



Dr. Raja Ramanna: A brief Bio-memoir

by

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Dr. Raja Ramanna was, in many ways, a towering personality with interests and accomplishments covering wide areas of nuclear science and technology, institution building, music, philosophy, human resource development, science policy, planning and administration. He passed away on 24th September 2004 in Mumbai at the age of 79 years. I had known him personally for close to fifty years.

Raja Ramanna was born on 28th January 1925 in Tumkur, Karnataka. He had his early education in Bangalore; and graduated from Madras Christian College, Tambaram with B. Sc (Honors) in Physics; it was one of the very good colleges of those days that imparted not only good academic training but also encouraged a breadth of interests. Dr. Ramanna has written admiringly about his teachers and their influence on him. But as Dr. Ramanna has remarked in his autobiography, the greatest early influence on him was his mother, Rukminiamma, the grand daughter of a very distinguished personality of Karnataka-Shri B.V.K. Iyengar. His mother was a brilliant personality, very modern in outlook, a voracious reader in English and Kannada and totally unconventional.

Early in his life, Raja Ramanna got deeply interested in music, particularly playing the piano, and came to the notice of the Maharaja of Mysore, Krishna Raja Wodeyar as a prodigy; the Maharaja was kind to him and encouraged him in many ways that he was grateful for. Homi Bhabha was also impressed, when he noticed Raja Ramanna playing the piano at the State Government Guest House in Mysore in 1944; it was thus that Homi Bhabha recommended Raja Ramanna to the J.N. Tata Endowment for the Higher Education of Indians for a scholarship to enable him to go to England for a Ph. D in Physics.

Along with music, in which Raja Ramanna could have made a professional career, he was also deeply

interested in nuclear physics, a subject to which he was introduced through the famous article of Hans Bethe in the 'Reviews of Modern Physics'-and so he went to London for a Ph. D in nuclear physics. Raja Ramanna interacted with some of the top figures in nuclear and condensed matter physics during his stay in England. His first supervisor was Prof. Alan Nunn May, who was later arrested for leaking atomic secrets to the Russians! He worked with Prof. F. C. Champion; and was advised by Dr. D.H. Wilkinson and also, at some stage, by Prof. James Chadwick, the discoverer of the neutron. He learnt quantum theory through lectures given by Prof. Neville Mott, who later won a Nobel Prize. (Incidentally, I also attended the lectures of Prof. Mott on quantum theory and solid-state physics when I was at Bristol).

The problem Raja selected for his research was "study of angular distribution of fission fragments – produced by neutrons emitted in fission – using a collimated beam of fast neutrons". Though he could not solve this problem at that stage completely, he succeeded much later whilst working at Trombay. This was the area, which was to become his lifetime mission: namely, neutron physics and fission physics; and this were the underpinning science for both the generation of nuclear power and for nuclear explosives. By 1948, he had obtained his doctorate degree in physics from London University.

In his autobiography Dr. Ramanna has remarked on fashions in science, particularly physics;-how, in the post war years, high energy elementary particle physics and become fashionable, and areas like low energy nuclear physics and solid state physics were given lower status; but he chose to work on problems in low energy nuclear physics since he found them exciting. This was a good attitude to take e.g. not necessarily follow the fashion. (I myself was in the fashionable (!) area of high energy elementary particle physics, having worked in this area



entirely by personal motivation, as I found it exciting, at the University of Bristol, when it was regarded as the Mecca for its particular areas of specialization.)

Dr. Bhabha had already identified Dr. Ramanna as one of the potential leaders of India's atomic energy program, and offered him a job. With foresight, Dr. Bhabha permitted Dr. Ramanna to stay on for a further year in England after his doctorate, to familiarize himself with developments in nuclear physics and atomic energy.

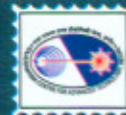
Dr. Ramanna returned in 1949 and joined the Tata Institute of Fundamental Research (TIFR), which was by then located at the Royal Yacht Club near the Gateway of India in Bombay. (I joined TIFR at these very premises a few years later after my Ph. D and postdoctoral research in Bristol).

Interestingly, (as recounted by Prof. B.V. Sreekantan), two rooms in the hostel of TIFR, (which were the modified servants quarters of the Yacht Club), were allotted to Dr. Ramanna; one was for himself and the other was for his piano! This was a remarkable reflection of the attitudes of the time of research scientists living in what were the servant's quarters of the Yacht Club; and the need of Dr. Ramanna to continue his music practice on the piano every day, for which special consideration was given by Dr. Bhabha. On the ground floor of this hostel block Dr. Ramanna started his first work on nuclear fission and neutron scattering – small beginnings for the great venture that lay ahead. (Incidentally, many of the most distinguished scientists of TIFR, who later occupied the highest positions in their areas in the country, became FRS and so on, lived in these hostel rooms; they were very happy with their lives and highly productive).

The public image of the Atomic Energy Program is of a huge engineering establishment, cloaked in secrecy, particularly because of its relevance to, and of its capabilities relating to, nuclear explosions and weapons. One tends to forget that underpinning the entire effort was science of the highest quality. Indeed, in the earliest large scale efforts in this field, on the Manhattan Project, involving the design and fabrication of the first atomic bomb, some of the greatest scientists in the world were involved such as: Bethe, Bohr, Cockcroft, Fermi, Feynman, Lawrence, Seaborg and many others; the project

was led by a great theoretical physicist, Oppenheimer. And even prior to the Manhattan Project, all the understanding and discoveries relevant to this area were made by scientists. In its efforts, India was not just copying what was done elsewhere; it must be remembered that this was from the 1940s a closed, highly secret field; and we know of countries who moved ahead in this field using underhand means, including espionage! For India, the entire development was based on the vision of scientists like Homi Bhabha who conceived the atomic energy programme from scratch, as early as 1943, and then the detailed work on the underlying physics by those like Dr. Ramanna and on related areas by other distinguished scientists & engineers.

In those days one did not do experiments based wholly on imported equipment and materials, as significantly done now. The purpose of science then was not to build up what has today become an important aim e.g. an "impact factor" or a "citation index" – leading even to underhand means such as plagiarism, falsification etc. to achieve this, even in the scientifically advanced nations. In the earlier days, the motivation was to understand natural phenomena – and many scientists were engaged in this, wholly driven by curiosity and a sense of excitement and fun. With difficulties in imports in those days, particularly with the foreign exchange shortage, it became imperative to build one's own equipment. This was the philosophy of Homi Bhabha and of TIFR. A range of commonplace nuclear and electronic systems were designed and fabricated, significantly from war disposal items, (rejected, obsolete or surplus stores left behind after the Second World War); these were principally obtained from what was then referred to as the 'Chor Bazaar'. (I have fond recollections of my sallies to purchase and haggle for price in the "Chor bazaar" for electronic equipment that I had built as an M Sc research student at the Royal Institute of Science Bombay in the late 1940s). It was this effort that resulted in the nucleation of the Electronics Production Unit and Technical Physics Division at TIFR which then moved to Trombay; later all electronic production was transferred to Hyderabad, to become the public sector company, ECIL. This indigenous effort constituted the underpinning of the capabilities in these fields of the atomic energy programme.



The first imported item at TIFR was the 1MV cascade generator installed in a tall hut at the Holiday Camp (now referred to as 'Navy Nagar'), where TIFR is presently located. It was with this that Dr. Ramanna and his group worked on nuclear reactions.

Dr. Bhabha had very good personal relationships with some of the greatest nuclear scientists of the world in various countries (Canada, France, UK, USA, and USSR). Through these he managed to get a very large number of his key personnel trained at nuclear establishments in those countries. He arranged to send a team of scientists and engineers for a year 1953-54 to Paris to familiarize themselves with aspects relating to reactor building and associated controlled instrumentation. Dr. Ramanna was one of the key members of the group (There were also groups who went to the nuclear establishments in the other countries).

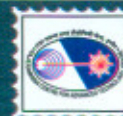
On his return from France, Dr. Ramanna got fully involved with work at the new site of the Atomic Energy Establishment at Trombay (renamed the Bhabha Atomic Research Centre (BARC) after Dr. Bhabha's death). In 1955, the Atomic Energy Commission took the decision to build the Swimming Pool Reactor at Trombay, appropriately given the name APSARA by Sri K.S. Krishnan, which became critical in 1956. For this, Dr. Bhabha got the fullest cooperation from the UK, particularly through his friendship with Sri John Cockcroft. Apart from continuing some interest in the research activities at the cascade generator, and occasionally attending Physics Faculty meetings at TIFR, Dr. Ramanna became increasingly committed (in 1955 and thereafter) to work on the building up of the major physics facilities at Trombay.

In his famous visionary letter of 12th March 1944, to the Chairman of the Sir Dorabji Tata Trust, proposing the setting up of what became the TIFR, Dr. Bhabha had remarked; "moreover, when nuclear energy has been successfully applied for power production, in a couple of decades from now, India will not have to look abroad for its experts." This was Dr. Bhabha's vision of human resource development for a sophisticated and closely held area of science and technology. He made TIFR the basis for generating some of the initial manpower required for the atomic energy program. Apart from leaders like Raja

Ramanna and A.S. Rao, there were many trained at various levels in different areas that, thereafter, worked at Trombay. However, as the program developed, human resources were required on a much larger scale. Initially this was accomplished by recruiting a large number of engineers who were given crash courses to familiarize themselves with the needs of the atomic energy program. It was then decided to embark on a long-term training program in its own right. This would involve bright young individuals who had just completed their science and engineering degrees, putting them through a year of intensive training, with lectures and practical work, at a training school, and most important guaranteeing jobs for all those who were successful. I remember the extensive discussions; I had with Dr. Bhabha on the role that TIFR should play in this activity (participating in giving lectures, ensuring excellence of the courses etc.) and the benefits that would accrue, particularly in terms of high quality personnel for research. Some of the best and brightest, which later manned the atomic energy program, as also institutions of pure research like TIFR, came through this training program. The products of this school have reached some of the highest levels in science in the country. This was the area assigned to and executed brilliantly by Dr. Ramanna.

Dr. Ramanna's scientific contributions to the Indian Atomic Energy Program were very significant. As mentioned earlier in this article, from the time that he worked on his Ph. D in England, his lifetime interest in research was neutron and fission physics. He was indeed the pioneer in this field in India. The additional year he spent after his Ph. D in the UK, as also the year Dr. Bhabha sent him to Paris, clearly established for him the relationship between his scientific interest and the atomic energy program. It was thus that, (during the period he spent at TIFR), during the several initial years after he returned to India, he worked on the one MV cascade generator, to carry out investigations on the process of neutron thermalization in different types of moderating assemblies. This was relevant to reactor design at Trombay, starting with that of APSARA.

As facilities became available at Trombay, Ramanna's group was able to carry out several landmark experiments in the area of thermal neutron induced fission.



An important result was that about 10 percent of emitted prompt neutrons from U^{235} are pre-breakup neutrons; the group was able to prove that the neutrons are emitted during the saddle to breakup stage. In the liquid drop model of the nucleus, a heavy nucleus keeps changing its shape, away from spherical, often oscillating in shape and elongating; there can be long saddle-to-saddle times, which would allow for evaporation of some neutrons. They developed special techniques for obtaining angular information. From all of these experiments, they were able to develop a stochastic theory of fragment mass distribution and charge distribution in fission. A great deal of this is now becoming relevant in the newly developing area of heavy ion reactions.

Without going into further great detail relating to the scientific work of Dr. Ramanna, (for which one can see the special issue of *Pramana*, 1985, 24 nos 1 and 2, dedicated as a *Festschrift* to him) it would suffice to say that he built a major group in the physics (relating to neutrons and fission) relevant to the whole atomic energy program; established the necessary experimental facilities, including instruments and detector systems; obtained the basic data that was relevant to both reactor physics as well as to nuclear explosions, and did all of this with a necessary theoretical underpinning enabling this to be applied meaningfully. It is interesting that a later Chairman of the Atomic Energy Commission, Dr. P.K. Iyengar, was his first Ph. D student, Dr. Iyengar brought to bear on the programme his further understanding of the behavior of neutrons, some acquired during his work in Canada with Dr. Brockhouse who later won a Nobel Prize. Dr. Iyengar's contributions related to neutron scattering, diffraction and lattice dynamics.

In January 1966, following Dr. Homi Bhabha's tragic death in a plane accident, Dr. Vikram Sarabhai took over as Chairman of the Atomic Energy Commission, with Dr. H.N. Sethna as Director of the Trombay Establishment, and Dr. Ramanna as the Director of the Physics Group. After Dr. Vikram Sarabhai passed away in December 1971, Dr. H.N. Sethna became Chairman of Atomic Energy Commission and Dr. Ramanna, Director, Bhabha Atomic Research Centre. The activities relating to the space program, until then under the AEC, were hived off to operate independently. I took charge of these as Chairman,

Indian Space Research Organization.

It was during this phase that the peaceful nuclear explosion (pne) at Pokharan of 1974 was planned and executed. A detailed account of the sequence of events and work done is contained in the autobiography of Dr. Ramanna. There were three important components relating to the success of this work: the production of nuclear materials of the necessary purity and quality through processes of chemical and metallurgical engineering; the understanding of the physics involved (neutron, fission and high pressure physics); and an understanding concerning the generation and propagation of explosive waves, on which a great deal of expertise had been developed in work done in the Defence Research and Development Organization.

The pne involved significant mastery over advanced technology and coordination. It was done at very low cost, being a by-product from the basic nuclear program. What was remarkable was its successful accomplishment with a degree of secrecy that surprised most. Most of all it was a science-based self-reliant effort.

A few years after the 1974, pne conducted at Pokharan, Dr. Ramanna moved to become Scientific Advisor to the Minister of Defence, (SA to RM) as my successor. I had the pleasure of organizing a major meeting of the Defence and Research Development Organization (DRDO) in New Delhi, in the summer of 1978, involving all Directors of the DRDO establishments, as well as those from institutions involved with DRDO in the armed forces and the Ministry of Defence. It enabled me to introduce Dr. Ramanna to those who manned the organization, and to expose him to the range of problems that were being dealt with. He occupied the position of SA to RM for a relatively short period, of less than 4 years. He however, accomplished a great deal during this period-particularly in bringing into DRDO some of the culture introduced by Dr. Bhabha in the functioning of the atomic energy program; this resulted in: reduced bureaucracy; making the organization more scientist-friendly; considerably improving recruitment and personnel policies (and after he left the post, with independence from the Union Public Service Commission); and ensuring protection of heritage areas such as the Metcalfe House in Delhi and the areas occupied by LRDE and ADE in the heart of Bangalore; the



latter now the public areas with a Planetarium Complex. In many of these areas he was able to bring to fruition, some of the initiatives that I had struggled with, battling the bureaucracy. He also gave Dr. A.P.J. Abdul Kalam, now President of India, the opportunity to move from ISRO, after his success on the SLV-3 project, to head the Defence Research and Development Laboratory in Hyderabad responsible for the missile program.

After his stint as in DRDO as SA to RM Dr. Ramanna returned in 1981 to his primary roots e.g. the atomic energy program as Director, BARC with the rank of Secretary to Govt.(1981-1983). Thereafter, during 1983-1987 he was Chairman of the Atomic Energy Commission and Secretary to the Govt. of India, Department of Atomic Energy. This was a period when the large research reactor, DHRUVA at BARC was completed, and the Fast Breeder Test Reactor (FBTR) of the Indira Gandhi Atomic Research Centre at Kalpakkam became critical in October 1985; India became the 7th country in the world to built an FBTR. Of course, the vision of ultimately using, through the breeding process, the vast resources of thorium that India possesses, was due to Dr. Bhabha. The implementation of this dream called for all the highest quality human resources that the Indian atomic energy programme had generated through its history particularly those with leadership quality in physics, chemical, materials and reactor engineering and the like. Dr. Ramanna also envisaged attaining a capacity of 10000 Mw of nuclear power by the end of the 20th century on a wholly self reliant and indigenous basis. He had to fight to get this target accepted and to do it with his philosophy, which was against the import of reactor systems. He felt that research capabilities as also necessary support from Indian industry had matured sufficiently to execute this programme wholly indigenously provided adequate support was given.

Immediately after his tenure as Chairman, Atomic Energy Commission he was invited by Mr. J.R.D. Tata to be founder Director of the National Institute of Advanced Studies (NAIS) in Bangalore. This institution was conceived by J.R.D. Tata "to conduct advanced research in multi-disciplinary areas and also the forum to bring together administrators and managers to industry and government academic community in natural and social sciences"; in particular, its objective was to ensure the

influence of scientific analysis and thinking on the important issues handled at the highest level. I am aware of the whole background to the creation of this Institute he was a member of the Committee that JRD Tata had set up (well before he had invited Dr. Ramanna to take charge) to visualize and plan for such an Institute.

Dr. Ramanna started the institute by inviting a certain number of distinguished individuals to give lectures on a variety of topics; the first of these courses were held at the Tata Management Centre in Pune. It was only when program activities had moved ahead that he proceeded to set up a campus of NIAS on a plot of land, which was part of the Indian Institute of Science, Bangalore. It is not a large campus, but one designed for academic pursuits in peace, elegance and with all the necessary facilities, particularly the JRD Tata Auditorium. It was in this act of Institution-building that Dr. Ramanna spent the last year of his life. (A more detailed account of the growth of NIAS under Dr. Ramanna is contained in Reference 3).

Dr. Raja Ramanna was happily married (1952) to Malathi and has three children-two daughters and a son. As an aside, it is interesting that Raja Ramanna was deeply concerned about his son, Shyam, who was not too interested in studies when very young. But Shyam first went into the computer graphics industry involved in advertisement and documentary films, and then took after his father through music, and has done remarkably well in integrating this with his earlier interests; and Dr. Ramanna was Chairman of his company!

Dr. Ramanna received all the standard important distinctions of the country that a scientist can have; Shanti Swarup Bhatnagar Memorial Award of CSIR (1963); Padma Shri (1968); Padma Bhushan (1973); Padma Vibhushan (1975); President, Indian National Science Academy (1977-78); Member of Parliament (during 1990 and thereafter, from 1997-2003); Chairman, Governing Council, Indian Institute of Science (1974-2004); as well as many honorary doctorates and other awards. He was chosen by Prime Minister V.P. Singh to be Minister of State for Defence during the brief tenure of that Government in 1990. He and I were colleagues as Ministers.

Apart from all of this he was truly an erudite



individual. He was deeply interested in music and Indian Philosophy. I can do no better than to quote in this connection from an article written by K.R. Rao (Reference 4) on Dr. Ramanna. "He has rendered into English, Mukundamala of Kulashekhara Alwar, a publication of the Gandhi Centre of Science and Human Values of Bharatiya Vidya Bhavan, Bangalore (1997). Although this work was published as recently as in 1997, interestingly, the Introduction to this translation by Ramanna dates back to 1974, the year, which saw him leading the Pokharan-I test. Ramanna wrote in the Introduction, 'It is unfortunate that many of the gems of ancient poetry are so much associated with the ritualisation aspect of religion that their beauties are available only to a few who belong to the associated sect or caste and who in turn consider them as their sole property. This great Bhakti poem... is usually associated with the Vaishnavite sect; the sect itself was in the nature of a Hindu reformist movement which rose to its zenith of influence under Sri Ramanuja.... It was a reaction against the agnosticism of the Buddhists and the intellectualism of Advaita...'. He continues: 'Social conditions have changed in the last thousands years and while we may have lost sight of the worldly problem referred to in the poem in the original sense, the greed for money and aimless seeking of ephemeral pleasures of life are so much around us, that the word "world-liness" (free translation of samsara by Ramanna) can be interpreted as to refer to these ills'. One would wonder if Ramanna had implied this broad vision whenever he referred to his own interest in yoga, because a yogi is said to be aware of the ephemerality of all that is associated with this life, as stated in the other classic poem Bhaja Govindam or the greatest epic-poem Bhagavad-Gita. Concluding the Introduction, Ramanna notes: "Whatever be the thoughts contained in this inspiring poetry, it brings out the fact that no human activity reaches its full glory without "Bhakti", whichever way one interprets the word". In this one sentence he seems to have encompassed many a concept like Akaamyakarma (performing every action as a duty without seeking fruits of action), if not Sharanagati.

Dr. Raja Ramanna lived and died with a full sense of confidence in himself, his faith and ideas in science, and self-reliance, as also in the country to which he belonged. He found fulfilment in science, music and philosophy.

Acknowledgement

I am deeply grateful to Prof. B.V. Sreekantan, former Director, Tata Institute of Fundamental Research for providing me with a great deal of information relating to Dr. Ramanna. Prof. Sreekantan had known Dr. Ramanna from the time the latter joined the TIFR in 1949 and particularly during the last 15 years of his life at NIAS; the last was the period when I did not have too much interaction with Dr. Ramanna.

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