

Sir Kariamanickam Srinivasa Krishnan (1898–1961): the scientist and the man

Purabi Mukherji

Quite often these days, one comes across some negative remarks about Indian scientists. It is often discussed and also reported in different media that after J. C. Bose, Srinivasa Ramanujan, C. V. Raman, P. C. Ray, S. N. Bose and M. N. Saha, Indians have failed to make any notable contributions in scientific fields comparable to global standards. There may be some truth in the statement, though not completely. At least in physics, D. M. Bose, S. K. Mitra and K. S. Krishnan are all pioneer scientists in their respective fields. Using indigenously designed and manufactured instruments, meagre funds and little assistance from foreign colonial rulers, they made a mark in the world of science with their path-breaking research. Unfortunately these are almost forgotten names; perhaps vaguely remembered in the scientific community of modern India. They have practically gone into oblivion. It is indeed shameful on our part, that we do not remember their scientific contributions, and also do not show any interest to know about them. This includes the student community as well.

From a personal urge to atone for this collective sin, here I write a brief note about one of them. The man who was a scientist of the highest class; who dedicated his entire life to the cause of science and to the propagation of scientific knowledge for betterment of the lives of his fellow countrymen – Sir Kariamanickam Srinivasa Krishnan (K. S. Krishnan). He was responsible for setting up the first national scientific laboratory in post-independent India, and also tried to initiate the use of basic science in everyday life.

A brilliant scientist, a first-rate scholar of Sanskrit and Tamil literature, a perfect gentleman and a great human being – are inadequate adjectives to describe Krishnan.

Perhaps, independent India's first Prime Minister, Pandit Jawaharlal Nehru aptly described Krishnan when he said¹: 'He is a great scientist, but something much more. He is a perfect citizen, a whole man with an integrated personality'.

Childhood, family and education

Krishnan was born on 4 December 1898, in an obscure village named Vizhupanoor in Virudhanagar district of the erstwhile Madras Presidency. The temple town of Srivilliputtur was close to Krishnan's birthplace. His father Srinivasa Iyengar was a scholar of Sanskrit and Tamil religious literature and scriptures. He was a Vaishnavite Brahmin by religion and a landed peasant by profession. Krishnan's mother Nachiar Ammal was a dutiful lady with a strong character and personality. She looked after the family's domestic and social commitments, and also took care of the land and property with remarkable competence. Krishnan was respectful towards his parents and greatly admired his mother's sense of responsibility. From his father he had inherited his love for religion, literature and philosophy, and from his mother his total sense of dedication to work².

When Krishnan was about a year old, his parents left the village and the whole family took up residence in the nearby small town of Watrap. Krishnan had his entire school education there and in 1914, he passed the matriculation examination from the Hindu High School in Srivilliputtur. He secured highest marks among the successful students of Srivilliputtur taluk. In the meantime, Krishnan's father had passed away. Thereafter Krishnan left Watrap and moved over to the temple town of Madurai, where he joined the American College to pursue the FA (First Arts) course. He had a fruitful tenure at the American College, where he excelled in studies and also took part in various outdoor games. Here he had developed a special liking for playing lawn tennis, a love which remained with him forever. Even at the peak of his career, whenever he found some free time, he enjoyed playing a game of tennis. Another thing that impressed him greatly, while at the American College was the practice of 'community reading' initiated by the Principal of the College. This was a collective exercise in which a group of students studied together, had informal

discussions and exchanged ideas to enhance the general level of comprehensions of the entire group². This novel method of academic endeavour of groups of students left a lasting impression in the mind of Krishnan. Later during his first teaching engagements in the Madras Christian College (MCC), Chennai, Krishnan successfully utilized this method.

After completing his FA from the American College, Krishnan moved to Madras (now Chennai) to pursue higher studies in science. In 1916, he joined MCC to study in the science stream. In 1918, Krishnan appeared for his B A examination at the University of Madras and excelled in both physics and chemistry. He received the prestigious 'Aberdeen Prize' for his proficiency in physics. This Prize was annually awarded by the University to the student securing highest marks in the subject. Unfortunately, in the University examination Krishnan could not secure pass marks in English. So according to the University regulations, Krishnan had to wait for a year, clear the backlog in English and only then was he awarded the B A degree by the University of Madras.

Even before Krishnan secured his B A degree from the University of Madras, as a special initiative and with much effort from his former physics teacher, Reverend Alexander Moffat, he was offered the job of a demonstrator in chemistry at MCC. Krishnan turned out to be an excellent teacher. Apart from chemistry, at the request of some students, he also started an informal 'lunch break' tutorial. There the students were encouraged to bring any questions or problems in physics, chemistry or mathematics. Gradually the practice became so popular that students from other colleges in Madras also started attending and the Physics Gallery at MCC was always packed to capacity. Many of Krishnan's tutorial class students, who later became well-established in their professional careers, recall these special classes with nostalgia and profound gratitude for him. Krishnan was much admired and loved by his students for his deep knowledge in science, for his capacity to explain scientific concepts

lucidly, and for his sympathetic and kind behaviour. These were the qualities which remained with him throughout his life.

Around this time Krishnan came to know about C. V. Raman's decision to give up a highly prestigious, well-placed and lucrative Central Government job and join as the Palit Professor of Physics in the newly formed Department at the University of Calcutta, Kolkata with a meagre salary. He had also read many of Raman's research papers which were published in reputed international journals like the *Philosophical Magazine* and *Nature*. These incidents inspired and prompted Krishnan to devote himself whole-heartedly to scientific research.

In 1920, Krishnan finally arrived in Calcutta (now Kolkata) after a two-night train journey from Madras. With luggage in hand, riding a tram car, he reached his dream destination, the 'Indian Association for the Cultivation of Science' (IACS), at Bowbazar Street in Calcutta to work under the guidance of Raman. This is where he was to spend the better part of the next 25 years, and pursue an eventful and glorious scientific career³.

At Raman's advice, Krishnan enrolled in the first year M Sc class in the newly set-up Physics Department of the Science College in the University of Calcutta. There he was taught by giants of physics such as Raman himself, D. M. Bose, S. K. Mitra and P. C. Mahalanobis. As the laboratories in the Department were still not fully equipped, students had to often improvise and conduct experiments independently. This first-hand experience of carrying out experiments on his own helped Krishnan to become a highly motivated, world-class experimental physicist. To compensate for the lack of adequate facilities, Raman had made special arrangements so that the students of the University of Calcutta were allowed to work in the well-equipped laboratories of IACS. In addition, Krishnan was asked by Raman to take up residence there. So he started living in a room next to the main lecture hall of IACS. Though Krishnan attended M Sc classes at the Science College, he did not appear in the final examination at the end of the term. However, he continued with his research work at the IACS. In 1923, Krishnan finally joined IACS as a research scholar to work under the direct guidance of Raman. In 1926, he was made a research associate. The five years that Krishnan spent at IACS under the

personal supervision of Raman was referred to by the former as 'gurukulvasam'. This was the beginning of a scientifically creative period of his life, which took Krishnan to great heights in the years to come.

Krishnan made notable contributions in the following areas: scattering of light, discovery of the Raman effect, bonds of magnetism, studies on graphite and its anomalous diamagnetism, electrical resistivity of metals and alloys, and initiation of cryogenic research in India².

As advised by Raman, in 1927, Krishnan sent an application along with a dozen of his published research papers, to the Registrar of the University of Madras, making a request for awarding him the M Sc degree by research. The University had the provision for awarding such degrees. The application was forwarded by Raman with an attached letter of recommendation.

Between 1923 and 1927, Krishnan had published about a dozen research papers of high quality. Half of them dealt with scattering of light. The remaining papers were related to various problems of birefringence and electric as well as magnetic double refraction in liquids. In 1927, the University of Madras awarded him the M Sc degree.

From February 1928, Raman specially recruited Krishnan to help him with experiments related to light scattering in various liquids and vapours. This work ultimately led to the discovery of the famous 'Raman effect' on 28 February 1928. In 1930, Raman was awarded the highest scientific recognition, namely the Nobel Prize for this discovery. Unfortunately, Krishnan's contributions were not highlighted. In the months following the discovery, Raman projected himself as the sole discoverer, and Krishnan was completely ignored. The latter must have felt deep anguish at the way the events had shaped up. But he was too modest and respectful to Raman, and never sought recognition. His relationship with Raman remained as cordial as ever.

Encouraged by Raman, Krishnan applied for an advertised faculty position in the newly set up Dacca University in the erstwhile East Bengal (present-day Bangladesh). In the middle of December 1928, Krishnan, after completion of due formalities, joined the Physics Department of Dacca University as a Reader. Raman was the Chairman of the Selection Committee.

After Krishnan left Calcutta, all scientific collaborations between Raman and him ceased forever. After 1928, Krishnan never again worked on the Raman Effect.

At Dacca University, Krishnan served in the newly established Physics Department from 1928 to 1933. S. N. Bose was the Head of this new department. Krishnan had excellent personal relations with Bose. During his tenure at this University, Krishnan was able to set up a modern, well-equipped laboratory with facilities for experimental work in X-ray spectroscopy, X-ray diffraction, optical spectroscopy and scattering of light. He started investigations on the magnetic properties of crystals in relation to their structure. He was successful in developing precise and elegant experimental techniques for measuring the magnetic anisotropy of diamagnetic and paramagnetic crystals. Krishnan and his students developed methods for accurate measurement of feeble susceptibilities and anisotropies. They published a dozen research papers on these topics in reputed national and international journals. Krishnan laid the foundation stone for the development of modern scientific disciplines such as crystal magnetism and magneto-chemistry. The research school on crystal magnetism that Krishnan developed at Dacca University attracted international attention⁴.

In 1933, Krishnan submitted his doctoral thesis titled 'Magnetic susceptibilities of crystals in relation to crystal structure', to the University of Madras for D Sc degree. His examiners, including the Nobel Laureate W. H. Bragg and other eminent physicists, were much impressed with his work and highly recommended the award of the degree. In 1933, the University of Madras awarded him the D Sc degree².

Raman took great initiative and created the post of 'Mahendralal Lal Sircar Research Professor' (MLS) at IACS, before his departure to Bangalore (now Bengaluru). Shortly thereafter, Krishnan was offered the newly created post. He accepted the offer, resigned from Dacca University and joined IACS as the first MLS professor on the 21 December 1933. In this context, it would be appropriate to mention a heart-touching incident involving Krishnan. When he resigned from Dacca University, a handsome amount of money had accumulated in his 'Provident Fund' account with the University. Krishnan requested the

University authorities to accept that amount as a corpus and from the interest of the invested money make arrangements to award three prizes every year to the most successful students from the disciplines of mathematics, physics and chemistry respectively. He also suggested that the prize in mathematics should be named after Srinivasa Ramanujan, that in physics after his teacher and mentor C. V. Raman, and that in chemistry after Acharya P. C. Ray. They were the three Indian scientists Krishnan admired the most. This small gesture reflects the commendable humane qualities of Krishnan. Incidentally, Dacca University still awards these three prizes every year.

Krishnan's second stint at IACS had an unpleasant beginning. Due to unhealthy rivalry between two groups, one led by Raman and the other by his adversaries, a huge confrontation took place in the special General Body meeting of IACS held on 19 June 1934. As a consequence, Raman resigned as the President and Krishnan as the Secretary of IACS. Krishnan, however, retained the MLS Chair Professorship. Overcoming the many undesirable and unsavoury situations that he had to face at IACS, following Raman's exit and related matters, Krishnan maintained his composure and concentrated on his scientific research with dedication and sincerity. His excellent research work soon attracted the attention of international experts in the field. He was invited by Lord Rutherford to the Cavendish Laboratory, Cambridge, UK and William Bragg to the Royal Institution, London, UK to teach courses. In 1937, Krishnan left for Europe; this was his first foreign visit which was followed by many more in the future³.

Krishnan's research works carried out during 1934–1941, were precursors to concepts that were developed in detail after about 4–5 decades. The nanocrystalline forms of fullerenes and carbon nanotubes were discovered in 1985 and 1991 respectively. Krishnan's work on the anisotropic susceptibility of graphite provided early and definite confirmation of the validity of quantum mechanics-based electron theory of metals.

In March 1940, as a mark of recognition to his original contributions to physics, Krishnan was elected a Fellow of the Royal Society (FRS) of London. This added another feather to the cap of IACS, which had been famous world-

wide because of the discovery of Raman effect in its laboratories in 1928.

Due to the ongoing Second World War, towards the end of 1941, normal life in Calcutta started getting disrupted. The authorities of IACS had never been helpful to Krishnan, though after Raman, it was the former who had brought international fame to the institute. Because of the unsettled conditions at Calcutta, carrying out day-to-day research activities was getting increasingly difficult for Krishnan at IACS, and the unhelpful attitude of the authorities added to the problems. In spite of his deep sense of loyalty to IACS, where Krishnan had spent the best years of his research career, on 23 May 1942, he decided to leave Calcutta for good. He accepted Professorship of Physics at Allahabad University in Uttar Pradesh. Because of war, Allahabad got a brilliant new professor and IACS lost its second most eminent scientist.

Krishnan served at Allahabad University for five years. During his tenure, he took great interest in his teaching assignments. But because of the ongoing war, the colonial rulers were not ready to sanction funds for experimental research and laboratory facilities. A frustrated Krishnan finally abandoned the idea of experimental research and devoted himself mainly to theoretical studies. A major contribution from the theoretical studies that he undertook in collaboration with A. B. Bhatia on the electrical conductivities of metals and alloys led to the much acclaimed Bhatia–Krishnan–Ziman theory of the electrical resistivity of liquid metals. Apart from this path-breaking work, Krishnan also wrote two purely mathematical papers, one of which was based on Ramanujan's theory. Both these papers were praised by experts in the field. In this connection, later in Krishnan's obituary, Lonsdale and Bhabha³ had commented:

‘Krishnan loved mathematical reasoning and his skill as a mathematician would have gained him international recognition even without his ability as an experimental physicist.’

During his stay in Allahabad, Krishnan gradually became part of various Indian scientific delegations visiting Europe and USA. Around this time, he also became acquainted with Jawaharlal Nehru, who later became the first Prime Minister of independent India. Nehru greatly ad-

mired Krishnan's ability as a scientist and personally requested him to take up responsibilities of a scientific administrator to help set up a proper scientific infrastructure in a newly independent country.

After lot of introspection, at Nehru's personal request, Krishnan finally left Allahabad and in June 1947 took charge as the first Director of the National Physical Laboratory (NPL) in New Delhi.

Apart from the administrative duties at the new institute, Krishnan became more and more involved in other scientific management-related activities. In 1948, he was made a member of the Atomic Energy Commission, set up by the Government of India (GoI). Shortly thereafter he became a member of the Defence Science Advisory Committee to GoI. Though he was getting more and more involved in the scientific administration of the country and official responsibilities at NPL were on the increase, Krishnan remained focused on his priority, namely scientific research. While at NPL, he identified two areas of research: lattice oscillations in ionic crystals and thermionic properties of metals and semiconductors.

Krishnan and his two student collaborators, S. K. Roy and S. C. Jain, carried out notable research in these areas and published a series of papers in high-end international journals like *Proceedings of the Royal Society* and *Philosophical Magazine*⁵.

Gradually Krishnan's workload in scientific administration increased further. He was associated with many national and international scientific bodies. He was Chairman, Scientific Advisory Committee, UNESCO; Vice-President, International Council of Scientific Unions and the International Union of Pure and Applied Physics; Chairman, International Geophysical Year and Chairman, Sub-Commission for Co-operation with UNESCO. Along with P. Ewald, M. V. Laue and W. L. Bragg, Krishnan was a founder member of the International Union of Crystallography.

On 13 June 1946, Krishnan was decorated with knighthood by the British Government for his remarkable scientific contributions. In 1949, he was elected as the General President of the Indian Science Congress. In 1953, he was elected President of the National Institute of Sciences¹. In 1954, GoI awarded him the Padma Bhushan as a mark of recognition

for his outstanding contributions to science and for his pioneering services to Indian scientific programmes.

In 1961, Krishnan was the first recipient of the prestigious S. S. Bhatnagar Award, the highest scientific award of India at that time. The award was handed over to him by Prime Minister Nehru himself. In 1958, Krishnan was made 'National Professor' by GoI. It was the most deserved honour to an outstanding teacher who was loved and admired by his students wherever he taught.

Apart from being an excellent scientist, an innovative, exemplary teacher and a dedicated, hard-working scientific administrator, Krishnan was also a philosopher and a well-known scholar of Tamil and Sanskrit. He loved to read books, attend literary discourses and take

part in philosophical discussions. He revered Raman and praised him to the end. Among his contemporary scientists, Albert Einstein, Neils Bohr and Arnold Sommerfeld had a profound influence on Krishnan's academic life. He was a great admirer of S. N. Bose.

As a human being, Krishnan was a true SriVaishnavite, modest, extremely polite and unassuming. He was also full of humour and wit.

On the 14 June 1961, Krishnan died of a massive heart attack in New Delhi. A shocked nation lost a brilliant scientist, an extraordinary scholar and a great human being.

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Purabi Mukherji is in the Indian National Science Academy, New Delhi 110 002, India.

e-mail: rubym1945@gmail.com