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Book Review

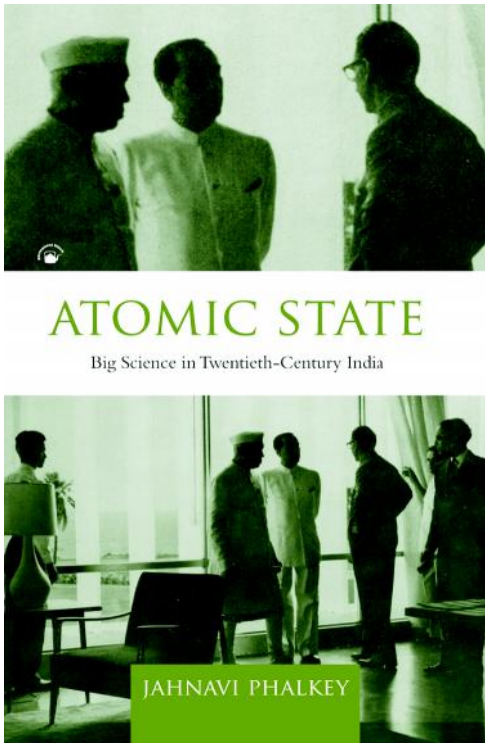
Atomic State - Big Science in Twentieth Century India

Jahnavi Phalkey, 2013, Permanent Black, Ranikhet 263645, ISBN 8178243768, 9788178243764, Pp- 335 (Price: Rs. 795.00)

"Atomic State – Big Science in Twentieth-Century India", authored by Jahnavi Phalkey, is a compilation of fascinating and well researched trans-national histories of nuclear physics education and research, based on low energy particle accelerators, in pre-and post-independent India. The commentary connects the contemporary political history of the world and the sub-continent and the changing relationship between science and politics, during the period from late 1930s to late 1950s, highlighting three distinct but related stories of the following three prominent physicists and their Institutes:

- C V Raman, FRS (1924), the first Noble Laureate (NL) in Physics (1930) in Asia and the first Indian Director of IISc in 1933 and who started the physics department at IISc;
- M N Saha, FRS (1927), Palit Professor at the Department of Physics, University of Calcutta (now Kolkata) and who founded the Institute of Nuclear Physics (INP); and
- H J Bhabha, FRS (1941), founder Director of the Tata Institute of Fundamental Research (TIFR), Chairman of the Atomic Energy Commission of India (AECI) and the first Secretary of the Department of Atomic Energy (DAE), Government of India.

The other eminent physicists in this book are R S Krishnan and B D Nagchaudhury who were student and close associates of Raman at the Physics department of IISc and Saha at the INP respectively. They were trained abroad on cyclotrons during 1938-41. The book also mentions about D Y Phadke, a colleague of Bhabha and an expert in electronics and vacuum technology, who was in In-Charge of the accelerator group at TIFR in the 1950s.



S S Bhatnagar, FRS (1943), a physical chemist and the first Director of the Council of Scientific and Industrial Research (CSIR), established by the British in India in late 1942 for war-related research, also finds a prominent place because as a science administrator he facilitated the TIFR to be the dedicated laboratory for nuclear research under the CSIR.

The book also highlights the key role played by Jawaharlal Nehru, the first prime minister of independent India, who resonated well with Raman, Saha, Bhatnagar and Bhabha from the pre-independent days and shared their views on building a modern India based on state-funded science and

technology and realised the importance of being nuclear. Patrick Blackett, NL of the Cavendish laboratory, UK and Jean Juliot Curie, NL of Radium Institute, France advised and influenced Nehru on India's nuclear programme during the initial years of the AECI and interacted closely with Saha and Bhabha.

The story focuses on the accelerator based research ambitions of Raman, Saha and Bhabha in establishing nuclear physics in India, mentions about their close contacts and interactions with the best nuclear physicists of their times in Europe and USA and unravels their professional competition, at times unpleasant confrontation and seldom collaboration. Raman was driven by the 'modernist imperative' of cyclotron, Saha wanted a cyclotron and a state-of-the art nuclear physics laboratory for cutting edge research and also had in mind medical application of cyclotron. Bhabha was interested in accelerators to train young physicists in nuclear science and wanted to have a betatron in particular to further his research interests in cosmic ray physics.

Nuclear physics had emerged as the frontier of modern science in the 1930s in the West, after some historic discoveries and inventions in quick succession. First, Chadwick, NL discovered the 'neutron' in 1932 in the Cavendish laboratory, Cambridge, and Cockcroft and Walton, NLs invented the electrostatic particle accelerator. In the same year in USA, Anderson, NL (California Institute of Technology) discovered the 'positron' and Lawrence, NL (University of California, Berkeley) invented the 'cyclotron' (an advanced type of particle accelerator) for smashing the atoms. Next, the Joliot–Curie couple, (NLs, Radium Institute, France) in 1934 and in 1938-39, Otto Hans (NL) and Meitner & Strassmann (University of Berlin, Germany) discovered the 'fission' of uranium atom by neutrons and the enormous energy that is released in fission.

In the early 1940s, during the World War II (WW II), plutonium, the man-made element, which can also undergo fission with neutron, was discovered and isolated by Seaborg, NL and his colleagues (University of California, Berkeley) in 1940-41 and in December 1942, Fermi, NL (University of Chicago) demonstrated the fission chain reaction in the make-shift nuclear pile (reactor). Soon after, USA secretly developed the uranium and plutonium based atom bombs and used them on Japan in August 1945, causing unprecedented deaths and destructions. The power of the atom overwhelmed the scientific community and political leadership all over the world, including India. The arrival of the nuclear age, following WW II, and the departure of the British provided unique opportunity to the leading scientists of India to embrace nuclear physics and promote their science, their career and develop independent India into a modern state, based on science and technology in collaboration with the political leadership. The quest in physics progressively changed from spectroscopy, astrophysics and quantum mechanics to nuclear and high energy particle physics as the Indian scientists did not want to lag behind the most modern branch of science.

The three eminent physicists shared the common vision with Jawaharlal Nehru who in the eve of India's independence in 1947 envisioned a 'great atomic energy research institute' as a state agenda. Nuclear research became inextricably linked with warfare after WW II and became a matter of state legislation. The use of nuclear fission for peaceful purpose emerged only after the historic 'atom for peace' initiative by USA in December 1953 at the United Nations General Assembly, balancing the fears of continuing nuclear armament with promises of peaceful use of atomic energy using nuclear reactors. The 'atoms for peace' opened up nuclear research to civilians and countries that had not previously possessed nuclear technology.

Raman in Bangalore and Saha in Calcutta were the first to initiate action in the late 1930s on the development of infrastructure in their laboratories for participating in nuclear physics research as an international activity. Earlier, in 1936 Saha had visited the cyclotron facility at Berkeley and Copenhagen. Towards their endeavour in nuclear physics since the late 1930s, Raman, Saha and Bhabha had received funds and patronage of the Tata Trust, grants from overseas research foundations,

support and encouragement of the political leadership, particularly Nehru, and advice and technical support from fellow physicists in Europe and USA. During this period there have been frequent exchange of experts and training of Indian physicists in leading laboratories in Europe and USA. Thus, the history of nuclear research in India is indeed trans-national.

The author has narrated the transition in the quantum and source of funding, transition in research facilities for doing experimental physics and transitions in the political scenarios in the Indian sub-continent and in the world during 1930-1959 and tried to connect and correlate them. First, there has been the transition from low budget research activities in the University laboratories by an individual or a small team using makeshift, table-top experimental set up to 'big' science, involving complex and interdisciplinary 'big' experimental set up and 'big' machines with sophisticated instrumentation and controls, and 'big' money, in state-funded national or multinational institutes. Secondly, the dramatic political changes during 1945-47 after the end of WW II and the beginning of cold war between USA and USSR, changed the world order. India achieved independence from British in 1947 but had to bear the pain and agony of the 'partition'. These political developments had significant impact on the availability of funds, import of equipment and transfer of nuclear knowledge and expertise from Europe and USA to India. All nuclear research activities were looked with suspicion because of their built-in dual use for peaceful applications and weapons development. For example, the construction of cyclotron at INP was slowed down because of these factors and the political turmoil in Calcutta due to influx of refugees following the partition.

Phalkey has chosen "particle accelerators" or the 'atom smashers ', particularly the 'cyclotron', and the laboratories and prominent scientists around these 'big' machines in Europe, USA and India, as the central theme of her book. The introduction of cyclotron in the 1930s marked the advent of 'big' science in the West.

In Chapters 1 and 2, Phalkey has traced the academic roots of physics research in universities and research institutes since the beginning of the twentieth century in pre-independent India and, the onset of nuclear physics activities in the late 1930s till the mid 1940s. The National Planning Committee and the CSIR were established in 1938 and 1942, respectively for science based industrialization of modern India. The TIFR was set up in Bombay with grants from the Tata Trust in December 1945, as a CSIR laboratory for nuclear research, with Bhabha as Director. Soon after WW II, the structure of the nuclear physics research in India was outlined and the Atomic Energy Research Committee (AERC) was formed in May 1946 with Bhabha as Chairman. The author has also referred to the historic Indian Science Congress at Delhi in January 1947, where Nehru presided. Several Noble Laureates and eminent scientists from Europe, USA, Russia and China and delegations from the Royal Society and British Association for Advancement of Science (BAAS) attended the conference. In his presidential address Nehru announced his plan of having a state-funded atomic energy research institute in India. The chapter then mentions the formation of the Atomic Energy Commission of India (AECI) in August 1948 with Bhabha as Chairman and Bhatnagar, K S Krishnan, and Patrick Blackett, NL as Members.

The first chapter has highlighted an important fact that in pre-independent India, physics research was rarely funded by the state. Grants came mostly from princely states and national philanthropist. The institutionalization of physics research in India began with the establishment of the Indian Association for the Cultivation of Science (IACS) at Calcutta in 1876. I may add that IACS was set up with funding from Mahendra Lal Sircar, a private medical practitioner and a philanthropist. Likewise, the Indian Institute of Science (IISc) in Bangalore was set up in 1909 by the generous funding of Jamshetji Tata and the Maharaja of Mysore; the University Science College (USC), Calcutta was also established in 1914, at the initiative of the then Vice Chancellor of Calcutta University, Asutosh Mukherjee, with private funding from T Palit and R Ghosh, The funding for setting up the TIFR came mainly from the Tata Trust, who also

provided grants for nuclear physics research at TIFR, IISc and USC in the 1940s.

Phalkey has referred to the golden era of physics in India in the first quarter of the twentieth century, particularly in Calcutta. J C Bose, C V Raman, K S Krishnan, M N Saha, and S N Bose did pioneering research in electromagnetic wave, spectroscopy, astrophysics and quantum mechanics from this city and were all decorated with the prestigious Fellowship of the Royal Society (FRS) in London. S N Bose and M N Saha were from the 1915 MSc physics batch of USC. J C Ghosh, the successor of C V Raman as Director of IISc and frequently referred to in this book in Chapter 3, was his batch mate. The pioneering contributions of J C Bose in radio and microwave optics and later in plant physiology are also mentioned. I may add that J C Bose, the first physicist from the sub–continent to be elected FRS in 1920 was Professor of Physics in Presidency College, Calcutta where he used his own money to set up make-shift experimental facility. His contribution received attention in Europe but ironically he could not get state support for setting up a laboratory for his research. Likewise, Raman and Krishnan also made low cost, table-top experimental set up at IASC for their spectroscopy experiments for which Raman received the Noble Prize in 1930.

The Chapters 3, 4 and 5 elaborate the efforts and local histories of nuclear physics education, training and research, around particle accelerators at IISc (Raman and R S Krishnan), USC – INP (Saha and Nagchaudhury) and at TIFR (Bhabha and the accelerator group led by Phadke). The histories did not seem to have happy ending. Raman and Saha were marginalised mainly because of the centralization and state-led organization that recognised only TIFR to engage in large scale research on nuclear physics in India. The team responsible for building accelerators under Phadke was more or less dissolved by 1959.

In Chapter 3, the author has described the beginning and termination of nuclear physics activities at IISc, Bangalore. Raman, being aware that nuclear physics with particle accelerator had become an important field of inquiry, deputed his student R S Krishnan in October 1938 to the Cavendish Laboratory for training on the operation of cyclotron and conducting experiments. Krishnan ran the cyclotron almost single handed for nearly two years and successfully studied the bombardment of heavy elements like uranium and thorium with deuteron for his PhD degree on 'investigations in artificial radioactivity'. On his return to IISc, Bangalore, he and Raman jointly submitted four research proposals during 1945-47 for setting up a radiation laboratory in IISc with a cyclotron, an electrostatic generator, an intense natural radium source and detecting instruments. The AERC did not accept any of the proposals but Krishnan was invited by Bhabha to join the TIFR accelerator group at Bombay. Krishnan did not leave Bangalore, succeeded Raman as Head of the Physics department in IISc and changed to solid state physics research.

The Chapter 4 narrates Saha's initiative on education and research on nuclear physics at USC, Calcutta. Saha's own research area has been theoretical work of high temperature ionization of elements and its application to stellar atmospheres. Many eminent physicists in India and abroad thought that he deserved the Noble Prize in astrophysics for his pioneering contribution of the famous Saha's thermo-ionization equation. Initially, Saha was not actively engaged in research on nuclear physics, but following his educational tour in Europe and USA in 1936, where he met leading physicists like Neils Bohr, NL (Copenhagen) and Earnst Lawrence, NL (Berkeley), and was impressed with the cyclotrons in their laboratories and their medical applications. This motivated him to embark on setting up a nuclear physics laboratory at USC. As the first step in August 1938, Saha arranged a graduate program for his student B D Nagchaudhury on design, construction and operation of cyclotron at Berkeley directly under Lawrence, the inventor of cyclotron. Saha introduced nuclear physics as a compulsory subject in the MSc Physics curriculum at Calcutta University with focus on biophysics and nuclear chemistry. Nagchaudhury completed his experimental work with cyclotron at Berkeley with PhD degree for his thesis on artificial radioactivity. On his return to Calcutta in 1941,

Nagchaudhury was entrusted by Saha with the responsibility of constructing a 37 inches cyclotron, similar to one of the initial cyclotron models at Berkeley. The cyclotron was commissioned in 1954 under very challenging circumstances after a long struggle of nearly 14 years and Saha was successful in transforming the university set up of Palit laboratory into the Institute of Nuclear Physics (INP) with a working cyclotron. However, Saha's dream to 'establish INP as the central laboratory for experimental nuclear research in India with cyclotron, research reactor and other facilities was not realized. Saha entered the Indian politics as an elected independent MP in 1952 and left the reins of INP mainly in Nagchaudhury's hand. The author has nicely concluded the chapter by stating that 'despite conflict, contest and the inability of the AECI to make place for the INP within its agenda for nuclear research, the AECI appeared aware of the INP as an asset for promoting the image of Indian nuclear research and continued funding it'.

Chapter 5 elaborates the nuclear physics activities at TIFR under the stewardship of Bhabha (1909-1966), the Founding Director, who was much younger than Saha (1893-1956) and Raman (1888-1970) and the only one of the three to have studied and trained abroad. Bhabha had a first Tripos on mechanical sciences and a second Tripos in mathematics from Cambridge and worked at the Cavendish laboratory for his doctorate in theoretical physics. His priority in nuclear physics research, when he shifted to Bombay in December 1945 was in theoretical physics of elementary particles and experimental cosmic ray physics. He believed that nuclear and cosmic ray physics are inseparable being closely connected theoretically. The AERC established TIFR as institute of national priority in May 1946. Over the three years between end of WW II and the year after India's independence, Bhabha emerged as the leader of nuclear research in independent India and the TIFR was provided funds for increasing its research and man power training activities. TIFR was in fact the last of the three centres at Bangalore, Calcutta and Bombay to enter the field of particle accelerators in the first half of the 1950s 'on the margins of atomic energy related research and in continuing subordination to cosmic ray research'. A 1 MeV Cascade generator was purchased in TIFR in 1950 and three accelerator groups were formed for construction of a 12 "cyclotron, an open air 1 MeV Van de Graaff and a 1 MeV linear accelerator.

This Chapter also narrates Bhabha's meteoric rise as a 'science administrator' and as a world leader in nuclear science during 1954 to 1957. First, the Department of Atomic Energy (DAE) was set up in August 1954 with Bhabha as Secretary of the Government of India reporting, directly to the Prime Minister. In August 1955, Bhabha was invited to Chair the historic 'atoms for peace' conference at Geneva. In August 1956, India's first research reactor APSARA was commissioned at Trombay in the presence of Pt. Jawahar Lal Nehru. In January 1957, Atomic Energy Establishment Trombay (AEET), an independent research establishment of AECI, was dedicated to the nation and in August 1957, AEET had its first Training School.

The author has critically analysed the ambiguity in the role of TIFR since its formation as a CSIR laboratory for nuclear research and also a national laboratory for AECI. As per CSIR mandate, TIFR should have developed an agenda of applied and industrial research. It did not. Instead, it was caught in Bhabha's ambitions and pragmatism in cosmic ray during 1945-53. Then, between 1954 and 1959 TIFR was caught between AECI's priority of building nuclear reactor on one hand and fusion research on the other. The author has concluded that 'if the TIFR was to remain an institution of fundamental research in nuclear physics, the AECI had to have its own research establishment for applied research. This was accomplished by the establishment of AEET in the relative marginalization of experimental nuclear physics in TIFR'.

To conclude, I might say that the research and development efforts of the AEET (renamed BARC in the memory of Bhabha) in the formative years of the nuclear programme in India in the 1950s and 1960s have paved the way for the country to do 'big' science with 'big' machines and 'big' money and

become a self-reliant 'atomic state', with state-funded training schools, research institutions and industrial units dedicated to nuclear science and engineering under the DAE, Government of India. The outcomes of these initial efforts have culminated in opening of several technological fronts in the peaceful use of nuclear energy. The so called peaceful nuclear explosion (PNE) at Pokharan, Rajasthan in May 1974, mentioned by the author, is a small but important spin off. I fully agree with Phalkey on two important issues. First, that the history of nuclear physics in India is much longer than the history of PNE and can be traced to 1938. The author has rightly stated that the history of the PNE is rather recent and cannot be convincingly dated before the mid 1950s. Secondly, that Raman, Saha, Bhabha and Bhatnagar did science mainly for their love of science and for nation building. At times, they might have mobilized their political connections to further their science but they were not motivated by politics to do science.

Finally, I congratulate Phalkey for her brilliant contribution to the history of nuclear physics research in the formative years of the atomic energy programme in India till the late 1950s. The book should find a prominent place in the libraries of all universities, academic institutions, CSIR laboratories and the DAE units in India and will make for delightful reading for all scientists including physicists and social scientists and historians who are sure to savour some of the hitherto unpublished anecdotes and facts, which Phalkey has untiringly collected from personal and institutional archives.

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