scientific community in Calcutta change so much so suddenly? This question has broader implications for the history of science. The transmission of European science to very different kinds of societies around the world has been a subject of considerable interest to historians of science (Basalla, 1967; Choudhuri, 1985). In this case, we encounter a peculiar situation. A few individuals from a community without a prior scientific tradition suddenly reached the pinnacle of scientific glory. However, instead of leading to the establishment of a new strong tradition in physics, this brilliant era ended almost as abruptly as it had begun. An analysis of the decline of the physics community in Calcutta provides important insights into the challenges of establishing a new scientific tradition in a society that lacked a previously established tradition. The scientific autobiography of Raychaudhuri, indisputably the most important physicist to emerge from Calcutta in the next generation, provides a firsthand account of the physics community in Calcutta during that era of rapid decline.

One can identify some external causes behind this decline fairly easily. The Indian freedom struggle entered a new, intense phase in 1921 with the launch of the non-cooperation

[2] This documentary is available at the website https://www.youtube.com/watch?v=i9_hm2qe34s.

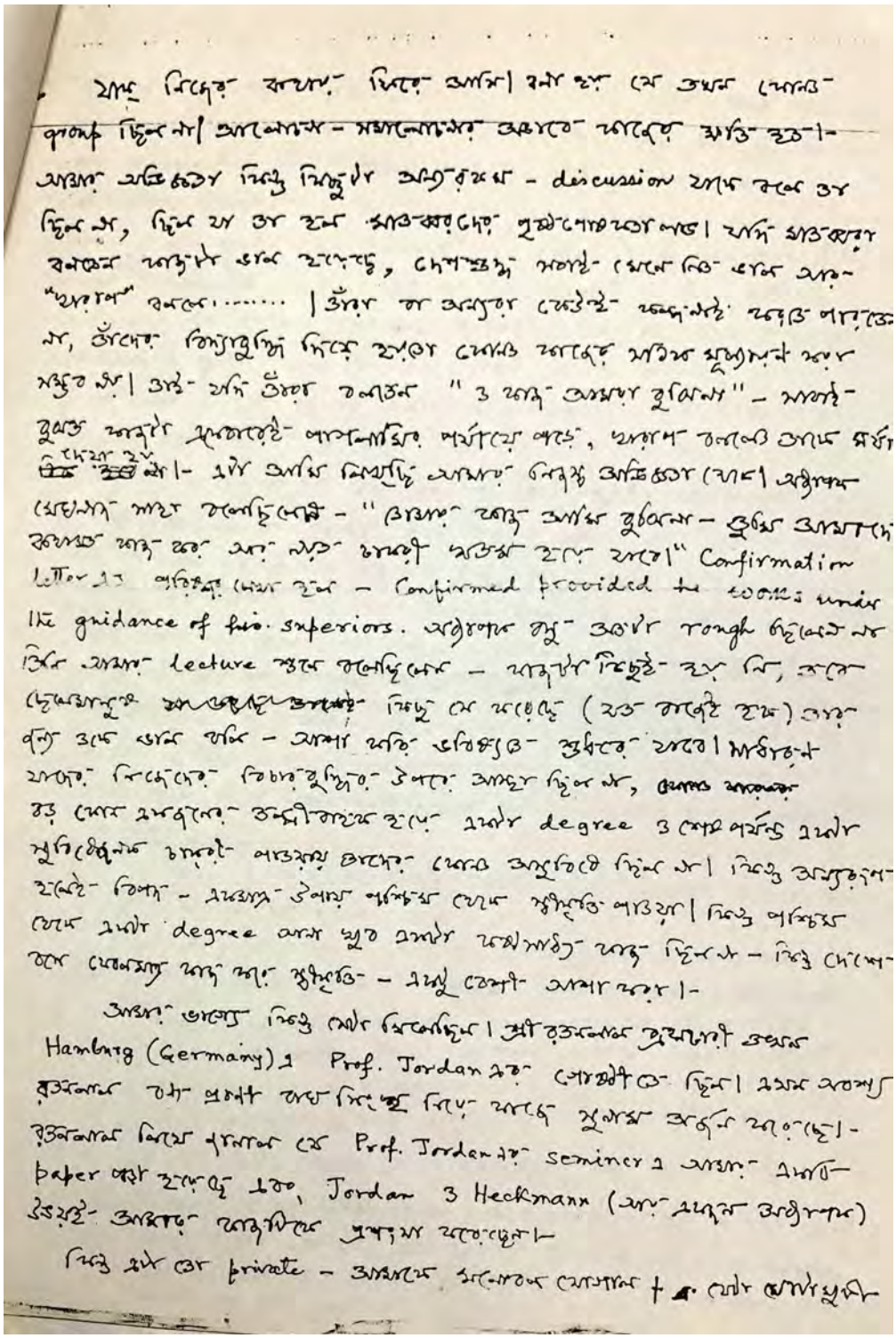


Fig. 2 A representative page from the manuscript of the scientific autobiography in Raychaudhuri's handwriting. *Credit* Parongama Sen

movement by Gandhi, exactly when the Physics Department of Calcutta University was gaining international visibility. The colonial government realised that many professors and students of Calcutta University were sympathetic to the freedom movement. To punish the University, government funds were cut drastically, leading to the non-payment of many faculty salaries for several months. Many famous professors of Calcutta University started leaving for other jobs.

Bose left for Dacca University in 1921 (Bose's famous work was done from Dacca) and Saha for Allahabad University in 1923. Both Bose and Saha eventually returned to Calcutta University in 1945 and 1938, respectively. By that time, Raman had left Calcutta (in 1933) to take up the Directorship of the Indian Institute of Science in Bangalore. When the young Raychaudhuri was a budding physicist, Bose and Saha were the towering figures in the physics community of Calcutta. Raychaudhuri has vividly described his negative interactions with both of them. While acknowledging the intellectual brilliance of Bose and Saha, Raychaudhuri has accused both of them—especially Saha—of failing to provide the right kind of leadership for the intellectual growth of the next generation of physicists. After presenting Raychaudhuri's text in Sect. 2, we shall make some more comments in Sect. 3 on Raychaudhuri's accusations against Bose and Saha.

Raychaudhuri spent several crucial years of his youth (1944–1949, 1952–1961) at the Indian Association for the Cultivation of Science (abbreviated as IACS). Most of the events described in the scientific autobiography took place at IACS. This organization was established by Mahendra Lal Sircar in 1876 and is the oldest scientific research institute of India.[3] The Raman effect was discovered in the laboratory of this institute. In 1961, Raychaudhuri left IACS to join Presidency College, which had been the most famous undergraduate college in Calcutta for many decades. Both Bose and Saha had been undergraduate students at this college—in fact, they were classmates. Teaching at Presidency College for nearly a quarter of a century, Raychaudhuri became known as a legendary physics teacher. A disproportionately large fraction of today's leading Indian physicists, belonging to the age group of 55–80, would say that they were inspired by Raychaudhuri's teaching to take up physics as a profession. Perhaps the best way of forming an idea of Raychaudhuri's brilliant teaching style is to look at the book (Raychaudhuri, 1983) based on his lectures on classical mechanics given to the MSc class, which were written down almost verbatim by two students in the class: Sumit Das and Palash Pal. I had the good fortune of being taught by Raychaudhuri at Presidency College. I was also lucky to hear about many of the incidents described in this autobiography from Raychaudhuri himself. Once, he described his struggles as a young researcher to three or four students of our class (this must have happened around 1976–1977). Some of us urged him to write down an account of his struggles. He said that he described his experiences to us because he felt that the next generation should know about these things, but he would never write an account of them, as it would be inappropriate for him to do so.

While reading this scientific autobiography, readers should keep in mind that for a very long time, Raychaudhuri was unwilling to write down his experiences. This autobiography was written in 11 days (May 25–June 4, 2002), when Raychaudhuri was 79 years old and recovering from a serious illness, with the first part written from his hospital bed. Raychaudhuri was interested in getting this scientific autobiography published in the reputed Bengali magazine *Desh*, which declined to publish it (private communication: Parongama Sen).

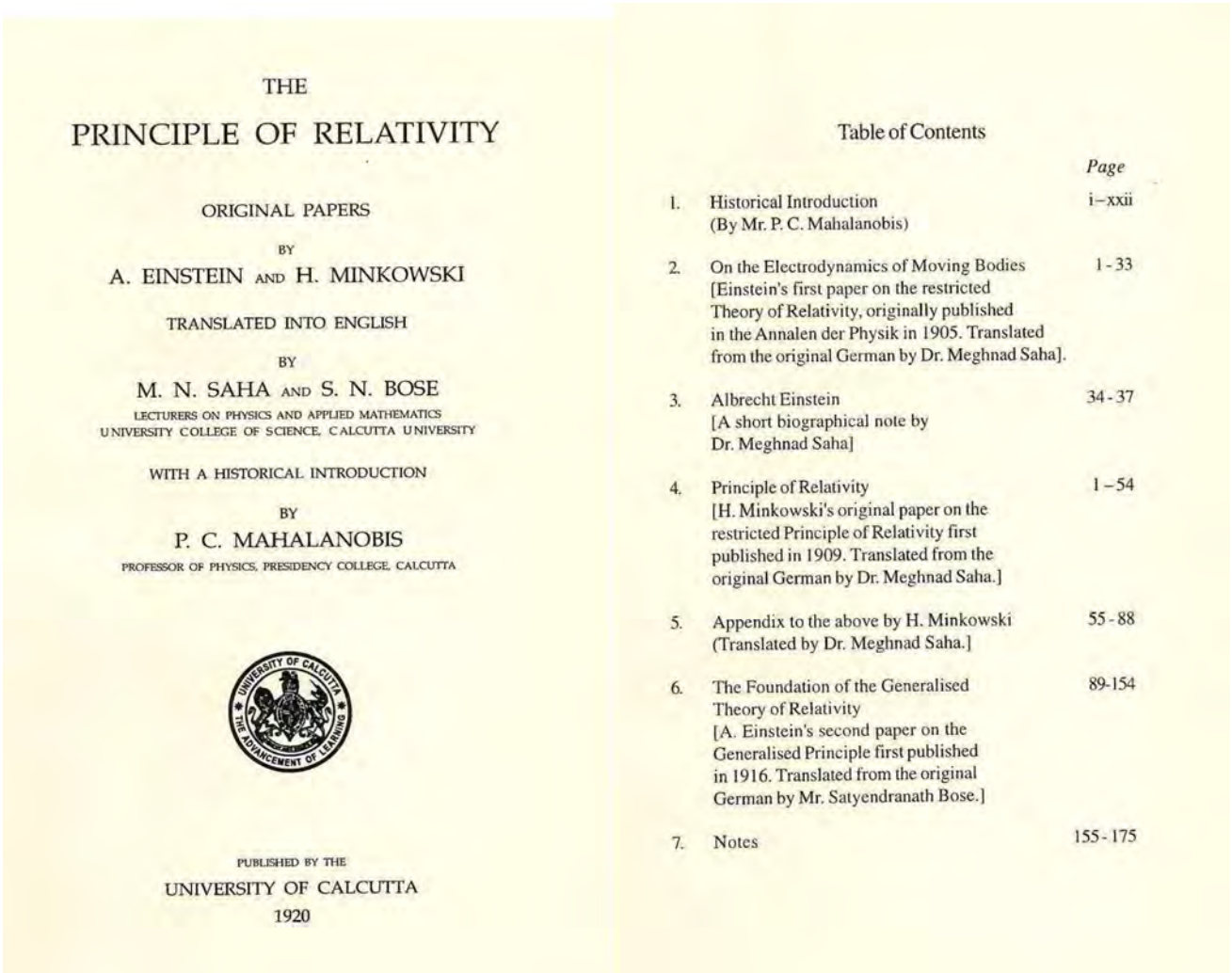
Although Raychaudhuri lived for three more years after writing this scientific autobiography, it was not published during his lifetime. His family decided to publish it 2 years after his death, i.e. about 5 years after its composition. Raychaudhuri's frank opinions on several matters are expressed in a rather raw form in many places in this document. Since Raychaudhuri's public writings and speeches were always reasonably restrained, it was almost a shock for me when I read some parts of this autobiography for the first time and realised that, at last, when Raychaudhuri felt that he might not live much longer, he had the urge to write down his experiences for posterity. Although I have deleted some materials on non-scientific topics in my translation, I have retained everything pertaining to science in Raychaudhuri's autobiography. I must confess that I felt somewhat awkward translating certain passages and was almost tempted to delete them. I knew that taking such liberties with a historically important document would be unpardonable, and I refrained from doing so. In those places where I disagreed with the opinions expressed by Raychaudhuri, I was particularly careful to ensure that my translation conveyed the sense of the original text faithfully.

Some of the lesser-known persons appearing in this autobiography are Kedareswar Banerjee, Nikhil Ranjan Sen, Debidas Basu, and Priyadaranjan Ray. Readers interested in learning more about them may consult their biographical memoirs, written by Banerjee and Sen (1975), Burman (1963), Mukherjee (2009), and Chatterjee and Banerjea (1982), respectively. More detailed biographies of Kedareswar Banerjee and Nikhil Ranjan Sen have been written by Singh (1921) and Singh and Roy (2021), respectively. Since Raychaudhuri (Amal-babu to us) often followed the Bengali custom of referring to a gentleman by adding 'babu' at the end of his first name (such as Debidas-babu), I have followed this in the translation. It will be seen from Raychaudhuri's autobiographical account that Debidas Basu, who was the Head of the Theoretical Physics Department, made Raychaudhuri's life particularly difficult. Readers should keep in mind that in many Indian organisations of that time, a Head of the Department often had almost dictatorial power over the department's members. A faculty member could

[3] A history of IACS was compiled on the occasion of the centenary of IACS: *A Century* (1976), published by Indian Association for the Cultivation of Science.

not even submit a paper to a journal without the permission of the Head. Debidas Basu, who was only 6 years older than Raychaudhuri, was Saha's protégé, having worked as Palit Scholar under Saha's supervision when he published a joint paper with Saha in *Indian Journal of Physics* (Saha & Basu, 1945).

Some of the problems which Raychaudhuri faced were caused by his working alone on general relativity. It seemed that nobody in Calcutta understood his work or its significance. Although general relativity was formulated by Einstein in 1916, it stood in majestic isolation for about half a century, almost disconnected from the rest of physics. Till the 1960s, it was very unusual for a typical professional physicist to know general relativity at a technical level. It may be worthwhile to make a few comments regarding the awareness of general relativity in the physics community of Calcutta at the time when Raychaudhuri worked alone on this subject. Curiously, the awareness about general relativity within the physics community of Calcutta at that time might actually have been higher than what would be the awareness about it within most other physics communities around the world! Saha and Bose (1920) prepared the first English translation of some of Einstein's papers on relativity. Figure 3 shows the title page and the Table of Contents of the book, which was published by the University of Calcutta Press in 1920. The widely used translation of the papers on relativity by W. Perret and G.B. Jeffery (Lorentz et al., 1923) appeared only in 1923. It is interesting to note in the Table of Contents shown in Fig. 3 that the first name of Einstein was given as 'Albrecht' rather than 'Albert'! Einstein's papers normally would give the author's name as 'A. Einstein'. Clearly, this first translation of Einstein's papers on relativity was done at a time when Einstein's name had not yet become a household name, and even the translators did not correctly know his first name. The foundational paper on general relativity was translated by S.N. Bose, who clearly understood



THE

PRINCIPLE OF RELATIVITY

ORIGINAL PAPERS

BY

A. EINSTEIN AND H. MINKOWSKI

TRANSLATED INTO ENGLISH

BY

M. N. SAHA AND S. N. BOSE

LECTURERS ON PHYSICS AND APPLIED MATHEMATICS
UNIVERSITY COLLEGE OF SCIENCE, CALCUTTA UNIVERSITY

WITH A HISTORICAL INTRODUCTION

BY

P. C. MAHALANOBIS

PROFESSOR OF PHYSICS, PRESIDENCY COLLEGE, CALCUTTA

PUBLISHED BY THE
UNIVERSITY OF CALCUTTA
1920

Table of Contents

Fig. 3 The title page of the book presenting translations of some of the important papers on relativity along with the Table of Contents

general relativity at a technical level. M.N. Saha, who translated the paper on special relativity, probably never learned general relativity at a technical level. However, he clearly had an interest in the subject. Soon after the famous eclipse expedition of Eddington provided the first experimental proof of general relativity, Saha (1920a) wrote a popular account of it for the magazine *Calcutta Review*.

D.M. Bose, who was the Rashbehari Ghosh Professor of Physics at Calcutta University and was a Senior Colleague of S.N. Bose and M.N. Saha, was a student in Berlin exactly when Einstein was formulating general relativity (Roy & Singh, 2017) and took a course on relativity theory in 1914 taught by Einstein himself (we do not know whether the course included some initial ideas of general relativity). Figure 4 shows D.M. Bose's course registration book with Einstein's signature. A few years later, Nikhil Ranjan Sen (Fig. 5) obtained his PhD from Berlin, working on general relativity under the supervision of Max von Laue, a remarkably versatile physicist who received the Nobel Prize for his pioneering work in X-ray crystallography. We shall see in Raychaudhuri's autobiography that he had some interactions with Sen which were not too fruitful, although he always respected Sen for his scholarship. We have already mentioned the *Golden Oldies* series of reprints published in the journal *General Relativity and Gravitation*. Two papers published from Calcutta in the 1930s are included in this highly exclusive *Golden Oldies* series: one by N.R. Sen (1934) and the other by B. Datt (1938), reprinted as Sen (1997) and Datt (1999), respectively. Virtually nothing is known about Datt,

Fig. 5 Nikhil Ranjan Sen (1894–1963), pioneer of general relativity research in India, with whom Raychaudhuri interacted in the early years of his research career

who gave his address as Presidency College, where Raychaudhuri worked for many years in later life. It is believed that Datt died at a very young age, soon after writing this paper. Given this background, the difficulties Raychaudhuri faced in his early career cannot be simplistically explained away as due to a lack of awareness and knowledge about general relativity within the physics community of Calcutta.

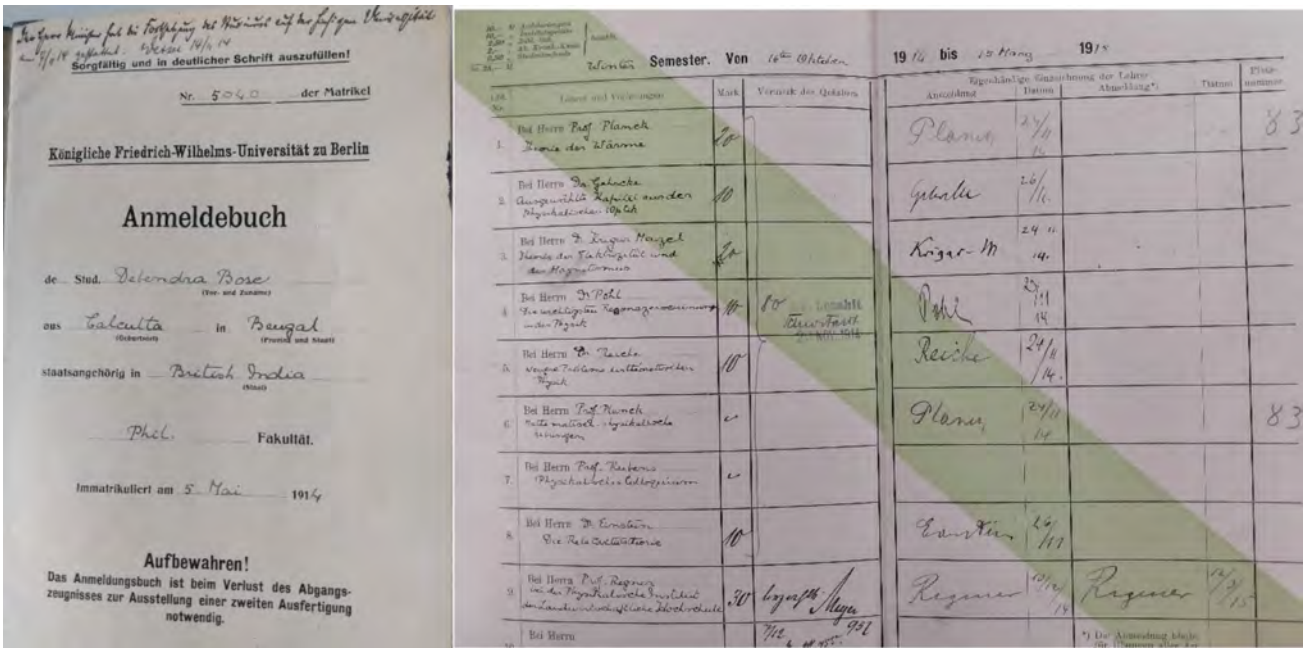


Fig. 4 D.M. Bose's course registration book. Among the courses he took in 1914 were 'Theorie der Wärme' (theory of heat) taught by Plank (line 1), and 'Die Relavitatstheorie' (the relativity theory) taught by Einstein (line 8). Signatures of Plank and Einstein can be seen. *Credit* Humboldt University Archive

It may be worthwhile to comment on the status of general relativity research in the rest of India. Vishnu Vasudev Narlikar, who greatly distinguished himself as a student at Cambridge, was invited by Madan Mohan Malaviya, the founder of Banaras Hindu University, to start a general relativity group there as early as 1932 (Narlikar, 2015; Vaidya, 1992). His student Prahlad Chunilal Vaidya obtained the metric corresponding to the gravitational field of a radiating star, now known as the Vaidya metric (Vaidya, 1943). This work was also done under difficult circumstances, as described by Vaidya in his scientific memoir (Vaidya, 1997). It may be noted that Vaidya also featured in the *Golden Oldies* series of *General Relativity and Gravitation* (Vaidya, 1999), with three of his classic papers reprinted together (Vaidya, 1943, 1951, 1953).

I now present the translation of Raychaudhuri's scientific autobiography, *Atmajijnasa,* in Sect. 2, after which I shall again make some more comments on it in Sect. 3.

2 Translation of Raychaudhuri's text *Atmajijnasa*

2.1 25th May, 2002

I am writing from bed # 9 in the ICCU of Calcutta Medical College. I have been admitted here on the 22nd, presumably in a fairly serious condition. I am given to understand that my condition was even considered life-threatening.

I have never been hospitalised before. I now find that the experience of staying in a hospital can be pretty interesting, if the physical pain is not overwhelming. Doctors, sisters, ward boys and girls, patients—they together give rise to a curious ambience. Visitors of patients add colour to that. I am not a writer, and I feel that writing about anybody's personal life would be improper. However, many patients around me have shown eagerness to talk about themselves. Since I have not encouraged them much, it is unlikely that an account of my hospital experience would result in an essay of high literary merit.

I am thinking about my own future. An air conditioner has been installed at home for my comfort. Apart from the several thousand rupees already spent on fixing it, the monthly electricity bill is likely to increase by about a thousand rupees. I do not grudge it. Money is meant to be spent, and I can afford it. I hope that my children will not face financial hardships in the future, and in case they do, my limited savings will not be enough to solve their problems.

Anyway, considerations of money play an insignificant role in my thoughts about the future. I believe that my mental power still has not deteriorated much, given the fact that my mental power was never of very high order. What I had is this:

A very high degree of common sense to feel that I know little – indeed very little. However, within this limitation, I felt strong enough to stand against anybody in the world.

2.2 26th May, 2002

Today Shankar[4] will return from ICTP.[5] If he reaches Calcutta in the morning, he is likely to visit me in the afternoon. He is a fine boy.

Perhaps many people think that I had some hand behind Shankar's success as a physicist—at least he has got some inspiration from me. But that is completely untrue—he alone is responsible for what he achieved, although I feel proud of having such a nephew.

Let me get back to what I was writing yesterday. Perhaps it is not possible to make a real breakthrough in theoretical physics if one has a limited understanding of the subject and is handicapped by not knowing sufficient mathematics. I have not succeeded in making a breakthrough. Perhaps the maximum that a person with such limitations can provide are occasional flashes of insight. Since I have been able to do that, perhaps it can be said that I have been successful in research with my very serious limitations. I sometimes wonder whether Professor Satyendra Nath Bose also faced a similar limitation, which prevented him from undertaking any other significant work beyond his famous one.

But his fans have created an image of him that he was not an ordinary scientist—he was like Einstein. He was a seer who was expected only to make occasional profound utterances. The paucity of research output was natural for somebody like him.

However, Bose had a considerable command over mathematics of his time, and that enabled him to do some significant work on Einstein's equations of the unified field theory. But his forays into subjects like chemistry only indicate the tragedy of a very talented person.

Let me come to my own saga. It is often said that there were no proper physics research groups in Calcutta during my younger days, and the lack of constructive criticism hindered the scientific growth of young persons. My own perception is somewhat different—while there were no proper scientific discussions, what existed in their place were pronouncements from important persons. If an important person declared a young scientist's work to be good, the scientific community uncritically accepted the work to be good. On the other hand, if the important person considered the work

[4] 'Shankar' is the informal name of Raychaudhuri's nephew Amitava Raychaudhuri, a particle physicist, who was the Palit Professor of Physics at Calcutta University.

[5] ICTP is the acronym of the Abdus Salam International Centre for Theoretical Physics, located in Trieste, Italy.

to be worthless, then ... These important persons and their admirers would not admit the possibility of the important person not being able to judge some work outside his area of expertise. On the rare occasion when an important person said "I do not understand this work"—it was taken to imply that the work was nonsensical, for which even "bad" was not an appropriate adjective. I am writing this based on my own experience. Professor Meghnad Saha had told me: "I do not understand your research. You have to do the kind of research that we approve if you want to retain your job here." My confirmation letter (Fig. 6) stated: "confirmed, provided he works under the guidance of his superiors." Professor Bose would not go to such extremes. After listening to my lecture on my work, he commented: "Although

PHONE: P. K. 2726 & 3943
GRAM: INDASSON, JADAVPUR

INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE

From—SRI S. N. SEN, M. Sc.
REGISTRAR.

JADAVPUR,
CALCUTTA - 32.

In reply please quote I.2/110

April 29, 1954.

Sri Amal Kumar Ray Chaudhuri,
Research Officer,
Dept. of Theoretical Physics,
I.A.C.S., Jadavpur.

Dear Sir,

I am to inform you that the Council at its meeting held on March 29, 1954 has been pleased to confirm you in your post as Research Officer to the department of Theoretical Physics with effect from 15.9.53 on condition that you should continue to work on problems to be suggested by the Director and the Head of the Department.

The receipt of the letter may kindly be acknowledged.

Yours faithfully,

S. N. SEN
REGISTRAR

Fig. 6 The confirmation letter of Raychaudhuri from IACS administration. It may be noted that the letter was signed by S.N. Sen, a pioneer of history of science research in India, who was the Registrar of IACS when Raychaudhuri was working there. *Credit* Parongama Sen

this work is not of any value, we should encourage a young person who is trying to do something – perhaps he will eventually learn to do good research." Those who did not have much faith in their own understanding or judgment would often blindly obey a senior person, taking the easy path of obtaining a PhD and eventually a job. The problem arose for those who dared to be different. The only option for them was recognition from the West. While some went to the West to obtain a degree, it was challenging to get the recognition from the West for a work done in India.

I am lucky that my work got some recognition from the West. Dr. Ratanlal Brahmachari was working at that time in Prof. Jordan's group in Hamburg (Germany). Afterwards, he left physics to become an expert on wildlife. He wrote to me in a letter that my paper was discussed in the seminar in Prof. Jordan's group. Both Jordan and Heckmann[6] (another professor in the group) expressed their high opinion about the paper.

This was a private communication that provided me with a moral boost. The first official recognition came when Prof. John Wheeler sent his report on my DSc thesis (Fig. 7). He wrote: "He has given an answer to the most outstanding problem in relativistic cosmology. If the rules allow, he should be given 'doctorate cum laude'"—a degree above the regular doctorate. Prof. N.K. Siddhanta, the Vice-Chancellor of Calcutta University at the time, read the full report in the Syndicate meeting and commented that he had rarely seen such an exceptional thesis report. He also called me to make my acquaintance and said that he could try to get me a position as a lecturer at the University if I were interested.

A few years later, I got an inkling of Prof. Satyen Bose's reaction to my international recognition. A student who had completed a PhD under my supervision asked him for a letter of recommendation. Prof. Bose asked the student to return after two or three days to pick up the letter. When the student went back to him, Prof. Bose enquired who his supervisor was. On hearing my name, Prof. Bose suddenly said: "I shall not give you a recommendation letter." I do not know the reason behind this. My guess is that Prof. Bose did not like anybody from Calcutta getting international recognition without his blessings. I hasten to add that my guess could be wrong.

Prof. Saha had already passed away by the time some international recognition started coming for me. I have no way of knowing what his reaction would have been.

A big change came to my life after I received the DSc degree. I got selected through the Public Service Commission and joined the Physics Faculty of Presidency College.

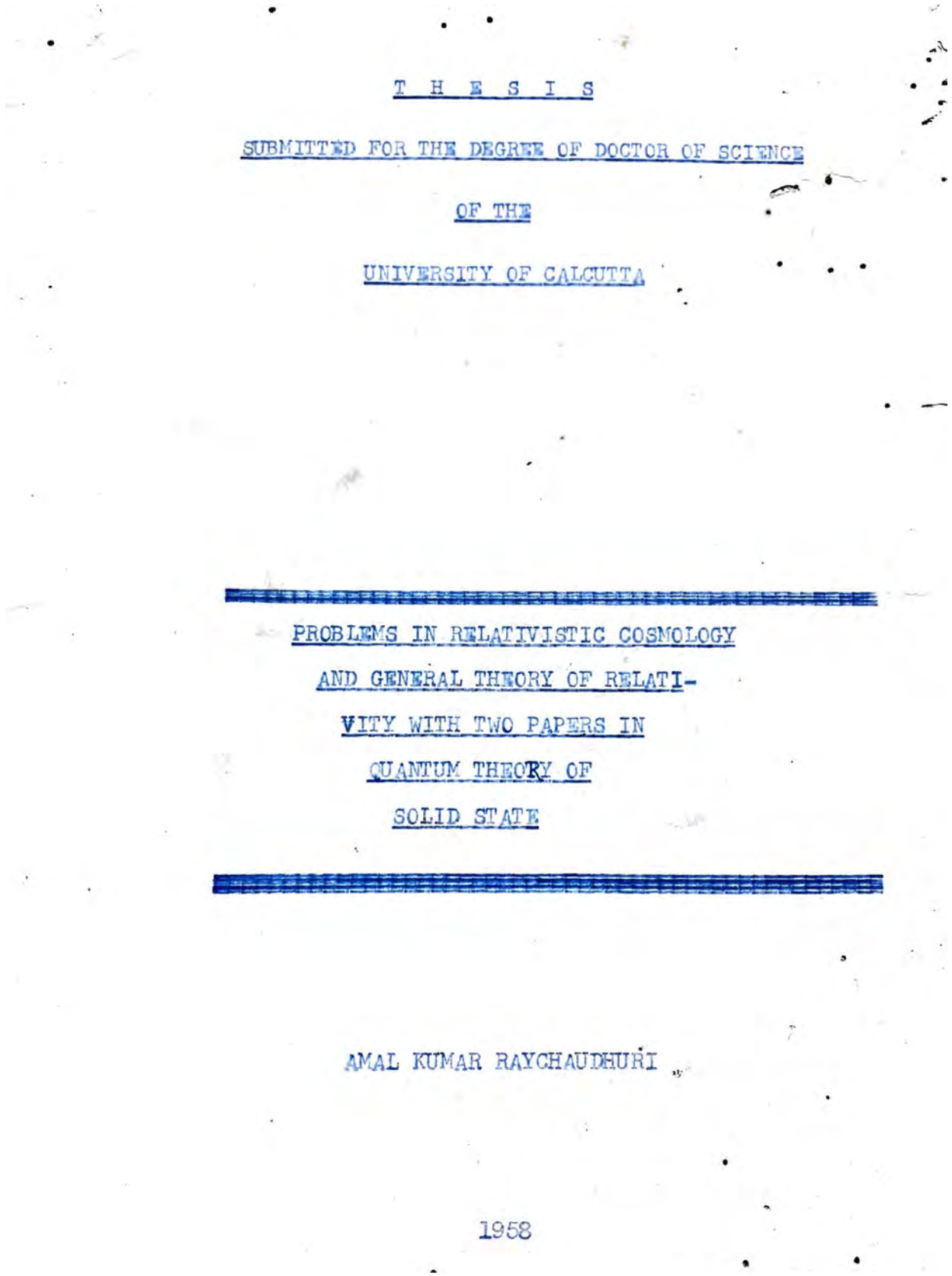
A research institute like IACS would have been a very coveted place for a young researcher. However, a powerful lobby there had been excessively kind to me and tried to make my tenure there as unbearable as possible. It is true that the Director of that time was sympathetic to me, but it was not possible for him to overcome the demands of "democracy" as well as technical rules and regulations. When I think of my experience at that time, I sometimes wonder if a good dictator can better serve the cause. However, I would not agree with this under normal circumstances.

One big question arises from my experience of that time—how much freedom should be given to researchers within an organisation, and how much control should be exerted from the top. When Professor Saha wanted to take away my freedom, my blood boiled. But I could not afford to lose my job and accepted slavery like a dog—I sold myself for a mass of pottage. A considerable amount of time has passed since then. Still, when I think of those days, my blood pressure goes up and I feel like shouting at the top of my voice that taking away the freedom of a researcher is as grave an offence as taking away the freedom of a nation. I recall that when British rulers presented various arguments against granting freedom to India, Gandhi once said, "Leave us to anarchy"—perhaps even anarchy is preferable to the loss of freedom.

I have to admit that I understand the problems associated with too much freedom. I have come across researchers who cannot distinguish between complete madness and genuine research. I once asked a recently retired professor of Calcutta University what he planned to do after retirement. He replied that he was planning to write a book to demonstrate that much of physics accepted at the present time is incorrect, and he would show the world how to formulate physics in a completely new way. What must have been the condition of this gentleman's brain! It is possible even for young researchers to suffer from such delusions. Should Indian taxpayers' money be used to provide complete freedom for such persons to conduct their research?

There is no doubt that a problem exists here without an easy solution. Perhaps a sympathetic science administrator ought to judge each individual case separately, setting aside their ego, and make an appropriate decision. Too much ego got in the way of a scientific genius like Professor Saha recognising the potential of a young scientist.

[6] J. Ehlers (2007), who was a student of Pascual Jordan and Otto Heckmann, has given an account of the excitement created in their group by Raychaudhuri's paper. Jordan was one of the creators of quantum mechanics, being a co-author in two of the foundational papers on the subject (Born & Jordan, 1925; Born et al., 1926). At the time when Raychaudhuri's famous paper came out, Heckmann was interested in finding solutions for spinning universe—a problem which was related to the problems Raychaudhuri studied: see Heckmann and Schücking (1958). Schücking has been credited for coining the name 'Raychaudhuri equation': see the last paragraph in Sect. 1 of Ehlers (2007) and Reference [3] thereof.


T H E S I S

SUBMITTED FOR THE DEGREE OF DOCTOR OF SCIENCE

OF THE

UNIVERSITY OF CALCUTTA

PROBLEMS IN RELATIVISTIC COSMOLOGY

AND GENERAL THEORY OF RELATI-

VITY WITH TWO PAPERS IN

QUANTUM THEORY OF

SOLID STATE

AMAL KUMAR RAYCHAUDHURI

1958

Fig. 7 The title page of the DSc Thesis of Raychaudhuri. *Credit* Parongama Sen and National S&T Digital Archive at BITM, Kolkata

2.3 27th May, 2002

[A few paragraphs dealing with Raychaudhuri's medical condition and hospitalization are deleted here.]

What am I? Should I think of myself as a scientist? I have undoubtedly practised science, and I have been lucky to receive some recognition from the scientific community. But I still hesitate to call myself a scientist. To my mind, an ideal scientist is somebody whose thoughts are always based on purely objective scientific considerations, who would never be willing to make compromises due to social pressures to choose the path of least resistance, who would be ready to accept an idea which has been logically established even if the idea is not to his liking. I have to admit that I have not succeeded in living up to this lofty ideal.

Should I then identify myself as a physics teacher? Teaching has been my profession for many years, and I am aware that I have won the appreciation and respect of the student community. However, the duty of a true teacher is not only limited to educating students in a particular academic discipline, but also to help them become complete human beings and to aid in the development of their full potential. One other factor I would like to add here: a teacher becomes a truly successful teacher only when one or two students trained by him surpass him in professional achievements. I cannot claim these things for myself. Ashoke Sen was my student only in the sense that he attended my lectures. I have not contributed to his intellectual growth in any manner. Then what am I? I am reminded of an English phrase: a jack of all trades, master of none. I have accomplished many things throughout my career, but I have excelled in none.

2.4 28th May, 2002

[Some comments on Tagore and Gandhi are omitted here.]

I have returned home from the hospital—this fills me with such hope and joy that I don't feel like writing anymore today.

2.5 29th May, 2002

[Some more comments on Tagore and Gandhi are omitted.]

How successful have I been? I estimate my professional success to be 100%. This may appear like a curious statement to many. The reason behind this assessment is that I have achieved whatever little was possible for me to achieve with my limited capability—achieving more would have been beyond me.

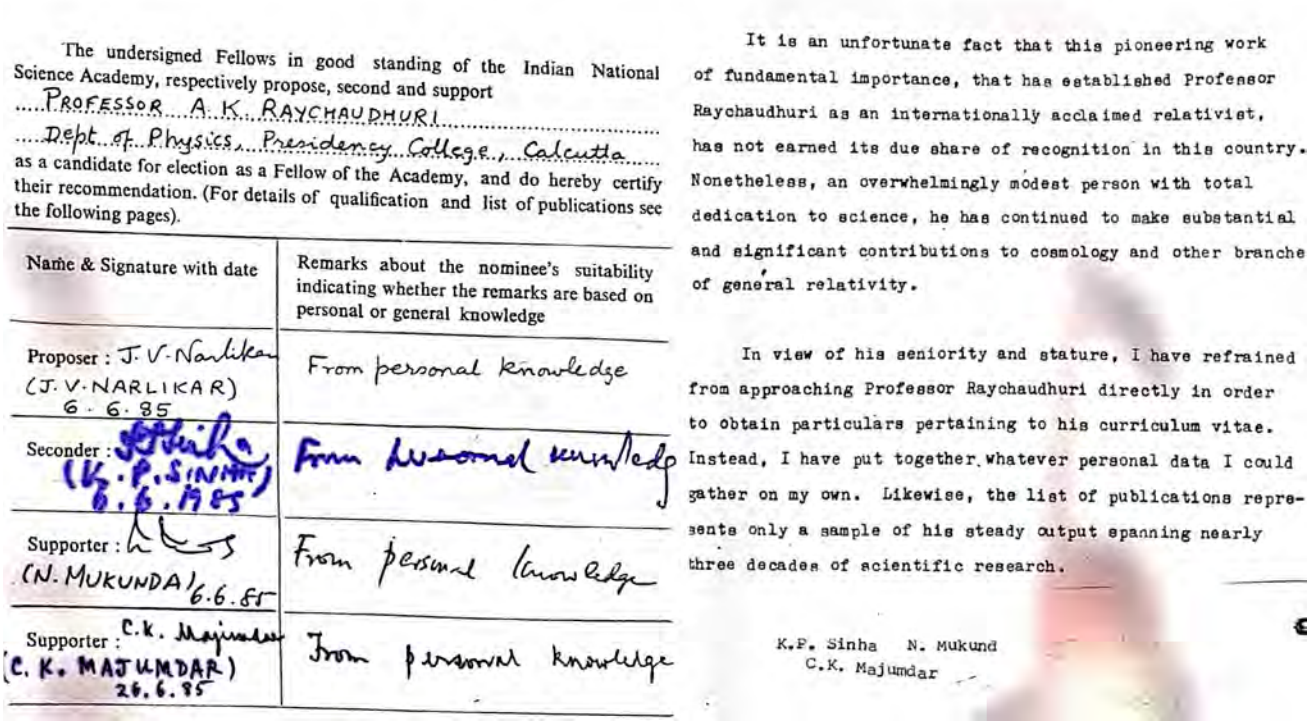
But how do I appear to others—especially to other scientists and academics in our country? This is an interesting question, to which I would like to give a somewhat detailed answer.

India happens to have three national academies of science, among which the Indian National Science Academy (abbreviated as INSA) has the highest prestige. The headquarters of this academy is in the national capital, Delhi. The second academy is located in Bangalore. The third one is in Allahabad, of which the prestige is somewhat lower. Being elected a Fellow of these academies is considered an important honour in the Indian scientific community. By electing someone a Fellow, senior members of the community recognize this person's scientific contributions to be important. The Fellow election process is as follows. After two or more Fellows nominate a person for election, a couple of committees select a few names from all the nominations. The Council of the academy then recommends some of these names, which are sent to all Fellows for approval. Unless the majority of Fellows disapprove of some name, the recommended persons are elected as Fellows. Of these steps, the last one is merely a formality. There is essentially no possibility that the majority of Fellows disapprove a name. This never happens. Essentially, a few influential persons in the Council control the whole process.

I had once made an attempt of becoming an INSA Fellow soon after receiving my DSc. I could make Professor Satyendra Nath Bose agree to nominate me. I had thought that, when somebody like him willingly or unwillingly had agreed to nominate me, I would get elected a Fellow easily. I had not realized that Bose's influence was more or less limited to Calcutta. He was not a Council member of the Delhi Academy. The two Bengali Council members were Professor Ramesh Chandra Majumdar of Delhi and Professor Kedareswar Banerjee of Calcutta. They did not consider me deserving. Afterwards, I had not shown any further interest in such elections.

After many years, when I was close to 60, Professor Ramaseshan (who first got recognition for his research under the supervision of Raman and was Raman's nephew) attended a lecture at the Royal Society in England, in which the "Raychaudhuri equation" was mentioned several times. After returning to India, he started making some enquiries: who is this Raychaudhuri? Is he Indian? Is he working in India or working abroad? He felt that a person whose name was mentioned in this manner in a lecture at the Royal Society should be honoured in an appropriate way. He is an influential member of the Bangalore Academy and was perhaps its President at that time. After certain formalities, I became a Fellow of this academy. Since I heard this account of my election from Professor Ramaseshan himself, I believe this account is correct.

My election to INSA took place somewhat differently (Fig. 8). Since I have heard the account of this from persons who were not directly involved in the election process, it is possible that this account has some inaccuracies



The undersigned Fellows in good standing of the Indian National Science Academy, respectively propose, second and support
.....PROFESSOR A.K. RAYCHAUDHURI.....
.....Dept. of Physics, Presidency College, Calcutta.....
as a candidate for election as a Fellow of the Academy, and do hereby certify their recommendation. (For details of qualification and list of publications see the following pages).

Name & Signature with date	Remarks about the nominee's suitability indicating whether the remarks are based on personal or general knowledge
Proposer : J.V. Narlikar (J.V. NARLIKAR) 6.6.85	From personal knowledge
Seconder : K.P. Sinha (K.P. SINHA) 6.6.1985	From personal knowledge
Supporter : (N. MUKUNDA) 6.6.85	From personal knowledge
Supporter : C.K. Majumdar (C. K. MAJUMDAR) 26.6.85	From personal knowledge

It is an unfortunate fact that this pioneering work of fundamental importance, that has established Professor Raychaudhuri as an internationally acclaimed relativist, has not earned its due share of recognition in this country. Nonetheless, an overwhelmingly modest person with total dedication to science, he has continued to make substantial and significant contributions to cosmology and other branche of general relativity.

In view of his seniority and stature, I have refrained from approaching Professor Raychaudhuri directly in order to obtain particulars pertaining to his curriculum vitae. Instead, I have put together whatever personal data I could gather on my own. Likewise, the list of publications represents only a sample of his steady output spanning nearly three decades of scientific research.

K.P. Sinha N. Mukund
C.K. Majumdar

Fig. 8 The first page of the INSA nomination certificate for Raychaudhuri and the last two paragraphs of the attached statement. Note that the ink signature of J.V. Narlikar at the bottom of these paragraphs is almost illegible. *Credit* Suprakash Roy and National S&T Digital Archive at BITM, Kolkata

or exaggerations. "The story should be taken with a pinch of salt." Anyway, the account I heard is as follows:

Professor M.G.K. Menon is an influential person in the scientific community of India and is one of the very few Indians who has had the honour of being elected FRS. In a meeting at INSA, he commented: "Those scientists who have crossed 60 should not be elected INSA Fellows. The non-election of a scientist till that age would indicate that this person had not achieved anything significant till that time, and the possibility of the situation changing afterwards is rather unlikely." Professor Jayant Vishnu Narlikar was present at the meeting. He said softly: "I know Professor A.K. Raychaudhuri, whose work is known in the international scientific community. He is above 60, but not a Fellow of INSA. Does Professor Menon think that even such persons do not deserve to be elected?" I do not know whether Professor Menon said anything in reply. I only know that afterwards Professor Narlikar nominated my name for the INSA Fellowship without my knowledge or consent (perhaps as a guarded challenge to Professor Menon). In due course, I was surprised to receive the information that I had been elected an INSA Fellow. Whether this account is true or not,[7] it is certainly amusing.

The total number of Fellows of these two academies runs to several hundred. The third academy is not of much consequence. Every person who is one of these hundreds of Fellows cannot obviously be regarded as an outstanding scientist. Often, persons who have somehow managed to secure high administrative positions also become Fellows. One can cite examples of Dr Basanti Dulal Nag Chaudhuri and Dr Debidas Basu. Both of them are still alive. Anybody would admit that their scientific contributions are insignificant. However, both are Fellows of different academies—due to their various extra-academic connections. As these connections enabled them to secure high positions (such as Director or advisor to a ministry), the academies had to elect them Fellows.

Out of these several hundred Fellows of these academies, only a few (perhaps 15 or 20) can be taken to be really at

[7] The INSA nomination certificate for Raychaudhuri corroborates that this account of his election to INSA was true. Figure 8 shows relevant portions of the certificate. Suprakash Roy, who obtained a copy of this certificate from INSA, deposited it to National S&T Digital Archive at Birla Industrial and Technological Museum (BITM), Kolkata.

the top. Very often, scientific contributions are not enough to reach this top, but one also needs political connections or the blessings of some famous scientists from the West. Especially, if one can bring this famous scientist to India and make him utter some praises either publicly or privately (such as in the ears of the Prime Minister), then success is guaranteed.

I completely lack these qualities outlined above. I have always tried my best to avoid ministers and political leaders. Listening to what some of them say, I often wondered how they, with such childish intellect, could become important leaders.

I do not possess the necessary qualifications to become one of the top scientists in our country, and I have not succeeded in achieving this goal. I have no regrets for that. What I value is the appreciation from active and discerning scientists in my field of specialization, which I have received. The number of capable scientists in my field in India is very small. This has led to a curious situation. Even after I became well-known internationally in my field, my name was virtually unknown in the scientific circles of Calcutta. My students who had gone abroad for higher studies would often come and tell me: "Your works are known to many persons there. They ask about you."

Let me now recount an amusing incident. A young man, approximately 25 or 26 years old, once approached me to ask for help with the research problem he was working on. I told him that I did not have expertise on the subject of his research problem and had never considered the issues connected with it. Then he told me that he had written to Dirac (one of the greatest physicists of the twentieth century) that he wanted to work with Dirac on this problem. Dirac's secretary replied that, according to Dirac, there was no need for him to come so far. He could approach a scientist named Raychaudhuri working in India. I was astonished—Dirac knew my name! However, Dirac probably used my name to avoid this young man.

2.6 31st May, 2002

I had started with a discussion of my hospitalization experience and my self-assessment of myself as a researcher. However, to understand and assess me properly, one needs to take a look at my life from my childhood. I was born in the town of Barishal, the date of birth being 14 September 1923. Now Barishal is in Bangladesh. The standard way of referring to my birthplace is to say that I was born in Undivided India. The information about my birth given here is based on what I heard from my parents and others who witnessed the event, and I believe this to be essentially correct. However, if someone questions the details, I cannot provide appropriate official records. According to my university certificate, the service book from my job, and my passport, my date of birth is November 1, 1923. The reason behind this discrepancy is as follows. In 1933, I was first admitted to school: Barishal Brajamohan Vidyalay. My correct date of birth was given there. When we moved to Calcutta a few months later, my father requested a transfer certificate from the school. Brajamohan Vidyalay miswrote the date of birth in the transfer certificate. My father was opposed to all forms of falsehood. However, he thought that correcting this through correspondence would be complicated, and he would try to rectify the situation only when he had the opportunity to visit my earlier school in person. For the time being, he allowed this falsehood to continue, which eventually became permanent. So, the first page of the book of my life begins this way: "He will keep lying about his date of birth throughout his life."

The next significant event in my life occurred towards the end of 1935, when I was twelve years old. Due to an attack of malignant malaria and due to the excessive use of quinine for its cure, one day my heart almost stopped functioning. I remember that I could hear the wailing of my mother, who thought that I was dead, but otherwise my mind was numb. Due to the careful treatment of my doctor (who happened to be some kind of maternal uncle to me), I eventually recovered. As he had some doubts about my medical condition, he one day called Dr. Hodge, a Professor at the Medical College. I heard that Dr Hodge observed, "The boy has a peculiar heart, and it is a little strange that he is alive." He also urged my maternal uncle to do some experiments on me and send the report to him. He wanted to write a paper on 'A peculiar heart' in a medical journal. My maternal uncle did not oblige Dr. Hodge. He was worried that doing such experiments might have an adverse effect on my juvenile mind. Recently, over the last three or four years, I have undergone various tests, including ECG, ECHO, and Doppler. From the questions the doctors would ask me after reviewing the reports of these tests, I understood that I was found to be better than what would be expected based on these test reports. What is written on the second page of the book of my life is this: "His being alive is an exception to the rules – like the anomalies of Sanskrit grammar known as *Arshaprayoga*."

There is nothing particularly worth mentioning about my student life. While I have never failed an examination, I have also not broken any previous records. Although I never missed Class 1/Division 1 and even regularly earned first or second rank, nobody noticed any signs of unusual genius in me. That is why I do not have to write much about my student life. I cannot even think of any particular teacher who influenced my life or outlook in a significant way.

My research career, in contrast, has been full of complexities. After completing my MSc degree in 1944, I joined the research group of Professor Kedareswar Banerjee (Fig. 9) in IACS. As far as I remember, my research scholarship

Fig. 9 Three professors of IACS with whom Raychaudhuri had professional interactions: Kedareswar Banerjee (1900–1975), Priyadaranjan Ray (1888–1982) and Debidas Basu (1917–2005)

began in January 1944. After a few months, I was taken on a metal-alloy project. My monthly stipend jumped from Rs. 75 to Rs. 250.

I was given the job of setting up an X-ray tube—a demountable Hadding tube. I first had to create a leak-proof environment within which the tube would be kept. Making a leak-proof arrangement may seem like a trivial undertaking. Wherever there is a junction in the apparatus (for example, between glass and a rubber tube), one must seal the junction with a special type of wax to prevent air contact between the inside and the outside. I initially thought that it would be about a week's work, but our apparatus stubbornly refused to become leak-proof. Even if I could make it leak-proof temporarily, things would be back to square one in a day or two. Rats would gnaw through the wax. I do not remember the number of days which got wasted in this manner. The next task was to remove air from the inside. We were using an oil diffusion pump assembled in the Science College of Calcutta University. There was no direct way to measure the air pressure that had been reached. From the current that resulted from applying high voltage to the tube, one had to estimate the air pressure. The necessary lowering of pressure did not happen even after lots of efforts. When I told my professor that the oil pump was probably not functioning appropriately, he was not surprised. It almost seemed as though he had anticipated that something like this might happen. On the other hand, I was inexperienced and was almost hesitant to conclude that my problem could have arisen from the malfunctioning of the apparatus. When the pump was replaced with a commercially procured mercury diffusion pump, I thought the problem would be over. But I soon discovered that there were additional problems. I became somewhat bolder this time and said that probably the transformer was causing the leak. Radon House supplied the transformer. When they were called, they indeed found problems with it. They took the transformer for repair and returned it after a few days.

Time, however, did not stand still during all these troubles. Four years went by. An inspecting team from CSIR[8] had the task of evaluating the progress of our project. It was led by an accomplished researcher who had just returned from abroad to take up the position of Director in a CSIR Laboratory. He was furious to find that there had been virtually no progress in the project. Our CSIR project was terminated. I managed to find a job at Asutosh College as Lecturer, with a pay cut of about 100 rupees. This happened in 1949.

Four of the most valuable years of my youth—from the age of 22 to 26—ended in complete failure, with no tangible results to show. My incompetence was undoubtedly the primary reason behind this. However, was it not expected that my professor would monitor my progress, correcting me if I was doing things incompetently or even asking me to leave if I turned out to be incorrigible? The only thing he told me afterwards was that I should take the X-ray diffraction image of a liquid. This was certainly not like suggesting a research problem to a student. A proper research problem in this field would involve collecting experimental data and then analyzing the data within the theoretical framework. Perhaps Professor Kedareswar Banerjee at that time did not have a clear plan of this type and was also not concerned about wasting time. However, he had done good research in

[8] CSIR is the acronym for Council of Scientific and Industrial Research. This organization under the Government of India manages a chain of laboratories around India and also provides research grants as well as scholarships for research students.

his youth without anyone's help.[9] He was also a very good man. It is my bad luck that I came into contact with him at a time when he had almost lost interest in research.

Those were very dark days for me. I had only the stigma of failure behind me, and my career ahead appeared uncertain and bleak. What was particularly galling was the kind of sympathy I received from many well-wishers: such a brilliant student of the University could not do anything in research! Only what Professor Kedareswar Banerjee told me was a little bit comforting: "I had hoped that you would do good research. Although that has not happened, I have a hunch that you will be able to do important research in future." I still wonder whether he said this only to console me or if he really saw any promise within me. Anyway, those kind words meant a lot to me at that time.

When my mind regained some amount of its spirit a few months later, I went to Professor Nikhil Ranjan Sen of Applied Mathematics Department of Calcutta University. He discouraged me a little bit: "You are a student of physics. I do fairly mathematical kind of research. Will that suit you?" As I was still suffering from the ignominy of my failure, I was not in a position to give a proper answer. He asked me to read a few books and said that I could attend the weekly seminars held in his room on Tuesdays. After a few days, a change happened.

2.7 2nd June, 2002

In those days, while considering static equilibrium in general relativity, only the conditions of mechanical equilibrium were taken into account. Conditions of thermodynamic equilibrium used to be ignored. Now, according to general relativity, all forms of energy can be sources of gravity. While energy can give rise to gravity, the gravitational field can also determine the energy content. In such a situation, a lack of thermodynamic equilibrium would lead to a lack of mechanical equilibrium. Because of this, conditions of both kinds of equilibrium should be considered while discussing static equilibrium. It is not true that scientists of that era were not aware of these concerns. But they correctly surmised that the lack of thermodynamic equilibrium would produce comparatively less significant effects, and they were forced to neglect this to make their problems mathematically manageable. Anyway, after analysing the problem to some extent, I approached Professor Nikhil Ranjan Sen with my findings. Since the issues are logically straightforward, I had hoped that he would agree with me as soon as I explained the matter to him. Although he did not agree with me immediately, after asking me many questions and engaging in a prolonged discussion, he eventually admitted that I was correct. I realised later that Professor Sen was always reluctant to express an opinion quickly. My own explanation for this is as follows. Professor Sen was a classmate of Meghnad Saha and Satyendra Nath. They also had overlapping interests. Although Professor Sen was a deep scholar, he lacked the genius of Saha and Bose. This led to a kind of inferiority complex in Professor Sen, as a result of which he was always hesitant to give his opinion on any physics-related matter. However, Sen did not have the ego which Saha and Bose had. For some time after his retirement, he worked as a paid assistant of Bose, which was not very honourable for him.

Anyway, Professor Sen asked me to write up what I had done. After about a week, I met with him to discuss my write-up on the work. After reading it and discussing it with me, he said: "The work is OK, although the writing is not satisfactory. I am sending this as a note to *Science and Culture*." Then he wrote a summary of that work in one page and sent it to *Science and Culture*. I saw that he did not add his name as author. The paper was only in my name.

After a few days, I returned to him with some new results on this subject. This time, he himself did not write anything additional, but deleted some superfluous portions from my write-up and sent it to the *Bulletin of the Calcutta Mathematical Society*. I remained the only author of the paper. He told me: "Don't write too much. If you write more than what is necessary, you increase the probability of writing something wrong." Now, *Science and Culture* was not exactly a research journal, whereas the *Bulletin of the Calcutta Mathematical Society* had very limited circulation. Normally one would not be very excited about getting published in them. However, seeing papers in my name after a prolonged period of failure brought a transformation in my mental state. I got back some confidence in myself. However, today I am aware that those papers had some mistakes.

I kept looking at various journals with interest. Occasionally, some thoughts would come to my mind. Sometimes I would meet Professor Sen for discussions. But gradually I started becoming impatient with him for what seemed to me to be his unnecessarily cautious and conservative attitude. Gradually, I started detaching myself from Professor Sen, but I have always continued to feel a sense of respect and gratitude for him.

From time to time, I would send some of my papers to one of the reputed international journals. Except for one or two, others were rejected. However, the referee report sent to me by *Nature*, while rejecting a paper, took me to a different world. The referee wrote: "There is nothing new in it. I remember that, when Einstein came to England, he discussed some of these things." My God! Einstein himself had thought about and discussed the things which an insignificant person like me was thinking. I had not realized

[9] For a discussion of Kedareswar Banerjee's landmark work on X-ray crystallography put in the historical context, see Mande (2014).

one thing at that young age. While great scientific geniuses tackle the big problems of science, small issues also do not escape their attention, and the possibility that their statements may be wrong at times cannot be ruled out.

After two or three papers of mine appeared in *Physical Review*,[10] I happened to come across a job advertisement in a newspaper. IACS advertised for the position of a Research Officer in Theoretical Physics. I knew that this position had been advertised earlier a few times. Selections were also made, but the selected persons did not join. Perhaps the reason the position was not filled was the unavailability of a suitable candidate in Calcutta. Anyway, I applied for that position and received the offer letter in a few days. I was thrilled. I would be able to use the wonderful library of IACS all the time. Apart from the expected freedom to conduct my research in my own way, the additional benefit was a monthly salary increase of approximately Rs. 150.

I left Asutosh College in September 1952 to join IACS. The first few days of my year-long probation went smoothly. I managed to get a paper published in *Zeitschrift für Physik*.[11] By that time, Meghnad Saha joined as IACS Director. He was also simultaneously the Director of the Institute of Nuclear Physics (now the Saha Institute of Nuclear Physics), although this was an unpaid honorary position. I met Professor Saha with a reprint of my latest paper. The date was 14 September 1953. I had hoped that he would be impressed by my research and that would be helpful for my future career path.

What happened was the opposite of what I had expected. After taking a glance at my reprint, he said: "General relativity is a very difficult subject. Are you doing this work alone?" Then he called Debidas Basu (Fig. 9), Reader and Head of our department. He asked Debidas-babu: "Do you know and understand what Amal is doing?" Debidas-babu said: "I know it to some extent, but I do not understand it well." Professor Saha told me: "If you people work together as a team, that will be better. Anyway, one day you give a lecture explaining your work to us." Accordingly, I gave an hour-long lecture on a day which suited him. But, at the end, Professor Saha commented: "I did not understand anything." I had a feeling that there was something not genuine about his lack of understanding of my lecture. In a state of desperation, I consulted some of my well-wishers at IACS. They all said that nothing would come out of giving such lectures, and, as Professor Saha had once said that it would be better for me to work with Debidas-babu, that is what I should do—I should tell Professor Saha that I agreed to his suggestion. Meanwhile, I had looked at some of Debidas-babu's papers and realised that his work was of low quality. Some of his papers were essentially copies of other people's papers with some small modifications. In my despair, I met Professor Saha with one paper of his along with the original paper from which he had copied. I said: "Please look at these. Given the type of research Debidas-babu is conducting, working with him will be akin to not working at all. Whatever may be the standard of my own work, I do not merely copy others and try to do something entirely on my own." Professor Saha, however, said sternly: "Good work is not so plentiful. There, all of you stand on the same footing. If you do not want to listen to what we tell you, then you are free to look for a job elsewhere." Crestfallen, I said: "I shall do what you are suggesting." Soon after this, I received the conditional confirmation letter, which I already mentioned.

I still sometimes wonder: what should be expected from a Director? Should he demoralise young researchers by telling them discouraging things, or should he help in the blossoming of whatever little capability a young person has through words of encouragement? In my humble opinion, Professor Saha did not fulfil the expectations with which the nation had entrusted high responsibilities to him.

After a few days in a heart-broken condition, I went to Debidas-babu and asked him: "What research shall I do?" He replied: "I do not know. You go and talk to the Director." So, I was back with Professor Saha again. However, this time he did not repeat his earlier suggestion that I work with Debidas-babu. Rather, he said: "You may think of working in quantum chemistry." I responded in surprise: "I know quantum mechanics very little, and my knowledge of chemistry is also limited to what little I had to cram for passing my BSc examination." He said: "Somebody who is competent in mathematics can do many different things. For chemistry, you discuss with Prof. Priyadaranjan Ray." That was the first (and the last) time I heard a praise about me from Professor Saha: that I was competent in mathematics and that I could do many different things! Professor Priyadaranjan Ray (Fig. 9) asked me to look at a book written by himself, along with books by a few other eminent scientists in this field. My condition became very pathetic. After perusing some of these books, I gained a partial understanding of certain aspects and struggled to grasp others, but I was unable to develop a comprehensive perspective on the entire subject. I was also unable to identify any possible research problems. I felt that Professor Saha had pushed me into a situation in which my incompetence would be clearly demonstrated. If this was his intention, then he had succeeded in achieving that admirably.

Unexpected things do happen! I came across a rather simple and easy paper by Coulson. I understood it without any difficulty. Coulson was a Mathematics Professor at Oxford University—presumably because of some contribution of

[10] Three of Raychaudhuri's papers in *Physical Review* published at that time give Asutosh College as his address: Raychaudhuri (1951, 1952, 1953a).

[11] Raychaudhuri (1953b).

his to mathematics. However, his fame mainly rested on the application of quantum mechanics to chemistry. He was one of the world's top-ranking scientists in this field. He proposed a new method in the paper that I saw—the free electron network approximation. He could draw some conclusions about pure metals by applying this method. However, he commented towards the end of the paper that this method would not be applicable to an alloy of two metals. After considering this paper for a few days, I felt that his comment towards the end of the paper was not justified. I could show that this method would be applicable to some alloys. One needed courage to disagree with a scientist of Coulson's stature. However, as I mentioned earlier, although my knowledge and capability may be limited, I would be willing to confront even the world's leading authority on something I understand properly. I wrote a short note on this topic and requested Debidas-babu to communicate it to the journal in which Coulson's original paper had appeared. Although he commented that the work was inconsequential, he communicated it to the journal. The note appeared there after a short while. What was beyond my expectations was that a paper from Coulson himself appeared a couple of months later, pointing out that I had corrected a misconception he had and that my work had opened up the possibility of some new applications (Fig. 10). My name was mentioned about 10 times in the paper.[12] I took the paper to Professor Ray. When he saw that Coulson had referred to me in this manner, he was very impressed and told me directly: "You seem to have done a very good work." Afterwards, I came to know that he mentioned about my "good work" to a few colleagues. By that time, Professor Saha had passed away and Professor Ray had become the Acting Director (Honorary) of IACS. Whatever conditions might have been stipulated in my confirmation letter, I realised that now my freedom to work on research problems of my own choice would not be curtailed any more. I got back my freedom in a peaceful manner. I now give my own assessment of the whole episode. My work was not particularly significant, and the reputation I acquired in the chemistry community of Calcutta due to this work was perhaps undeserving. I found that Professor Ray did not have the ego and the lack of honesty which I had seen in Professor Saha. However, Professor Saha was undisputably a much greater scientist than Professor Ray. No one can question the importance of Saha's scientific contributions.

The few years I spent at IACS after Professor Saha's death were uneventful. During this time, Professor Kedareswar Banerjee came back to IACS as its Director. He had left IACS to take up the position of Professor at Allahabad University. My hunch is that he did not want to work under Professor Meghnad Saha as Director. Now I shall describe a few events that illustrate the humiliation I faced at IACS and the meanness of some influential individuals there.

A floor above the ground floor was constructed in IACS. There was then a reallocation of rooms among various departments. Chairs, tables, and almirahs—all started being shifted from one place to another. The helper of our department asked me: "Where shall I take your table and chairs?" I asked: "Hasn't Debidas-babu given any instructions?" He said: "No, you better ask him. He had only said that this room has been allotted to a different department and has to be vacated." I then went to talk with Debidas-babu. What he told me in a very sympathetic tone was this: "We regret that we are unable to allot you any space in the rooms allotted to our department. However, I have discussed this matter with Professor Phani Datta of the Organic Chemistry department. You will sit in the upstairs kitchen, which belongs to the Organic Chemistry Department. Here is the key of that room." He finished in a very sweet voice.

I took the key and asked the helper to take my table and chair to the upstairs kitchen. It was a small room, within which we somehow managed to fit the table and the chair. The afternoon sunlight entering the room through a large window made the room very hot. The Registrar of IACS visited the room and probably felt somewhat bad about the situation. He told me: "I am arranging for a fan and shall have a heavy curtain fixed in the window to block the sunlight as much as possible. Let me tell you one more thing. You should never leave the door open and should not give the key to anybody else." I did not understand the significance of his last statement at that time. However, the very next day, two students approached me and said: "We cook our food in this kitchen. Since you locked the room yesterday, we could not cook. Please leave the key with us in the evening when you leave. We shall not touch your books or papers, but shall cook our food here. We shall again give the key to you tomorrow morning." Then I remembered what the Registrar said and told them: "I am sorry that I cannot do what you ask. I am not supposed to give the key to you."

When Professor Kedareswar Banerjee joined a few months later as Director, he went around the building with all the Heads of Departments, presumably to get acquainted with everybody. When he came to the kitchen where I was sitting, he said: "Amal, this is a kitchen. Why are you sitting here?" I replied: "I have been asked to sit here." There was an empty room opposite the kitchen, reserved for the Director's use. Kedareswar-babu said: "I am right now sitting in my downstairs office. For the time being, you sit in this opposite room." Turning to Debidas-babu, he said: "From

[12] The papers referred to in this paragraph are Coulson (1954, 1955) and Raychaudhuri (1955b). Figure 10 shows the first page of Coulson (1955) in which Raychaudhuri is mentioned prominently in several places.

The Free-Electron Network Model for Metals: II

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Abstract. The free-electron network model for metals originally introduced by the writer is extended in two ways. First an allowance is made for the strong electron attraction towards the nuclei by inserting δ-function potential wells at the positions of these nuclei. Secondly, the potential between the nuclei is not regarded as constant but may be of arbitrary shape. Provided that this potential does not fluctuate too fast along the 'bonds', its influence on band shape is shown to be small, in agreement with the situation found without δ-functions by Raychaudhuri. Atoms of different kinds may be introduced into the lattice, and the particular cases of the diatomic cubic lattice AB and the planar hexagonal lattice of graphitic type (example, boron nitride) are studied in detail. A possible application to the problem of antiferromagnetism is pointed out, involving a splitting of one otherwise continuous energy band into two separated parts as a result of partial localization of electrons of similar spin on alternate atoms.

§ 1. Introduction

In a previous paper (Coulson 1954, subsequently referred to as I) the writer showed how to extend the so-called free-electron theory for conjugated molecules to make it apply to metals. Essentially all that was required was to suppose that the conduction electrons moved in a zero potential field, confined to the straight lines (i.e. bonds) which joined adjacent nuclei. It appeared that the resulting band distribution of the allowed energies was exceedingly similar to that found in the conventional tight-binding approximation.

There are several ways in which this model could be made more realistic, while still keeping to the network principle. Thus (*a*) we might suppose that the potential was not constant between the nuclei, but varied slowly. Raychaudhuri (1955) has recently shown that unless the variation of potential is rapid, the resulting band distribution is hardly affected. A second improvement (*b*) is to recognize that when a conduction electron is close to a nucleus it experiences a strong attraction. This may be simulated by adding a suitable delta function (δ-function) to the potential at each nucleus, while maintaining a constant potential between the nuclei. A third improvement (*c*), which is indeed essential if the method is to apply to diatomic and other intermetallic compounds, is to use different delta-function wells at the different nuclei. Finally (*d*) we may superpose on these delta-function potentials at the nuclei a varying potential between the nuclei, thus extending Raychaudhuri's work in which there were no δ-functions. Improvement (*a*) has already been made. In this note we show how to make the other three extensions (*b*)–(*d*). The essential point which is new concerns the type of boundary or continuity conditions to be satisfied at a nucleus where two or more bonds terminate in a δ-function potential well. For that reason we have discussed it carefully in § 2. The later sections then follow fairly simply, and require relatively little detailed analysis.

Fig. 10 The first page of Coulson (1955), in which Raychaudhuri's work is repeatedly referred prominently

now onwards, Amal will sit in this room." I got promoted from the kitchen to the Director's room!

When I received the DSc Degree, Professor Kedareswar Banerjee proposed to the faculty that I should be given a promotion because of the outstanding work I had done. But all the professors protested: almost everybody in the organization had been doing good work. If a promotion is given to somebody on the basis of a thesis examiner's laudatory report, then there would be no discipline in the place. Debidas-babu said that I could be given a promotion by transferring me to another department, but not in his department. Kedareswar-babu could not do anything against such strong opposition. I joined Presidency College a few months after this.

A few days after I moved to Presidency College, I received a phone call from my former colleagues. They asked me to come one afternoon so that we could all have tea together and chat. I readily agreed to go. Perhaps they wanted to organize some kind of a farewell party for me. However, I received a phone call a few hours before the planned get-together: some difficulties had arisen that day, and the get-together would take place on a later date. It never took place! I heard that Debidas-babu had expressed his opposition to such a get-together. This phase of my life with IACS came to an end.

Debidas-babu is still alive. He was raised to the position of the Director of IACS. At the time of retirement, he got into an argument with the Council. He claimed that he still had some years before his retirement and would continue as Director. However, he was not allowed to enter IACS. He filed a litigation with the High Court, but lost there. He had no other option left after this.

Today I do not have any grudge against anybody. Debidas-babu is a very ordinary person—not somebody worth having a grudge against. Professor Meghnad Saha would always rank much above me as a scientist. I respect him for his enormous scientific contributions. However, in my opinion, he completely failed in discharging his duties towards the next generation. His ego made him lose his power of judgement in many important matters. This is a tragedy not only for him, but for our entire nation. My suffering was an unfortunate consequence of this.

[Here Raychaudhuri quotes a poem by Tagore, in which a lonely man wishes to be left in peace to his corner so that he can play his flute and fill his surroundings with music.]

I never had the ability of filling my surroundings with music from a flute. The only thing I could do was to fill sheets of paper playfully with mathematical equations. This is all that theoretical physics is about. But shall I ever be able to play this game again?

2.8 4th June, 2002

There is an impression about me within certain academic circles that I am rather proud and arrogant. Although I think that this is a wrong impression, I have to admit that this may not be an impression created solely by my detractors. Certain incidents may have given rise to such an impression. Let me describe a few of these incidents.

2.9 Incident 1

I was appearing for the interview for lecturer's position at Jadavpur University. Dr. Triguna Sen was the Chairman of the Selection Committee.

Q: Why do you want to come to Jadavpur University leaving behind your research at IACS?

A: Is it forbidden to do research at Jadavpur University?

Q: Of course, not. But the demands of teaching may come in the way of your research.

A: Since all the outstanding works of research in our country in the past had been done by university professors, I do not believe that teaching comes in the way of one's research.

Q: Do you not have a research degree?

A: No, I do not have. Perhaps you know that Professor Satyen Bose also does not have a research degree.

Since it would have been clear to the Interview Committee Members why I applied for a job at Jadavpur University, the first question was pretentious. I believe that, when seniors are pretentious, they should be answered appropriately.

The second question was not a question at all, since it was clear from my application that I did not have a research degree. It was merely meant to prick me. However, a rumour got spread that I was comparing myself with Professor Bose.

2.10 Incident 2

Full of praise for Professor Bose, a young man once accosted me with a superior air: "Why do you publish your papers only in foreign journals? Are there no good journals in our country?"

I replied: "You should put this question to Professor Bose. Since he is internationally renowned, his papers may attract attention wherever they are published. Still, he publishes papers in foreign journals. As I am a small guy, perhaps nobody will take note of my papers if they are published in Indian journals."

This young man was younger than me. Since I was irritated by his air of superiority and his excessive praise for Professor Bose, I intentionally mentioned Professor Bose's name in my reply.

2.11 Incident 3

I had got up to deliver a lecture at a Summer School in Mussoorie. Professor Bose was chairing the session. He said: "Make your talk short."

I responded: "Sir, I know how to cut my coat according to my cloth. Please tell me how much time you like to give me."

2.12 Incident 4

Discussions were going on about my marriage. The elder brother of the would-be-bride came to IACS to make my acquaintance.

Q: Do you have much scope for your career advancement here?

A: No, I do not foresee much possibility of career advancement here.

Q: Who are the famous scientists in our country working in your field?

A: I would like to avoid using the adjective 'famous'. However, I am not aware of anyone in our country doing better research than me in our field.

I had innocently given what I considered to be honest answers. However, the brother of the would-be-bride understood me wrongly. After returning home, he commented that the boy seemed over-smart.

2.13 Incident 5

The following conversation took place with my wife a few months after our marriage.

Wife: You should make some efforts to go abroad to present your work.

I: I shall never make such efforts. Only if an invitation comes from abroad to present my work without my having to try for it, will I consider going abroad.

By that time, my wife had realised that I was not over-smart.[13] However, when I mentioned getting an invitation from abroad, she exclaimed, "Do such things happen?" I actually did not have a strong desire to go abroad. I had mentioned getting an invitation from abroad in a lighter vein. I myself never expected to receive such an invitation.

My wife must have described this conversation to her family members. This reinforced their impression of my being over-smart.

However, I did receive such an invitation in about 3 years. I received an invitation to an international conference in Dallas, where the organisers offered to cover my travel and local expenses. That became my first trip abroad.

*** *** ***

My days at Presidency College had been spent peacefully. While I have been a keen observer of many developments in the field of education, I have never been a member of such exalted bodies as the Senate or the Syndicate of any university. Perhaps the reason behind this is that I have always stayed away from politics of any kind. No ruling party considered me suitable to be made a member of any such exalted body. I have no regrets for that.

The ruling disposition of the present time has decided that the abolition of the widespread practice of private tuition is the need of the hour for reforming education. Only time will show how far they are correct. It would be unscientific for me to comment on this matter at this stage. Therefore, I will remain silent on this matter.

Sometimes I had felt an urge to write about my work, which had brought me some international fame, in simple, non-technical Bengali, without equations, for common Bengali readers. However, I then concluded that I do not possess the necessary writing skills to do this well. So, I finally refrained from such an effort.

How long will I or my work be remembered? My students will surely remember me occasionally. Perhaps this will happen for about 20 or 30 years more. Looking at the scientific community in my field, I believe that my work will be prominently mentioned in scientific discussions for about 10 or 20 years to come. Then, in perhaps half a century, my work will be completely forgotten. It is probably silly to indulge too much in such speculations.

3 Concluding remarks

What conclusions do we draw from this scientific autobiography? Since Raychaudhuri wrote this piece without the usual restraint which one finds in almost all other public writings and speeches of his, one can find Raychaudhuri's honest and candid opinion on many matters in this autobiography. Raychaudhuri gave examples of Basanti Dulal Nag Chaudhuri and Debidas Basu as physicists whose scientific contributions were insignificant but who became important in Indian academia for political reasons. The complete publication lists of Nag Chaudhuri and Basu are provided in their biographical memoirs, respectively, by Mukhopadhyay (2008) and Mukherjee (2009). A look at their publication lists would leave little doubt that Raychaudhuri's assessments of them as physicists were fully justified. Incidentally, both of these persons were Saha's protégés.

It is a glaring anomaly that Raychaudhuri, the most impactful Indian physicist of his generation, never became a member of the inner circles of the highest decision-making

[13] Curiously, in the documentary on Raychaudhuri, his wife Namita was asked what her first impression about her husband was. She gave a one-word reply: "Unsmart".

bodies in Indian science. He wrote that he was sure to be elected to INSA when S.N. Bose nominated him and, on not being elected, he concluded that Bose did not have influence outside Calcutta. This may appear to indicate a rather naïve view of the complex process of Fellow election in an Academy.

One important issue which Raychaudhuri brought up repeatedly is the question of how much freedom should be given to young scientists. Interestingly, he expressed rather different views on the amount of freedom to be given to doctoral students and young faculty members. While discussing the problems he faced while working in Kedareswar Banerjee's laboratory as a doctoral student, he wrote that senior persons should closely monitor young scientists and ask them to work on specific problems. On the other hand, while describing the unpleasant interactions he had with Meghnad Saha when working as a Research Officer at IACS, he opines that young persons should be given full freedom and senior persons should never impose any restrictions on the research of younger persons.

We now come to the most debatable issue raised by Raychaudhuri: his assessment of S.N. Bose and M.N. Saha, the two towering giants in the physics community of Calcutta when Raychaudhuri was a young, budding physicist. Why did their extraordinary scientific contributions not lead to a thriving tradition of physics research in Calcutta? While recognising both Bose and Saha as scientific geniuses, Raychaudhuri accuses them of not providing the right kind of scientific leadership and of failing in their duties to the next generation of scientists. This is a very serious accusation and is connected to the important question of why a healthy physics research tradition did not develop in Calcutta, despite the spectacular early achievements. Let us analyse this issue in some detail now.

In a different article on Bose's works on unified field theory, Raychaudhuri (1994) wrote (my translation from Bengali): "His remarkable mathematical prowess and his genius for easily wandering through different branches of physics were very apparent... Instead of randomly working on various things, had Satyendra Nath concentrated his efforts on some central key problems of physics and had he trained a group of outstanding students to be his fellow travellers in this effort, then would not the standing of India in the community of physicists be much higher today than what it is? While it is not possible to find universally acceptable answers to such questions, I find a curious blend of success and failure in the career of Satyendra Nath." Since Raychaudhuri had placed so much emphasis on student training, let us try to find out what Bose's philosophy on training students was. Purnima Sinha (1981, p. 70), who did her PhD thesis under Bose's supervision and worshipped Bose as a demi-god, wrote this (my translation from Bengali): "He never tried to establish a school by gathering the best students around him. After all, the best students can always find their own paths. But who will look after the less capable students? The great savant therefore took upon himself the job of guiding such students." No further comments are needed. We leave the readers to draw their own conclusions after reading the statements of Raychaudhuri and Sinha.

As Raychaudhuri's interactions with Saha constitute a major part of the scientific autobiography, we now turn to Saha. Before we pass our judgment that Saha treated scientists of the next generation in an insensitive and high-handed manner, we should consider how he treated younger scientists during the early part of his career. A striking example is the case of the young Subrahmanyan Chandrasekhar, who was only 19 and had already published a paper when he attended a conference in Allahabad where Saha was a professor at that time. According to the authorised biography of Chandrasekhar by Wali (1990, p. 64): "Chandra was not aware that Saha was acquainted with his own work; so when he met Saha at the Congress and introduced himself, he was pleasantly surprised by Saha's compliments on his paper in the *Proceedings of the Royal Society*. Saha said that it was very suggestive and that one of his students was working on extending Chandra's ideas. He introduced Chandra to his students, who also seemed to be familiar with his work, and he invited Chandra to his home for lunch with a small group of research workers, all of whom were older than Chandra... Chandra, so young, did not expect to be treated almost as an equal by an internationally renowned scientist of Saha's stature." While Chandrasekhar always had very fond memories of his first meeting with Saha, he was fully aware that the early heroes of Indian physics became very different kinds of persons in their later lives. In a conversation with Wali (1990, p. 248), he made a very perceptive comment: "when recognition, glamour, reputation continued to dominate as the primary motives in individual scientists' lives, deleterious effects took hold. Those who had made significant contributions were constantly aware of their successes. They wanted to be regarded as unique individuals, and therefore they turned around and discouraged younger people or attributed all kinds of motives to their contemporaries." This is exactly the atmosphere which Raychaudhuri encountered in Calcutta when he began his research career.

In the first part of his career, Saha was primarily a scientist, scholar and teacher. In the latter part of his career, he became an institute builder, a Member of Parliament, and a framer of science policies for the newly independent nation. He had less and less time for his academic work. In the early part of his career, Saha was known as a dedicated and enthusiastic teacher; his lectures leading to the outstanding *Text Book of Heat*[14] (Saha & Srivastava, 1931), which

[14] Renamed *A Treatise on Heat* in later editions.

was widely used for many years. However, later, when he had less time to prepare his lectures, his teaching became increasingly erratic. Even Banerjee (1993, p. 69), who was trained in research by Saha and wrote about his fond memories of Saha, gave an account of how Saha used to demoralize and humiliate students publicly in the MSc class during the late 1940s (shortly before Raychaudhuri's unfortunate interactions with Saha):

> Professor Saha's teaching was somewhat haphazard... He was also an absolute terror in the classroom... Often we failed to understand what he wanted as the answer to a question. I recalled vividly the day he asked, 'What is Zeeman effect?' I am confident that eighty percent of the students knew the answer. The first person started by saying 'When an atom is placed in a magnetic field ...' Professor Saha asked him to sit down with a show of dissatisfaction and went on to the next student with practically the same response and the same reaction from him. To this day, I do not know what answer he wanted. An inevitable consequence of this state of terror among us was the following exchange. Once he asked, 'What is meant by threshold (of nuclear reaction)?' After cutting a few students, he came to Himangshu Mukherjee, who blurted out, 'choukath,[15] Sir'. I am sure that it was a desperate guess of what Professor Saha wanted for answer rather than an attempt at impudence on Himanghshu's part.

Let us now come to Raychaudhuri's interactions with Saha. Apart from the scientific autobiography, there is another source in which we find a description of these interactions. In his diary, Raychaudhuri jotted down some of his experiences in English while working as a Research Officer at IACS. It was not a regular, systematic diary. Sometimes there would be no entries for several months. Only when something that appeared noteworthy to Raychaudhuri happened, he would make a record of it—usually in very telegraphic language, often not writing full sentences. Raychaudhuri's first meetings with Saha are about the only events which had been described in considerable detail in the diary. It is worth quoting the account of these meetings from the diary fully (Raychaudhuri, 2007b, pp. 109–110):

> It was a day in late August (1953) that I presented a reprint of my paper in Zeitschrift[16] to Dr. Saha. The Director had a glance at the title of the paper and remarked that relativity was a rather abstruse subject. He then asked me to explain what exactly I had done in that and what else I had done after joining the Association. He enquired whether I was working independently and also whether I had studied Bose's recent papers on unified field theory. I informed that save a note in the Comptes Rendus[17] nothing has been published by Prof. Bose as yet. He then asked me to call Dr Basu.[18] Dr Saha asked Dr Basu whether I was working on his problems and wondered if Dr Basu understood my work. Personally, Dr Saha said, he found my work abstruse and beyond his comprehension. On Dr Basu informing him that I was working on my own problems, Dr Saha told me that he thought it would be more fruitful if, instead of working on such abstruse problems independently, I joined Dr Basu's team so that we all pooled our efforts together, making our efforts more effective. He asked me to give my thoughts to his proposal.
>
> During the talks, I also informed him that lately I have felt interested in superconductivity and he asked me to tell the librarian to have a copy of Schoenberg's latest edition on Superconductivity. My next interview with Dr. Saha was in September – I remember the date – it was the 14th September (it being by the way my birthday). Dr. Saha called me to his office where Dr. Basu was already present. Dr. Saha asked me about my line of work and enquired about my studies in the field of cosmology. He again enquired whether I have studied Bose's work. He then told me that neither he nor Dr. Basu being men of that line, they were not quite able to judge the merits of my work. He therefore asked me to prepare and deliver a course of three lectures on cosmology and fixed 3rd, 5th and 6th Oct as dates for the same.

Presumably this account was written soon after these meetings of Raychaudhuri with Saha, before later incidents took place. It is to be noted that there was no trace of bitterness in this account, unlike what we find in the scientific autobiography. This account can almost be taken as an expression of exhilaration felt by a young budding scientist who had just joined an institute and met its Director, a famous scientist whom the young man greatly admired. Incidentally, the three lectures that Saha wanted Raychaudhuri to give kept being postponed as other work came up for Saha.

[15] 'Choukath' is the Bengali word for the threshold of a door.

[16] Most likely this refers to Raychaudhuri (1953b).

[17] Bose (1953). Approximately around the same time when Raychaudhuri began working on general relativity, Bose was writing his papers on unified field theory (using similar mathematical techniques). These papers of Bose made very little impact. However, even a cursory look at Bose's papers on unified field theory makes it clear that Bose had the physics and mathematics background necessary to understand Raychaudhuri's work, had he made an effort.

[18] Dr. Debidas Basu, the Head of Theoretical Physics Department, referred to as Debidas-babu in the scientific autobiography.

Comparing this account in the diary with what we find in the scientific autobiography, we are almost reminded of Akira Kurosawa's cinematic masterpiece *Rashoman*, in which different eye-witnesses describe an event differently. Here, we have two accounts of the same events by the same person—one account written immediately after the events and the other written half a century later. Why are they so different? Some discrepancies are clearly due to memory lapses. In his scientific autobiography, Raychaudhuri wrote that he had his first meeting with Saha on September 14, 1953. According to the diary, this was the second meeting. Conversations that were attributed to this one meeting in the scientific autobiography actually took place in two separate meetings, according to the diary. This suggests that Raychaudhuri likely had forgotten about the diary by the time he wrote the scientific autobiography and certainly did not consult it while preparing the autobiography. Upon careful reading of these two independent documents, we find that the accounts of the conversations presented in both documents are in full agreement with each other. Only, they are written in very different tones.

Saha clearly held the view that scientists in his institute could make a greater impact if they worked together—not an unreasonable view for a Director to have. According to Raychaudhuri's diary, Saha only "asked me to give my thoughts to his proposal" about working in line with others. In the culture of sycophancy that pervaded IACS at that time, the Director's suggestion was often taken by many to be his order. Debidas Basu, as well as Raychaudhuri's well-wishers, asked him not to work on general relativity any more because Saha was not favourably disposed towards his doing research in that field. However, Raychaudhuri continued to work on general relativity even after he began studying quantum chemistry under the guidance of Priyadaranjan Ray. When Raychaudhuri wrote a paper on general relativity, Debidas Basu refused to send it to a journal. Here is what we find in the diary (Raychaudhuri, 2007b, p. 110): "He however told me that it was extremely irregular for me to continue my work on relativity while the Director had told me to work on valence theory. I replied that while I was studying valence theory, there was no reason why I should not do some work in other lines if they came to my mind... Dr Basu however was adamant and said that he could not risk the displeasure of the Director by sending the paper for publication and therefore he would simply send it to the Director for his decision." Finally, the matter was settled with Saha's intervention (Raychaudhuri, 2007b, p. 110): "After two days, the Director called me to his office. He told me to act according to the suggestions of Dr Basu and also told Dr Basu to send the paper to Z. Astrophysik.[19]"

[19] This is most likely the paper Raychaudhuri (1955c).

Basu did not even want Raychaudhuri to give a lecture on his work on general relativity. Here is what we find in the diary (Raychaudhuri, 2007b, p. 109):

> 29.12.53.
> Dr Saha called me to his office. Dr Basu was also present. Dr Saha told me that I should explain to them my works between 11AM to 1PM on the following day. Dr Basu expressed the view that as Dr Saha has already told me to change my subject, perhaps it is useless to have a discussion on my old subject. Dr Saha, however, brushed aside the objection.

The most logical conclusion we can draw from these accounts is that Raychaudhuri felt suffocated by the oppressive atmosphere of hierarchy and sycophancy in IACS during Saha's tenure as Director. Initially, he probably did not hold much personal grudge against Saha himself. As the years went by and Raychaudhuri reflected more on his experiences at IACS, he must have felt increasingly strongly that Saha had failed to create the right kind of academic atmosphere in IACS and had allowed his protégés, such as Debidas Basu, who had a very poor academic record, to exercise too much power. Over the years, Raychaudhuri's feelings about Saha must have hardened, and we see a reflection of that in the scientific autobiography.

Saha initially wanted Raychaudhuri to give three lectures, although ultimately only one lecture took place. Given how busy Saha was at that time with too many things, it must have been rather unusual that he wished to listen to as many as three lectures from Raychaudhuri explaining general relativity and his own work. Although Saha advised Raychaudhuri to align his research interest with the ongoing activities of IACS, he was probably genuinely eager to know what Raychaudhuri was doing in general relativity. The fateful interaction between the two titans of Calcutta physics, belonging to the two succeeding generations, took place on 30 December 1953. The young Raychaudhuri, who would later mesmerise generations of physics students with his famously lucid expositions of complex physics concepts, made his presentation before the senior physicist for whom Raychaudhuri probably still had a very high regard. We find an extremely brief account of the lecture in the diary: "I spoke for about an hour before Dr Basu and Dr Saha. Firstly, I provided a brief review of the observational data and then proceeded to discuss relativistic cosmology. At this stage, Dr. Saha told me to stop for the day and asked me to continue on 4.1.54." A follow-up lecture never took place for various reasons. In this brief account, Raychaudhuri does not even mention Saha saying that he could not understand the lecture, as described in the scientific autobiography.

We can only wonder what could have gone wrong on that day. Were other thoughts occupying the mind of the busy Saha during the lecture? Was he simply tired? It is clear

that he could not focus on Raychaudhuri's presentation. Had Saha been able to concentrate on Raychaudhuri's presentation, had he said a few words of encouragement and had he given some responsibility to Raychaudhuri for developing a theoretical physics group in IACS, the history of how physics evolved in Calcutta during that era might have been totally different... In a review of theoretical astrophysics in India, Raychaudhuri (1992) wrote: "Would astrophysical research in India not have been somewhat different if Saha had devoted a good part of his energy to astrophysics and Chandrasekhar settled down in the land of his birth? One does not know – such questions will remain unanswered for ever."

It is interesting to note that *Physical Review* lists 28 December 1953 as the date of receipt for Raychaudhuri's famous paper deriving the Raychaudhuri equation, whereas the paper (Raychaudhuri, 1955a) was published on May 15, 1955—after more than 16 months. Curiously, Raychaudhuri gave the lecture in front of Saha only 2 days after the receipt date of this paper. The publication history of this paper, as provided by Raychaudhuri, is included in the Appendix of Earman (2000). Raychaudhuri first presented the equation in a short Letter paper, which he submitted to *Physical Review*. The referee pointed out that the paper was incomprehensible and that the author should prepare a regular paper giving the full derivation. Then Raychaudhuri wrote a regular paper with the derivation and "also made a conjecture that there exist [cosmological] solutions in which the vorticity brings about a bounce from a collapsing to an expanding phase." This paper, sent to the *Astrophysical Journal* was rejected. What happened next has been described by Raychaudhuri:

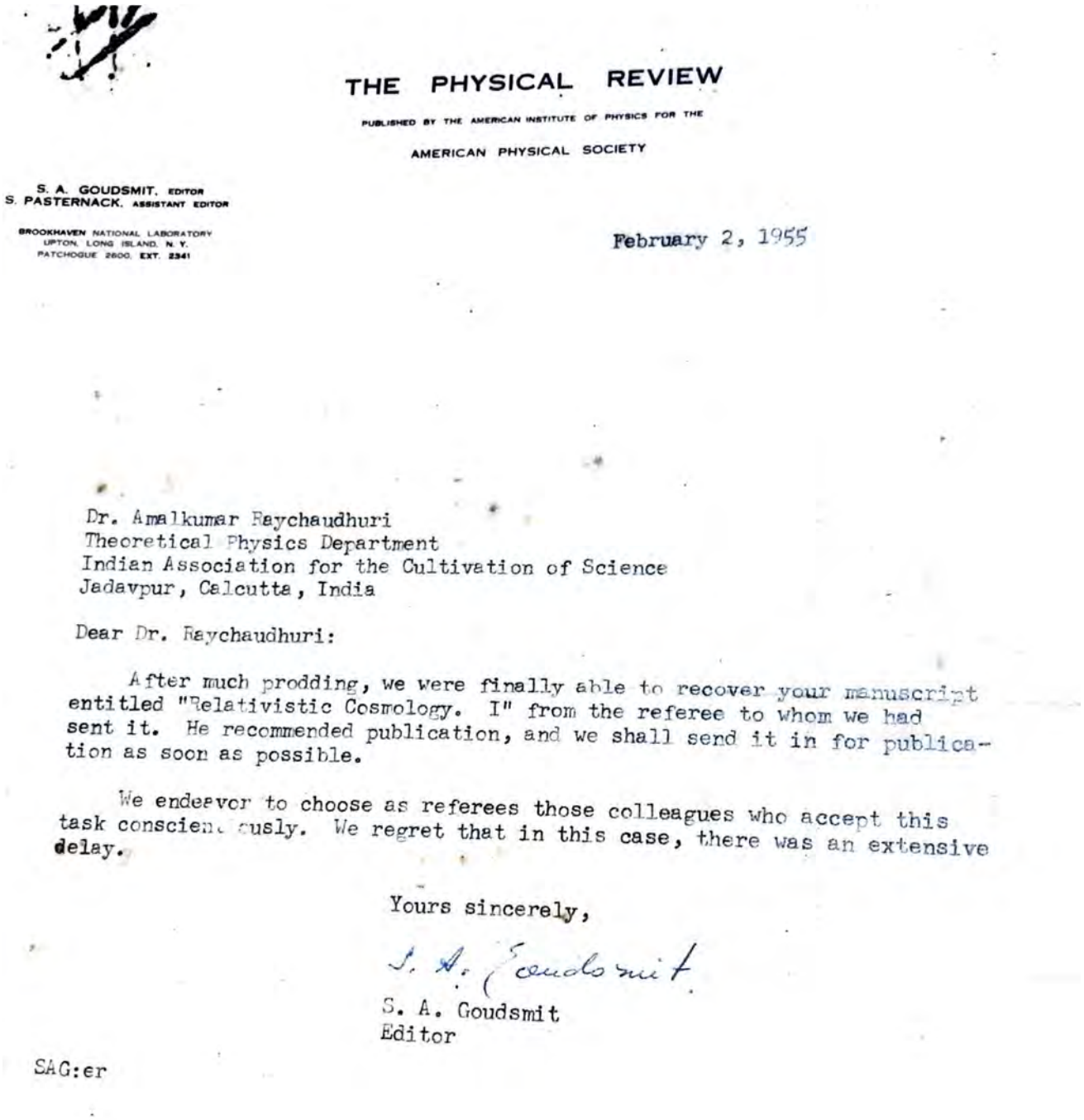
> The astrophysical part was then deleted and the truncated paper was sent to Physical Review with the title "Relativistic Cosmology I", the number was put in the hope that eventually it would be possible to display a rotating non-singular solution and then explore its astrophysical consequences. (However these were never realised.) The paper was received by the *Physical Review* on December 28, 1953. After a formal acknowledgement, there was a long silence when all enquiries to the editor elicited no response. Exasperated by the delay of over a year I sent a copy of the paper to *Zeitschrift für Physik*. Professor Max Von Laue[20] (editor of the journal) opined that the paper was "incomplete" and urged its resubmission after "completion." The acceptance from the *Physical Review* came almost at the same time. The editor made an interesting remark.

The acceptance letter is shown in Fig. 11. Only in the late 1960s singularity theorems made it clear that, within the framework of classical relativistic cosmology, the kind of solution which Raychaudhuri had hoped to present in a second paper could not exist.

It may be worth pointing out that the famous papers by Saha (1920b) and Bose (1924), almost immediately after their publications, were recognized as important by the international physics community of that era.[21] The freedom movement against British rule was gathering momentum in India at that time, and Indian scientists of that era sought to demonstrate that they could compete with their white counterparts. Saha and Bose quickly became the scientific icons for a nation under colonial rule. In contrast, Raychaudhuri was working on general relativity at a time when the community of physicists interested in that subject was quite small. The difficult publication history of the now-famous Raychaudhuri (1955a) paper indicates that the importance of the work was not immediately apparent even to many members of that small community. Commenting on Raychaudhuri's thesis, Ehlers (2006) wrote: "it was fortunate for AKR that John A Wheeler was chosen as his external examiner. Wheeler immediately recognized the significance of the work." Even if Saha had listened to Raychaudhuri's lecture with full concentration, it is unlikely that a non-expert like Saha would have grasped the importance of the work. However, Saha should have realised that the work was based on serious calculations and should have noted that, despite some difficulties, Raychaudhuri was regularly publishing his papers in reputed top journals. Among others in Calcutta, N.R. Sen undoubtedly possessed the technical know-how to understand the key paper (Raychaudhuri, 1955a), although it is doubtful whether he would have appreciated it. Perhaps S.N. Bose was the only person in Calcutta who could have understood the significance of Raychaudhuri's work if he had studied it properly. While discussing Bose's refusal to give a recommendation letter to Raychaudhuri's student, Raychaudhuri speculated that Bose was perhaps not happy with the international recognition Raychaudhuri was getting.

[20] I remind the reader that Laue was the PhD supervisor of N.R. Sen, the pioneer of general relativity research in India, with whom Raychaudhuri had interacted in the early days of his career. Although Laue is now remembered mainly for his work on X-ray crystallography, he had enough technical knowledge about general relativity to evaluate a paper in that field. From his letter to Raychaudhuri reproduced in Raychaudhuri (2007b, pp. 121–122), it appears that Laue himself evaluated Raychaudhuri's paper instead of sending it to a referee. Although he did not reject the paper, he asked Raychaudhuri to resubmit a more complete version of the paper after doing some additional work, without clearly specifying the nature of the additional work which Raychaudhuri was expected to do.

[21] The well-known fact that Einstein himself translated Bose's paper from English to German and published it with his laudatory comments ensured that the paper got immediate attention. For a discussion of the contemporary reception of Saha's work, see Choudhuri (2018).



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UPTON, LONG ISLAND, N. Y.
PATCHOGUE 2800, EXT. 2341

February 2, 1955

Dr. Amalkumar Raychaudhuri
Theoretical Physics Department
Indian Association for the Cultivation of Science
Jadavpur, Calcutta, India

Dear Dr. Raychaudhuri:

After much prodding, we were finally able to recover your manuscript entitled "Relativistic Cosmology. I" from the referee to whom we had sent it. He recommended publication, and we shall send it in for publication as soon as possible.

We endeavor to choose as referees those colleagues who accept this task conscientiously. We regret that in this case, there was an extensive delay.

Yours sincerely,

S. A. Goudsmit

S. A. Goudsmit
Editor

SAG:er

Fig. 11 The acceptance letter from *Physical Review* for the famous paper presenting the Raychaudhuri equation. *Credit* Parongama Sen

Quite likely, J.V. Narlikar was the first Indian to study Raychaudhuri's work in depth while working as a doctoral student of Fred Hoyle (Narlikar, 2006) and subsequently played a significant role in ensuring that Raychaudhuri received his due credit in his own country.

While Raychaudhuri eventually got enough recognition during his lifetime, his work kept attracting more attention after his death—both nationally and internationally—as the community of physicists who would be interested in Raychaudhuri's work kept growing in size. Writing in 2002, the modest Raychaudhuri estimated that his "work will be

prominently mentioned in scientific discussions probably for about 10 or 20 years more." However, during the 5-year period 2020–2024, Raychaudhuri's famous 1955 paper (Raychaudhuri, 1955a) received 195 citations according to Web of Science, despite more than 20 years having elapsed since this statement was made by Raychaudhuri.

I now describe a personal anecdote to indicate how little attention Raychaudhuri's work received within the physics community of India for many years. After I joined the Indian Institute of Science (IISc) as a Lecturer, Raychaudhuri told me that he had never been to IISc and would be interested in visiting it if an opportunity arose. Very soon, an opportunity arose when our Physics Department celebrated its Diamond Jubilee in 1993, and there was some fund to organize lectures by eminent physicists throughout the Jubilee year. I met the senior professor who was the convenor of the Diamond Jubilee programme and suggested to him that we invite Raychaudhuri for a Diamond Jubilee lecture. This senior colleague had never heard of Raychaudhuri's name. He told me that the limited funds available for the Diamond Jubilee celebration could be used only to invite very eminent physicists and could not be used to arrange a lecture by my college physics teacher. After seeing the expression of dismay on my face, he said in a kinder voice that, if I could give the name of a really eminent general relativist working in a prestigious research institute in India instead of somebody working in my former college, then my suggestion would be considered favourably. It remains my regret that, as a junior faculty member at the time without much say in important departmental matters, I could not arrange a visit by Raychaudhuri to IISc.

It may be noted that, at the very beginning of the scientific autobiography, Raychaudhuri expressed the opinion that "it is not possible to make a real breakthrough in theoretical physics if one ... is handicapped by not knowing sufficient mathematics." However, the majority of theoretical physicists working on normal research problems rarely feel handicapped due to inadequate knowledge of mathematics. Only the true pioneers pushing the frontiers of their discipline into totally uncharted territories are often handicapped this way. I end with what Sumit Das, who was a favourite student of Raychaudhuri and was very close to him, wrote to me on this issue in an e-mail dated 5/19/2025:

> I had very long chats with AKR about things scientific and otherwise and took the courage to ask him why he did not want to contribute to the vibrant period of singularity theorems, given the fact that Raychaudhuri's equation was the bedrock of much of those developments. He said something like this [not verbatim] "After a while I simply did not understand the developments around singularity theorems well enough." He was referring to the new mathematical global techniques which were essential in these developments. Then he said something really interesting [again not verbatim] "Maybe this is a tribute to one's achievement – the fact that one does not understand the developments which follow from his own work".

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Conflict of interest The author has no conflict of interest.

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