

## Homi J. Bhabha and Niels Bohr

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*Homi J. Bhabha was one of the scientists to ‘ignite the revolution’ in India in the fields of atomic energy and cosmic rays. Within India and abroad, he interacted with a number of scientists. Niels Bohr – the Danish Noble Laureate and one of the founders of atomic physics, was one of them. Bohr knew Bhabha as a young scholar in Copenhagen, and later as one of the builders of independent India’s nuclear energy programme. At Bhabha’s birth centenary, it will be worth to share a few words about the interaction. The present article is intended to show how the relation between the two started, and how in 1960 Bohr’s visit to India led to close co-operation between the two countries. More importantly, what were Bohr’s views about India’s scientific and cultural achievements? The present paper is largely based on the correspondence of Bohr, Bhabha and Pandit Jawaharlal Nehru.*

After India’s first Prime Minister Jawaharlal Nehru visited Denmark in 1957, the Indo-Danish political relation were marked (Figure 1). So far as the contacts between Danish and Indian physicists are concerned, they began with C. V. Raman’s letter of 21 March 1923 to Niels Bohr. In the letter, he recommended B. B. Ray (one of his early students) for doing research at the newly established Institute of Theoretical Physics (today known as Niels Bohr Institute). To work on X-ray spectroscopy, Ray stayed in Copenhagen (Figure 2) and Stockholm for about two years<sup>1</sup>.

According to the guest book of the Bohr Institute, after 1923 many Indian physicists stayed at the institute. Bhabha was one of them. The various aspects of his life and scientific work are given by different authors<sup>2–11</sup>. The present paper will explore Bhabha–Bohr interaction and Bohr’s views about Indian science and culture.

### Bhabha–Bohr interaction in post-independent India

In 1932 after finishing early education in Cambridge, Bhabha was interested to do research in theoretical physics<sup>12</sup>. Bhabha visited and worked with renowned physicists like Wolfgang Pauli (Zurich), Enrico Fermi (Rome), Hendrik A. Kramers (Utrecht) and Niels Bohr (Copenhagen). With a recommendation letter from Ralph H. Fowler (a theoretical physicist at Cambridge), he went to Zurich.

Fowler in his recommendation letter deformed Bhabha as too opinionated and unruly, who needed a strong hand. Pauli can be as brutal as he liked<sup>13</sup>. Bhabha, who was a self-confident personality,

came along with Pauli. In his first scientific paper titled *Zur Absorption der Höhenstrahlung*<sup>14</sup>, Pauli was thanked for taking interest in the work and discussions.

The Institute of Theoretical Physics with research facilities in experimental and theoretical physics was an intellectual centre. Bohr himself often visited other universities in the UK and Germany. It is very likely that before Bhabha wrote his first letter of 12 December 1935 to Bohr, he knew him. In the letter he asked for a reprint of an article. The paper was on the measurement of the electron magnetic field. About three months later, Bhabha asked for permission to work for 3–4 weeks at Copenhagen institute (Bhabha to Bohr, 9 March 1936). On 14 March 1936, he was informed that Bohr will be away for some days, ‘but [Chri-

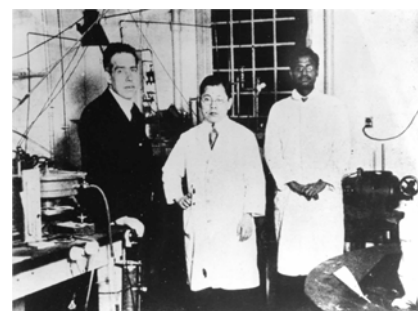
stian] Möller and [Léon] Rosenfeld will be here all the time, and Prof. Bohr himself looks forward to discuss with Bhabha the various interesting problems on which he had been working recently’. According to the plan, Bhabha stayed at the Institute.

In the middle of 1937, Bhabha applied for Warren Research Fellowship, for which he gave Bohr’s name for reference. Later he informed Bohr and apologized for not asking before, as the time was too short. The application was to be sent before 1 July (Bhabha to Bohr, 7 July 1937). So far as the Warren Fellowship is concerned, R. Winckworth – Assistant Secretary of the Royal Society asked for Bohr’s opinion (R. Winckworth to Bohr, 7 July 1937). Bohr recommended the case with high appreciation and stated as follows:

‘The published papers of Bhabha which contain several important contributions especially to our understanding of the secondary effects of so called cosmic rays show not only a complete mastery of the present methods of



**Figure 1.** Pandit Jawaharlal Nehru in Denmark with Karl Skytte and Niels Bohr – 1957 (Courtesy: Niels Bohr Archive, Copenhagen).



**Figure 2.** Niels Bohr, Yoshio Nishina and Bidhu Bhushan Ray – 1924. (Courtesy: Niels Bohr Archive, Copenhagen.)

atomic mechanics but also a great ingenuity in analysing the experimental evidence. Besides I have through my personal contact with Dr Bhabha on his various visits to this institute formed a most favourable opinion of his scientific enthusiasm and keen insight in all problems of actual interest in atomic theory. I do not therefore hesitate to express my great expectations in the fruitful future research activity of Dr Bhabha' (Bohr to R. Winckworth, 10 July 1937).

Bohr informed Bhabha about the recommendation. So far scientific work was concerned, Bohr stated that he is looking forward to see Bhabha's manuscript about the new particles of intermediate mass (Bohr to Bhabha, 11 July 1937). It was in response to Bhabha's letter in which he had written: 'I am just completing a paper on the penetrating component of cosmic radiation. A lot of new material has come to light since we discussed the subject in Copenhagen, . . .' (Bhabha to Bohr, 7 July 1937).

In one of his letters to Bohr, Bhabha had written that he wanted to spend about 3 weeks on the continent before sailing for India. He shall be back in Europe about the third week of October (Bhabha to Bohr, 7 July 1937). According to the plan, Bhabha came to India. From Bombay, in a letter of 30 August 1937 he regretted for not attending Copenhagen conference. He sent a manuscript and asked Bohr to comment on it. He hoped to meet Bohr in Paris Conference in October. Also, he sent his future address in London: Messrs Tata Ltd. Themer House, Millbank.

After a short stay in India, Bhabha returned to UK. While he was in Edinburgh, he received a letter from J. C. Jacobsen and E. Rasmussen, who were asked to collect photographs of Bohr's collaborators. Bhabha thanked for their letter of November 5th and promised to send the photographs, once he was informed about the size. At the same time he asked for data of an experiment on cosmic rays, which was being conducted at the institute (Bhabha to J. C. Jacobsen, 17 November 1937).

*Bhabha, Bohr and Meson:* A new particle with mass between electron and proton was discovered in the USA. The Americans Carl D. Anderson and Seth H. Neddermeyer named it as mesotron. Bohr in

his address at the British Association for the Advancement of Science called it as 'yucon'. Americans were not happy with it as they thought 'mesotron' (intermediate) is the most appropriate name. Robert A. Millikan wrote a letter to Bohr about his views. Bohr's reply was published in the *Physical Review*: 'I take pleasure in telling you that every one at the small conference on cosmic-ray problems, including [P] Auger, [PAM] Blackett, [E] Fermi, [W] Heisenberg, and [BB] Rossi, which we have just held in Copenhagen, was in complete agreement with Anderson's proposal of the name "mesotron" for the penetrating cosmic-ray particles<sup>15</sup>. One of Bhabha's contemporaries recalled that at a meeting in E. Bretscher's house in Cambridge, Bhabha, MHL Pryce *et al.* agreed henceforth to use the word meson<sup>16</sup>. Bhabha wrote to Bohr that in his paper to *Nature*, he had called the new particle meson. Dirac and other physicists in Cambridge find 'meson' better than 'mesotron', wrote Bhabha. But if he (Bohr) does not agree with the name meson, Bhabha was willing to change the name to mesotron. The change can be made in proof (Bhabha to Bohr, 17 December 1938). Bhabha's paper was published in February 1939 under the title 'The fundamental length introduced by the theory of the mesotron (meson)'. In the footnote Bhabha wrote:

'The name "mesotron" has been suggested by Anderson and Neddermeyer (. . .) for the new particle found in cosmic radiation with a mass intermediated between that of electron and proton. It is felt that "tr" in this word is redundant, since it does not belong to the Greek root "meso" for middle, the "tr" in neutron and electron belong, of course, to the roots, "neutr" and "electra". In these circumstances, it seems better to follow the suggestion of Bohr and to use electron to denote particles of electronic mass independently of their charge. It would therefore be more logical and also shorter to call the new particle a meson instead of mesotron<sup>17</sup>.

In his letter of 17 December 1938, Bhabha informed Bohr about the footnote. Due to support from influential European physicists, Bhabha's baptism of the new particle was accepted.

It is a well-known story that in 1939 Bhabha came to India for vacation.

Meanwhile the World War II broke out, which made his return impossible. C. V. Raman at the Indian Institute of Science, Bangalore, was fascinated with Bhabha's scientific work. He not only communicated Bhabha's papers, but also proposed him the Fellowship of the Royal Society of London (Figure 3).

### Bhabha-Bohr contact in independent India

Against Adolf Hitler's well-equipped armies, small countries like Denmark had little chance. Like other European Jews, Bohr's life was in danger. Overnight, he left Copenhagen and first went to England and then to USA. He worked in the famous Manhattan Project. The efforts of scientists lead to the production of atomic bombs. The defeat of Japan and Germany marked the end of the Second World War. The atomic bomb had shown the military potential of the new weapon. Not only the western, but also Indian men of science and politics took its notice. Indian politicians like Nehru and physicists, Bhabha and M. N. Saha took initiative to start the nuclear programme. 'Atomic material' – thorium containing monazite sand was available in Travancore. In 1945, the Dewan of Travancore permitted the minerals attaché of the US embassy to make a survey. In the beginning of the 1946, the newly founded Council of Scientific and Industrial Research announced that it would begin a survey of Travancore for searching atomic minerals. An immediate protest followed from the Dewan. After a meeting with the CSIR's Board of Atomic Energy Research, he agreed to support the national interests. However, the Dewan was not a reliable partner as he started negotiation with foreign firms. Nehru and Bhabha were determined to prevent it. Nehru not only prevented the sand-business, but also nominated Bhabha as scientific adviser to the government. This officially acknowledged Bhabha as the national expert<sup>18</sup>. In October 1946, Nehru as the President of the Indian Science Congress Association sent a letter to Bohr through P. C. Mahalanobis, and asked to send a delegation to attend the meeting in Delhi from 2 to 8 January 1947. It was ensured that all the expenses would be paid by the executive committee (J. Nehru to N. Bohr, 30 October 1946). At the first anniversary of India's

independence in 1948, Bohr was invited again (Royal Danish Ambassador to Bohr, 16 December 1947). However, due to pressing duties he could not attend. In the same year, the Atomic Energy Commission was created, with Bhabha as the chairman.

To establish atomic physics in India, Bhabha often invited renowned western physicists. For instance, Bernard Peters who had worked in the Manhattan Project stayed at the TIFR from 1951 to 1958. He taught Experimental Physics. After leaving India, on Niels Bohr's invitation, the family moved to Denmark. There he worked at the Institute of Theoretical Physics. Later, he established the Danish Space Research Institute<sup>19</sup>. C. Möller, whom Bhabha knew from his stay in Denmark, was also invited. One of Bhabha's letter states as follows:

'I am glad to know that you enjoyed your trip to India. . . I should like very much to attend a conference in Copenhagen again but it is doubtful whether I will be able to come from the 6th to the 10th July. . . In any case, if, after the date of the conference has been definitely settled, an invitation is sent to me by Bohr it will help me to make arrangements for attending it'

(H. J. Bhabha to C. Möller, 2 March 1951).

Needless to say, Bohr sent the invitation. Bhabha knew that in 1952 Bohr was being invited for the Annual Conference of the Indian Science Congress Association. He asked Bhabha to stay in Bombay (H. J. Bhabha to Bohr, 24 July 1951). However, due to his duties at the institute, Bohr did not come.

**Bohrs in India – offering collaboration in science and culture**

The copy of the 'Provisional itinerary of Prof. & Mrs Niels Bohr' shows that Bohr and his wife arrived on 3 January 1960 in Bombay. Apart from official lectures, the pair had time to visit the Elephanta, Elora and Ajanta caves. On 5 January 1960 at the Indian Science Congress Association, Bohr delivered a popular lecture on 'Atoms and Human Knowledge'. He suggested to the younger generation to pool their experimental evidence on nuclear science to unravel the mystery of the atom. He said that there was tremendous scope for international co-operation and exchange of knowledge for

the development of atomic science (*The Times of India*, 6 January 1960). At the University of Bombay he gave a convocation lecture. The University conferred Doctors of Laws (LL D.) degree on him (*The Hindu*, 6 January 1960). Bohr also visited Madras, Calcutta and Delhi. In Delhi a local newspaper reported:

'Denmark has offered to collaborate with India in the country's scientific development. Indo-Danish co-operation it is understood, will take the form of exchange of professors and scientists and Danish help on problems of nuclear energy. This offer was made today by Dr Niels Bohr, Chairman of the Danish Atomic Energy Commission, to Mr Humayum Kabir, the Scientific Research and Cultural Affairs Minister. . . The Danish offer, it is understood, has been welcomed by India' (*The Statesman*, 28 January 1960).

Another newspaper reported that Bohr has admired the progress in the scientific field in India, particularly with regard to the work done by the atomic energy establishment at Trombay (see Figure 4). He also said that India already had a highly trained and efficient set of nuclear scientists and what he saw at Trombay had made him greatly admire all that was being done to make the country self-reliant in atomic energy (*The Times of India*, 28 January 1960). When he was asked, whether India is in the position to make an atom bomb, he replied that any country that had powerful reactors could make the bomb. But he fervently hoped that bomb would never be used.

**The meeting of science and politics: Nehru, Bhabha and Bohr**

As we have seen above, Bohr and Nehru already knew each other. Their second



Figure 4. Homi J. Bhabha and Niels Bohr in 1960 (Courtesy: TIFR, Bombay).

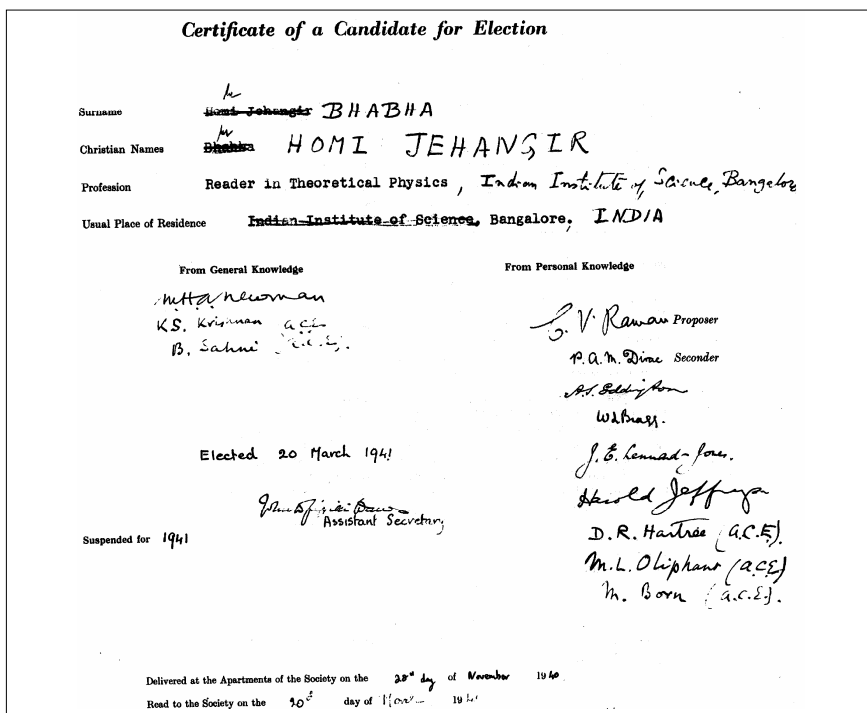


Figure 3. The lower and upper part of Bhabha's nomination letter to the Fellowship of the Royal Society London. Here 'the citation-part' is not reproduced. As one can see, C. V. Raman proposed and PAM Dirac seconded. From India, K. S. Krishnan and Birbal Sahni supported Bhabha's case (Courtesy: Royal Society of London).

## HISTORICAL NOTES

meeting took place in Delhi. After his return to Copenhagen, Bohr wrote a long letter to Nehru, dated 10 February 1960. The letter is produced below to show Bohr's testimony for Indian culture and science. In part it reads:

'During our travels in India we were both enchanted by the marvellous historical monuments, which speaks so strongly of what art can give if there is a true human culture behind. The spirit of Indian people which through the ages have been able to assimilate so many different cultural movements made us, indeed, in a deep sense feel at home in your country.'

After appreciating Indian culture, he turned to the scientific achievements and wrote:

'Through my contact with the Indian academic institutions I was also deeply impressed by the enthusiasm shared by the leading scientists as well as the students, and I greatly admired the foresight with which the endeavours for promoting the welfare of the people on the basis of the progress of science and technology were planned under your leadership.'

Bohr went on further:

'I feel, indeed, confident that these endeavours will not only be of great benefit for India, but will even come to serve as a help and encouragement for other peoples faced with similar problems'.

Bohr was much impressed by Nehru's private conversation, which took place on the 'unforgettable day' he and his wife spent with Nehru and his family. About his stay and talk he wrote:

'All what I learned, and especially from my talk with you which will always be some of my most treasured remembrances, reaffirmed my expectations of the role which your country is called to play in the creation of that brotherhood between nations which is necessary for the future of mankind. In this great cause the closest possible international collaboration will surely be of a decisive importance, and here in Denmark we shall be happy if in any field, even in a most modest way,

advice and assistance might be given from our small country.'

So far as the nuclear energy programme was concerned, he added:

'I talked with Dr Bhabha about the possibilities for such collaboration and we are looking forward to a visit from him in Denmark in the spring, when we will go thoroughly into technical matters.'

From the forging we see that it was not only a matter of cooperation in the field of atomic energy, but also other issues. It is further supported by the letter, which Bohr wrote to Humayun Kabir. It reads as follows:

'... I have given much thought to the question of ways to establish fruitful collaboration in the various fields, and in this connection my Danish colleagues and I are eagerly awaiting visits here in the near future of Professor (M.S.) Thacker (General Director of Counsel of Scientific and Industrial Research) and Dr Bhabha. At this institute we are also looking forward to a visit soon of Dr Radhakrishnan to discuss scientific and educational questions' (Bohr to H. Kabir, 4 April 1960).

After Bohr's visit to Bombay, Bhabha and Bohr came very close as their correspondence suggests. Bohr was no more 'Dear Professor Bohr' but only 'Dear Niels' to whom Bhabha sent best wishes and closed his letter with 'yours ever' (Bhabha to Bohr, 11 March 1960). What about Bohr? His letter was addressed not to 'Dear Dr Bhabha' but to 'Dear Homi' and closed with 'yours ever' (Bohr to Bhabha, 6 December 1960). Despite difference in age, a close friendship developed. During his next visit to Copenhagen, Bhabha stayed at Bohr's house.

A copy of Bhabha's programme shows that he made a world tour between 22 April 1960 and 12 June 1960. He visited Cairo, Vienna, Geneva, Copenhagen, Paris, Bonn, Zurich, London, and Moscow. In the end of 1960, Bohr was asked by Bhabha to attend on 16 January 1961 an inauguration ceremony of a reactor and other new facilities at Trombay by the Prime Minister. It was to be followed by lectures, a 12 days tour in India and

the last five days in Delhi to enable the delegates to participate in the Republic Day Celebrations in Delhi (Bhabha to Bohr, 19 November 1960). Bohr, who was already 75 years old, thanked Bhabha for the invitation, which he had to turn down 'to economize his time and strength', as he wrote. However, he assured that in response to the invitation to the Danish government to be represented at the great occasion, our Atomic Energy Commission will arrange for one of our all-round orientated experts to attend the inauguration. So far as the cooperation was concerned, he mentioned that the government and the commission have great interest for the plans discussed during Bhabha's visit to Copenhagen of a closer cooperation with exchange of experience for mutual benefit. He proposed to send H. H. Koch as the Chairman of Executive Committee and some of the Danish experts to discuss actual problems and future plans with Bhabha and his collaborators (Bohr to Bhabha, 6 December 1960). After informing Nehru about this initiative, Bohr wrote:

'As you may also know, we are expecting a visit to Denmark in the spring by Dr Thacker, with whom we are looking forward to discuss the best way of promoting the cooperation between India and our country as regards many other aspects of scientific and industrial development' (Bohr to Nehru, 4 January 1961).

While discussing the establishment of the Risoe Nuclear Research Centre in Denmark, historians Henry Nielsen and Kristian H. Nielsen show that 'No responsible Danish minister would ever think of taking any action concerning the topic of "atom" without consulting the nation's legendary physicist'<sup>20</sup>. Obviously, the decision taken to send particular person to India, was due to Bohr.

Christian Thomsen (Chief of the secretariat of the Danish Atomic Energy Commission) was sent to India as an official Danish delegate to attend the inauguration of the new great atomic reactor in Trombay (Bohr to Mahalanobis, M. S. Thacker, Jan. 12, 1961).

Bhabha once again invited Bohr to attend the inauguration ceremony of the new buildings of the TIFR (Bhabha to Bohr, 30 September 1961). Bohr apologized for not being able to come to India. Further he wrote: 'I hope you have recei-

ved my answer to your telegram, and I enclose a copy of the message to the inauguration, which some days ago I had given Peters on his departure for Geneva on his way to Bombay' (Bohr to Bhabha, 10 January 1962).

In the middle of January 1962, Bohr wrote to Nehru and introduced his close friend H. H. Koch (Chairman of the Executive Committee of the Danish Atomic Commission) who was going to India for consultation about cooperation between the Indian and Danish atomic energy organizations (Bohr to Nehru, 19 January 1962). The document suggests that due to illness, Koch could not come to India. His colleagues Jacobsen and P. Oelgaard were in Bombay. They proposed certain lines for cooperation. Before the next meeting with Koch, exchange of information reports, etc. was planned (Bhabha to H. H. Koch, 13 February 1962).

Further research is suggested to explore the story of the Indo-Danish cooperation after 1961. According to rules, one needs to wait till the 50-year ban on the documents lapses. In fact, none of Denmark's three research reactors at Risoe operates any more. The last to be taken out of service was DR3, and this happened in 2000 (ref. 21). Two larger and newer units have been shut down. Denmark can afford to do so, as she has ca. 5.5 million inhabitants. Apart from that it imports electric power from neighbouring countries. So far as India is concerned, India has 17 reactors operating, 6 reactors under construction, and is planning an additional 4, with 15 more proposed<sup>22</sup>. Even this number is small, if one considers the country's demand for energy for more than one billion population.

In order to give true homage to Bhabha, it will be fair to say a few words about those who accompanied him and later continued his dream. No doubt, Bhabha was one of the few Indian physicists who ignited atomic revolution, but there were/are many who kept/keep the light burning. A few of them are: K. Chandrasekharan, R. R. Daniel, M. G. K. Menon, B. Peters, D. Lal, R. Narasi-

mhan, K. G. Ramanathan, K. S. Singhvi and B. M. Udgaonkar<sup>9</sup>. In this context, it will be worth to quote from Bohr's speech at the University of Bombay. Before conferring the doctorate degree on Bohr, T. M. Advani (Vice Chancellor of the University) read out a six-page citation about Bohr's career and achievements. Bohr's response has been reported in a newspaper as follows: 'Prof. Bohr said that he had listened with "deep emotion" to the kind words spoken about him, but at the same time he felt that the question of personal achievements in the field of science was a "very dubious one"' (*The Hindu*, 6 January 1960).

Thus, the success of Indian atomic story needs to be seen not as a one-man show, but a common effort of many scientists and politicians. This is a true celebration of Bhabha's 100th birth anniversary.

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