

# Professor Sir C.V. Raman— Reminiscences

R.S. KRISHNAN

**I**N 1933, five years after the discovery of the Raman effect and nearly two and half years after he was awarded the Nobel Prize, Prof. Raman moved from Calcutta to Bangalore to join as the first Indian Director of the Indian Institute of Science. Immediately a new Department of Physics was created for him where he pursued his scientific activities for a period of fifteen years. I was one amongst the first batch of 8 students, fresh from the University who joined to work under him in July 1933. I was associated with him for the next fifteen years, first as a research scholar and later as a senior member of his academic staff.

Anybody who wished to work under Professor as a regular student had to undergo a searching oral examination in which the candidate's knowledge of fundamentals and capacity for original thinking would be seriously tested. Although he attached some importance to the academic records of the applicant, he always made his own assessment of a student. He never believed in admitting students to work under him on the basis of recommendations from friends and V.I.P's.

Once having selected, the student felt at ease with Prof. Raman. He was kind, generous and large hearted provided the student was sincere and hard working. He had his own ways of developing self confidence and self reliance in his students whom he treated as equals while discussing scientific matters. It was his habit to go round the laboratory every morning, meeting each student, discussing the progress of his work and often suggesting new ideas. He would give free expression to his thought when a new result was brought to his notice. In his public lectures in those days he gave the maximum publicity to the work of his students and would mention their names. All these were a thrilling experience to us as his students who under his influence imbibed intense zeal and enthusiasm for more and more creative research and sustained hard work. Professor Raman encouraged the students to develop capacity for clear talk and exposition. He often used to remark that one should be able to 'think on one's feet'. Whenever an old student called on him, the topic of

discussion would always be scientific.

Only his students know Prof. Raman's humanism. He would lend full support to the work carried out by his students. He was always anxious that all the credit for the work should go to the students. As far as he was concerned he guided the students so completely, and looked through every word of the final published paper that any distinction between his work and the student's work ceased to exist.

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He would follow the career of the student even after they had taken up job elsewhere. He seldom issued open certificate to any of his students. Whenever any student wanted a certificate to be sent to the authorities where he was seeking fresh employment, Prof. Raman was always very prompt in sending his recommendations directly to the authorities concerned. The students could always count on his support. In this context one is reminded of the famous Malayalam poet Vallathol's poem "Student and Son". As with Lord Siva, the student took precedence over the son in the case of Prof. Raman also. He often gave the following advice to his students whenever they left him for taking up job elsewhere. "Since you are going to earn your livelihood through scientific work, never grudge buying books. You will find an investment in books and journals very rewarding".

The range of Professor's scientific interests was amazing. He had working under him at the same time students of physics, mathematics, physical chemistry, organic and inorganic chemistry and even geology all of whom received his directions and guidance on the

problems on which they were working.

At least once a week there would be seminars where one of the students would report on the work he had been doing, experimental or theoretical, the difficulties encountered by him, the results obtained, etc. During these seminars Prof. Raman would think aloud and one would see and hear his intellectual brilliance and get illuminated and inspired. An interesting incident took place in 1935 to which the author was an eye witness. Parthasarathy, a student of Prof. Raman, was working on the diffraction of light by ultrasonic waves in 1935. While giving a seminar talk on the subject, he described the experimental set-up in detail and also the peculiar results reported by Debye and Sears in USA, by Biquard and Lucas in France in 1932, and Bar in Switzerland in 1933 which could not be accounted for satisfactorily with the well-known theory of Brillouin given in 1922 which was able to explain only the first order diffraction pattern. As soon as Parthasarathy finished talking, Prof. Raman got up and said that the entire phenomenon could be satisfactorily accounted for on the basis that the wave front of the incident light beam which was plane before entering the cell containing the liquid became corrugated due to compressions and rarefactions produced in the medium by the ultrasonic waves traversing it in the transverse direction. He immediately asked one of his students, N.S. Nagendra Nath who had a basic degree in mathematics and who was present in the audience, to work out the mathematical analysis and derive the formula for the intensities of the different orders of the diffraction pattern. Nagendra Nath brought the results of his calculations the next day. Then followed a series of papers of fundamental importance by Raman and Nagendra Nath wherein what is now called the Raman-Nath theory of the diffraction of light by ultrasonic waves was developed. Their treatment not only explained fully the observed facts already reported, but also led to several interesting new ideas and anticipations that were later verified by experiment. This is a typical instance of Raman's flash of intuition which led to the clue for solving a difficult problem using ordinary mathematical logic. In this context, it is worthwhile to quote what Prof. Max Born once said:—"Raman's quick mind leaps over mathematics". While discussing scientific matters with his students he often used to remark "something tells me that this is so and so". He combined in the highest measure the intuitive perception of a genius and the ability of an understanding experimental physicist.

Prof. Raman's first research paper on the "unsymmetrical diffraction bands due to a rectangular aperture" was published in the *Philosophical Magazine* of London in November, 1906, when he was still a student of the M.A. class in his 18th year. The paper was communicated by Prof. Jones of the Physics Department of the Presidency College, Madras, even though there was no acknowledgement or thanks to him. He, being an Englishman, knew that he had not suggested the problem and had nothing to do with the work reported in the paper and that it was his duty

to forward the research paper of his student. This kind of rare magnanimity Raman also developed to the highest degree and in his later years he never allowed his name to be added to the papers published by his students based on the work carried out by them even though in many cases the problems would have been suggested by him and many useful tips would have been given by him during the course of the work.

I shall quote what Dr. P.R. Pisharoti, a retired Director of the Institute of Tropical Meteorology and a former student of Prof. C.V. Raman wrote about Raman:

"On one occasion I was feeling depressed while carrying out an experiment with an X-ray apparatus at the Indian Institute of Science. Professor came in at about 7.00 A.M. and noticed my mood. He asked me the cause of my depression. I replied that a distinguished scientist in the United Kingdom was working on the same problem as myself and that he had a 5 KW X-ray tube at his disposal. He asked me about the power of my X-ray tube. "1 KW, Sir". He said: "That is all; there is a very simple solution. Put a 10 KW brain on the problem", smiled and moved off. He meant what he said. He had supreme self confidence; and more than that he generated it in his students. Time in and time out he would show by precept and example, that ambition, endeavour and courage are the three qualities essential for good scientific work".

Raman believed that it was essential for the Research Assistants and students to live close to the place of work so that they could devote maximum time for work. When he was given permission to work outside office hours in the Indian Association for the Cultivation of Science at Calcutta in 1907 while working as a Finance Officer of the Government of India, he himself took up a house adjoining the Institution, though it was not a desirable locality and had a door opened between his house and the Association so that he could reach the Laboratory informally for work at any time, by day or by night. After assuming the duties of the Director of the Indian Institute of Science in Bangalore he was the first Director to insist upon providing accommodation in the premises for the Research Assistants in preference to the supporting subordinate staff. Each research student was given a key of his room which enabled him to come and work in the Laboratory outside office hours and at night. Prof. Raman was the Central Sun around which the whole institution revolved and from which each part received its energy.

Prof. Raman used to admit students of different disciplines, physics, mathematics, chemistry, geology, etc., to work under him as research scholars. This has paid rich dividends. The development of the Raman-Nath theory was a typical example how a pure mathematics student like N.S. Nagendra Nath, who was working under Raman in 1935, was able to solve the problem of the diffraction of light by ultrasonic waves once the basic physical principle of the formation of the corrugated wave front flashed to Raman's quick mind and he wanted the resulting mathematical analysis to be worked out.

S. Venkateswaran and P. Krishnamurthi who were basically post-graduates in Chemistry were working as part time students outside office hours in Raman's laboratory at Calcutta at the time of the discovery. S. Venkateswaran along with A.S. Ganesan and S. Bhagavantam studied the Raman Spectra of a series of homologous related organic compounds of similar structure. Their work led to the important conclusion that each chemical bond could be identified by a characteristic Raman frequency. They along with the group under K.W.F. Kohlrausch at Graz were the pioneers in establishing the Raman finger-print for each and every chemical bond. P. Krishnamurthi was the first to investigate systematically a series of inorganic compounds, such as carbonates, nitrates, sulfates, etc., and established the characteristic internal vibration frequencies of various chemical radicals and the way in which they were influenced by the metal ion.

Prof. Raman was very fastidious regarding the upkeep of equipment in good condition and he could not tolerate any student found handling the apparatus rashly. He had a member of his academic staff always to be in charge of apparatus and facilities of the laboratory. In Calcutta it was Ashutosh De, while at the Bangalore Institute, it was C.S. Venkateswaran in the beginning and later myself. At the Raman Research Institute it was one Padmanabhan. One of the research students working on the Raman Spectra of uranyl nitrate had obtained some new results. While measuring the spectrogram he got the screw of the measuring microscope jammed and the matter had to be reported to Professor Raman who got terribly annoyed and enquired from C.S. Venkateswaran whether the student was given proper instructions for using the micrometer. The latter's answer was in the affirmative. Prof. Raman asked the student to explain how he got the instrument jammed. On being told by the student that he wanted to find out how far the screw would go and in the process it got jammed. The student concerned was immediately asked to leave the Department even though he had done some good work.

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Since 1928, it was Raman's policy to publish all the contributions from his Laboratory in Indian Journals, instead of in well-known journals published from abroad. Of course, he continued to contribute the first announcement of important discoveries in the correspondence columns of *Nature*. While at Calcutta, papers from Raman School appeared almost exclusively in the *Indian Journal of Physics*. From 1934, the papers from his Laboratory at the Indian Institute of Science and later at the Raman Research

Institute appeared in the *Proceedings* of the Indian Academy of sciences, Bangalore which he started and of which he was President till his death in 1970. He thereby raised the prestige of these journals. He used to encourage the students to get reprints of their papers and send them freely to scientists working in the respective fields abroad. This ensured maximum publicity to the work of his laboratory. The notable feature of the Academy was the unflinching regularity with which the *Proceedings* were issued on the last day of every month during the 35 years of Raman's association with the Academy. This is entirely due to Professor Raman's initiative and hard work.

Well over one hundred and fifty young men—mathematicians, physicists, chemists and geologists, etc., had their first training in research under Prof. Raman. Many of his past students occupied important positions all over the country as Professors, Readers or Lecturers in Universities and colleges or members of the scientific services of the Central and State Governments in India. Quite a large number of his students continued to make valuable scientific contributions after they left his laboratory. However, it was also not uncommon that some students who had done extremely well when they were with him, were never heard of again in the scientific field once deprived of his guiding spirit.

Raman always encouraged senior students and research assistants who had taken their doctorates to leave his laboratory and take up responsible positions outside. In this respect he followed the principle adopted by prestigious American universities of encouraging post graduate students to take up faculty positions in other Universities after they had obtained their doctorate degrees. Very few students of Raman had continued to work in his laboratory for more than five years. Even K.S. Krishnan, who joined as a research student in 1924 and was one of Raman's distinguished students and a close collaborator in the experiments leading to the discovery of Raman Effect, had to take up the post of Reader in Physics in the Dacca University in early 1929. I was an exception to this rule. I was associated with him for a period of fifteen years first as a research student, later as a seniormost member of his Academic Staff, and finally succeeded him as Professor and Head of the Department of Physics when Prof. Raman retired from the Indian Institute of Science, Bangalore. Prof. Raman often suggested to me to take up more lucrative positions outside the Institute.

Prof. Raman discouraged the practice of post doctorate students going abroad for further training. One of his students who was with him for just over ten years expressed a desire to take leave for a couple of years to take up a fellowship under a professor in one of the American universities. Prof. Raman was very much against it and when the candidate persisted he was asked to resign and leave the Institute permanently. Of course, he is much better off for that now. But after this incident Professor got disgusted with the behaviour of his students not heeding to his advice. He immediately asked the remaining five

research assistants and students who had all taken their doctorate degrees to leave. He got them all good positions in different Institutions in India.

Unlike the practice adopted by many Indian Professors and senior scientists, whenever Raman shifted from one laboratory to another he seldom took any of his old associates with him. When he shifted his activities from Calcutta to the Indian Institute of Science he started his researches with a fresh band of students. The same was the case when he moved from the Indian Institute of Science to the Raman Research Institute in Bangalore in 1948.

There was scarcely any university or cultural organisation in India during Raman's hay-days which had not in the past invited him to give lectures on scientific and other topics. Raman's exposition of any subject was masterly and most impressive. He had a good command of the English language. He started from the fundamentals and built up as he went along in a masterly way. His popular lectures on scientific subjects, always delivered extempore, attracted large audience and were listened to with rapt attention. He could talk on even the most obtruse subject in a simple and lucid way so that even a lay man could easily follow the same and go back satisfied.

According to Prof. Raman, the principal requisite for success in scientific research is not the maturity of knowledge associated with age and experience but the freshness of outlook which is the natural attribute of youth. The principal function of the older generation of scientific men is to discover talent and genius in the younger generations and to provide ample opportunities for free expression and expansion. Intellectual beauty is indeed the highest kind of beauty. Science is the fusion of man's aesthetic and intellectual functions devoted to the representation of nature. It is therefore the highest form of creative art.

Prof. Raman could be placed on a par with two other world renowned physicists: Lord Rutherford of Cambridge and Prof. Niels Bohr of Copenhagen. All the three had trained a large number of students who in turn have become world famous in the scientific field. Both Raman and Rutherford were outspoken, outgoing and direct. They liked physics, their experiments were simple, and they described their work in simple and concise language. Both had a loud and booming voice. Both were in the habit of making decisions easily and firmly. They could be rude and unreasonable at occasions. Both were fond of making disparaging remarks about theoreticians who were very much attached to formal mathematics.

Both Raman and Niels Bohr believed that truth and clarity are complementary. They were capable of enormous enthusiasm for a promising new idea in physics. They regarded mathematics as an important tool but never as an end itself. They were not deflected by unimportant details but gave painstaking attention to detail when it mattered.

The similarities in the behaviour of Lord Rutherford, Prof. Niels Bohr and Prof. C.V. Raman were responsible for the mutual respect they had for one another. In the inaugural

address to the South Indian Science Association at Bangalore on March 16, 1928 announcing the discovery of a "New Radiation", Raman had used the first person singular only once in the whole lecture. He was taught this modesty by the late Lord Rutherford who had said that a true man of science simply would say that he found something and if somebody helped him, he would say that so-and-so helped him. The lecture delivered at Bangalore, being of a historical nature, was meant to convey what Prof. Raman really felt.

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All the three Nobel Laureates were very fond of meeting their old students at least once a year to exchange scientific ideas. Prof. Raman, on his part, used the Annual Meeting of the Indian Academy of Sciences to meet all his past students who were still active in research for mutual discussion of scientific problems. Prof. Raman used to enjoy this annual treat, while his students got inspiration from his brilliant Presidential Addresses and scintillating after dinner speeches. During the year 1936-37 when Prof. Raman was passing through troublesome days in the Indian Institute of Science, it was said that Lord Rutherford had written to the Viceroy of India to ensure that under no circumstances should Raman's scientific activities be jeopardized by any action which the Governing Council of the Institute might take. Sir Mirza Ismail, the then Diwan of Mysore, was also responsible for insisting on Professor Raman's retention in the Institute at least as Professor and Head of the Department of Physics. This noble gesture had enabled Prof. Raman and his associates to continue to make notable scientific contributions in the field of crystal physics, X-ray diffraction, lattice dynamics, Raman and Brillouin spectroscopy, the physics of diamond, etc., thus bringing further recognition to the Indian Institute of Science in the world of science.

Prof. Raman was an egotist to the core and he took real pride in being a self-made man. He owed no man—European or Indian—any debt of gratitude for his achievements as one of the leading scientists of the world. His only inspiration was the *Collected Papers* of the Rayleighs (father and son) and his own ever enquiring mind and his intuitive perception of the deepest concealed secrets of Nature. Nature was his object of worship and inspiration. Subjects like colours of flowers, origin of minerals and gem stones, plumage of birds and butterflies, the blue of the sky and the ocean and other natural phenomena were his primary concern.

Prof. Raman was very frank in expressing his views. He

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was one of those rare courageous men who would call 'a spade a spade'. He was not tactful enough in administrative matters and in this process he created enemies for himself. Most of his students were "Yes men", an epithet given by an American professor (Visiting Professor in the E.C.E. Department of the Institute) who was staying in the Raman Research Institute campus. Very few of Raman's students had the courage to warn him about the consequences of some of his administrative decisions.

He was a man of emotion and he could violently get angry. In this connection I would like to narrate a personal experience. One of my students, N. Krishnamurthy had published a paper in the *Indian Journal of Pure and Applied Physics* in 1966, on the lattice dynamics of caesium bromide crystal using Born's theory of lattice dynamics. Prof. Raman could not see eye to eye on this subject with Prof. Max Born and they became bitter enemies. A request for a reprint of this paper went inadvertently to the Raman Research Institute. This brought to his notice the existence of such a publication from any laboratory at the Indian Institute of Science, and the fact that my students were working on lattice dynamics of alkali halides using Born's theory and explaining the observed spectroscopic data of such crystals satisfactorily. This he disliked very much. A few days later I went to meet Professor in some other connection. He was so angry and annoyed with me that he abused me profusely. I coolly pocketed what all he said and quietly walked out of his room in the Raman Research Institute.

We have a right to be proud of Chandrasekhara Venkata Raman. He was a graduate of the Madras Presidency College. He got no training in foreign laboratories or universities. He was the son of a poor school-master. He did not have a posh laboratory and modern ready made equipments to work with. He did everything from what he got in India and what his assistants fabricated and yet earned many laurels including the Hughes Medal of the Royal Society of London and the Nobel Prize in Physics for a fundamental and far-reaching discovery recognized as great by the whole world of science. This is not just foolish insular pride but an argument for greater confidence in ourselves (Indian) than that generally prevails now.

Sir C.V. Raman himself was grateful to Calcutta and the big men of Bengal. He always remembered and said that his scientific work was made possible only through the greatness of Dr. Mahendra Lal Sarkar who founded the Indian Association for the Cultivation of Science in Calcutta. No less was Raman's gratitude to Sir Asutosh Mukherjee who it was that persuaded Raman to give up his post in the Finance Department of the Government of India and devote himself entirely to the pursuit of science under the aegis of the Calcutta University. But for this C.V. Raman would have respectfully retired as a faultless Accountant-General.

May the example and memory of Professor Chandrasekhara Venkata Raman's life and work, his courage, his faith in young men and women and his ceaseless quest for truth be an inspiration to the young people of our country.

### Raman's thoughts

**"W**HAT is Research? It is only seeking after knowledge and must therefore be of the utmost fundamental significance in all schemes of education. You must remember that knowledge at the present day is not a dead knowledge enshrined in books but a living and growing knowledge with which we are all concerned. Can you imagine for a moment that living knowledge can be procured, can be obtained merely by the study of books, by turning your teachers and students into mere book-worms? No! your teachers and students will have to take part in that stream of human activity, which I have referred to. A university is not a university if this is not understood, if this is not daily practised. It is in the attempt to discover new facts and new relations between known facts, which we call research, that a true insight into the new and growing body of knowledge is obtained. You must be one of the seekers, or else you will be left behind."

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**"I**would warn my young friends very specially against regarding research as a pathway to self-advertisement and self-glorification. Self-advertisement for whatever

reason it may be pursued, soon becomes an end in itself and its results are most evil when seemingly it is most successful. The man of science who habitually indulges in it soon comes to believe in his own perfection and infallibility and loses that clearness of vision and rigid self-criticism, essential to an investigator. Self-praise is scientific suicide".

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**"S**CIENCE is nothing but a research for truth—truth not only in the physical world, but in the world of logic, psychology, behaviour and so on. The virtue of a truly scientific frame of mind is the readiness to reject what is false and untrue. It proclaims from the house-tops that there is no virtue in sticking to untruth. I think the latest biological discovery is that there is no fundamental cleavage between the life of man and the life of the lower creation and that salvation lies in the perfection of the biological instinct for the perpetuation of the race—the instinct to sacrifice the individual for the sake of the species". (Excerpted from *Indian Scientists—Biographical Sketches*, G.A. Natesan & Co., Publishers, Madras)