

# A co-traveler of light, colour and beauty

## Life and Work of C. V. Raman

Prof. V. P. N. Nampoory

Natural phenomena are not susceptible to explanation, they can only be described. One of such phenomenon was prof C V Raman who liked to be described himself as a co-traveler of light, colour and beauty. His 65 years long deep relationship with nature during the period of 1905 to 1970 had a strong foundation on the cosmic boon of sound and light.



Fusion of light and sound with spatiotemporal modifications resulted into the emergence of natural beauty, which was always an illuminating lighthouse for scientists, artists and literary workers. Both arts and science are the keys, which can open the inner corridors of Nature's secrets. The scientists who study Nature through observations and experiments and the poet who describes the astonishing spectacle enacted in the grand theatre of the Universe are pilgrims progressing along parallel roads aiming at the realization of truth. C V Raman was on such pilgrimage.

Raman Effect is a phenomenon which is known after a person which influences maximum number of diverse fields like physics, chemistry, biology, medicine, archeology, geology, agriculture, forensic science, communication engineering, computing, laser technology etc. In fact there doesn't exist not much areas which are not influenced by Raman Effect.

Invention of various types of lasers during sixties enhanced the horizon of Raman Effect and a number of new terminologies started taking shape in the dictionary of science and technology. On this National Science Day, which remembers the discovery of RE, it, is quite appropriate to recollect Raman and his work.

Born on 1888, Nov. 7 at Tiruchirappally as the second of eight children of R Chandra Shekhar Iyer and Parvathi Ammal, Chandra Shekhara Venketa Raman passed matriculation at the age of 11, FA at 13, BA at 15 and MA at 18, all at the highest rank. By the time he completed MA in 1907 from the Presidency College, Madras, Raman has already authored two research papers in the prestigious Philosophical Magazine shortening his tongue twisting name to C V Raman. Such shortening are quite common. For example, the Warren pump which is described in any UG physics textbook is the mercury diffusion pump invented by H P Warren or H Parameswarn of Trivandrum. This may not be known to even the majority of Keralites.

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Due to health problem, Raman was denied the opportunity to study abroad. He wrote the competitive examination of finance department and topped the list. In 1907 he was appointed as the assistant accountant general at Calcutta. Before catching the train to Calcutta the 13year old Lokasundari walked into the life of C

## V Raman.

Within one week of shuttling back and forth between the home and the office at Calcutta, Raman made a remarkable discovery - the Indian Association of Cultivation of Science at 210, Bowbazaar Road of Calcutta. It was a heart-touching scene. On knocking the door of IACS building, a young man called Ashuthosh Dey appeared in front of Raman - a historical meeting indeed, since later on for about 25 years of scientific pursuit Ashu Deay was going to be Ramana's right hand. Even without receiving any college education, Ashuthosh Dey published a number of single author papers in the Proceedings of Royal Society - Raman used to remember proudly.

The association was established in 1876 by Mahendralal Sircar who was a Bengali Medical Doctor. He believed that the problem of the country can only be solved by the modern science. He founded the IACS in the same pattern as that of the British Royal Institute. Unfortunately nobody came forward to do research. Disappointed by the nonrealization of his dream, Sircar died in 1904. In order to fulfill the dream of his uncle, Amrithlal Sircar took charge of the scene like a doorman of a temple in search of its idol. It was in this background that Ashuthosh Dey led Raman to Amrithlal.

Raman enquired about the complete silence in the institute. Answer was in the form of a question- what does Raman find interesting in this institute? When the guest unfolded his bundle of dreams, the host did not believe his ears. Through out his life the uncle requested in vain a number of people to use the facilities of the association. And, here, there is a rare specimen in flesh and blood- a young man of high govt official - who requests the facility to do research during his leisure hours!! May be, the Association might have been looking forward for this very moment through out its existence till then.

Amrithlal embraced the dream-incarnate of his uncle and asked " where were you till this time?" He invited Raman to use the key of the Association as he like. For ten years from 1907, Raman lived a double life. Day time-an efficient officer- during leisure hours a scientist who does research forgetting everything else. For all his endeavours Ashubabu was always ready.

From 1907 to 1919 Raman studied the acoustic properties of Indian musical instruments. Scientific journals like Nature, Philosophical magazine, Physical review started printing the name of Raman and the Association at a regular basis. Mahendra Sircar's Association became world famous.



People of Calcutta also started taking note of Raman. He used to present his discoveries with the help of demonstrations in front of the public. The legacy started by JJThomson, Faraday and Rutherford of England was imported to India by CVRaman.

The purity of sound from ekthara, acoustic difference between thambura and veena etc were the subjects of investigation carried out by Raman. Some of his valuable contributions during this period were the study of thabala and mridanga. The western percussion instruments are creating sound structures, while thabla and mridangam are sprinkling musical sounds. Raman found their secret by conducting a series of experiments . Raman and Ashu Babu even constructed a self working violin using discarded components available in the market shops.

1916 was the year which created a turning point in Raman's life. In that year Ahuthosh Mukherjee became the VC of Calcutta University. He invited Raman to take up the Physics professor's post and strengthen the science education in



Calcutta university. Raman did not wait to think- loss in salary will compensate for the time available in doing research. Finance department did not sanction leave. Without a second thought, he threw away the job and accepted the invitation of Ashuthosh Mukherjee. Raman's action made the VC emotional. Visibly moved VC said " this alone is sufficient to prove that this temple of Saraswathi will not lack the seekers of the truth"

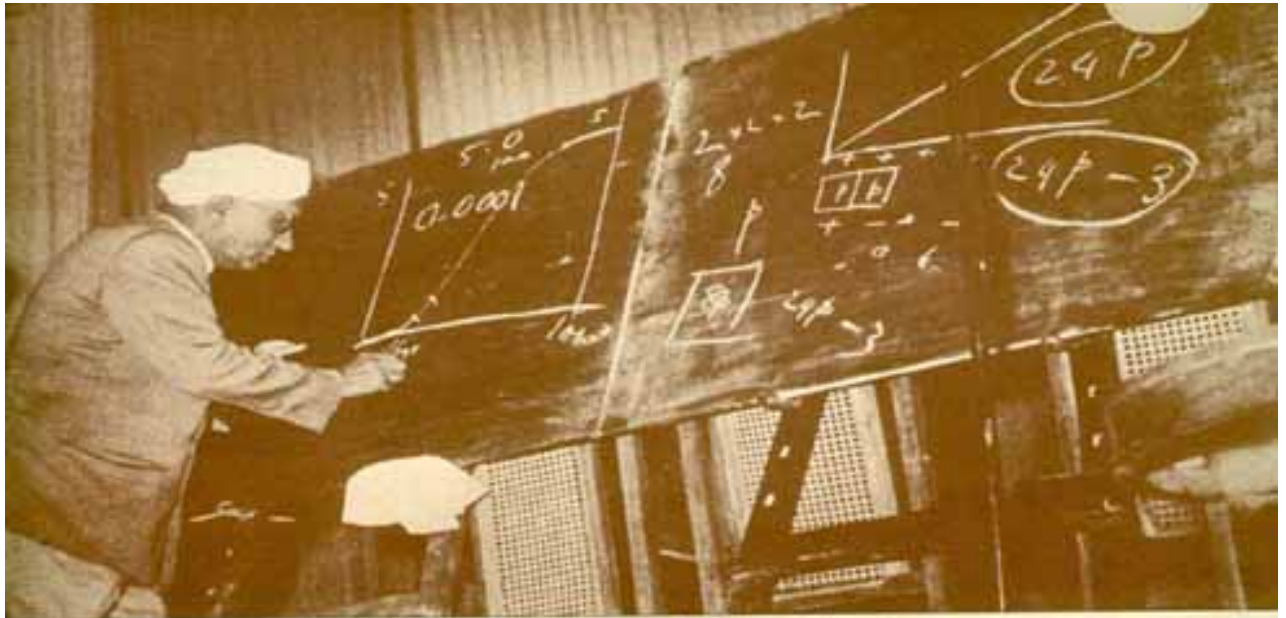


Then came an unexpected blow. The funding agency which finance the Palit Professorship has laid a condition of foreign experince for the candidates. Raman has not even put his leg on a foreign soil. As a solution authorities advised Raman to avail two months' experince in any foreign labs. Raman did not accept. He replied " I can train foreigners in my lab if they want" As a special consideration Raman was made the Palit Professor

Raman was arranging conducted tour for students to the infinite landscape of Physics. Calcutta University became the dream world of meritorious students. K R Ramanathan from TVM, K S Krishnan from Madras, Bhagavantham from Andhra - many came from the nook and corners of India to accept the discipleship of Raman.

Following the death of Amrithlal in 1919. Raman became the secretary of the Association. IACS echoed with enthusiasm and noise 24 hours a day. During this period Raman and his group were slowly sliding to the rich fields of light and colour.

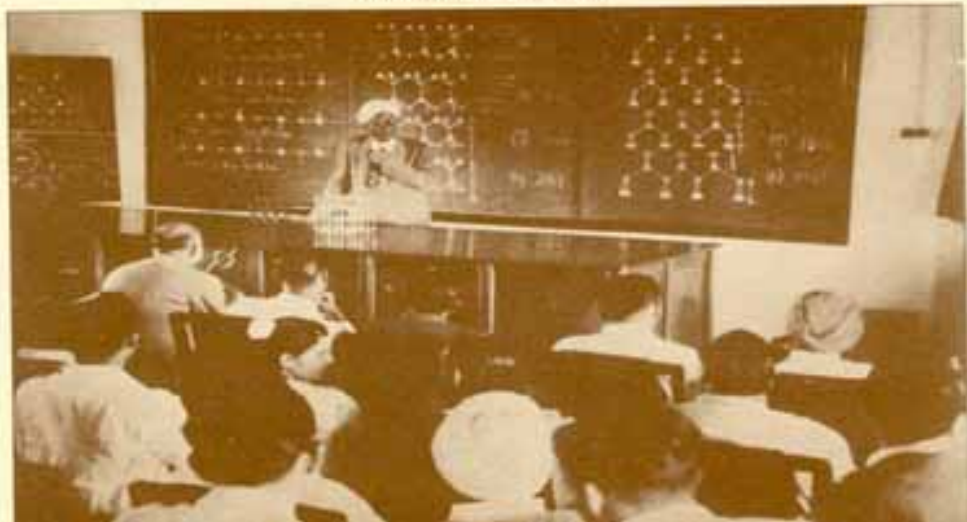
The first foreign trip of Raman was in 1921 - to take part in a conference at Oxford. During his stay there Raman made the phenomenon of whispering gallery at St Peter's Cathedral of London as the subject of one of his Nature paper. During his return journey, the deep blue of the Mediterranean Ocean tickled the scientific mind in Raman. He did some observation of the blueness of the waters using his Nicol prism which he always carries. He found that the blueness of the ocean is not due to reflection of sky as Rayleigh thought but due to light scattering by water molecules.



*Raman expounding his crystal dynamics*

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*Gandhi Memorial Lecture*



By 1923, Raman and Ramanathan started studying the scattering of X-rays from liquids. It was during this time that Compton discovered the wavelength shift in X-rays due to scattering by electrons. Raman immediately scaled up the phenomenon of Compton effect and argued that similar phenomenon will occur for light scattering by molecules. By this time Raman and Ramanathan discovered the X-ray fluorescence from organic liquids.

In 1924, FRS came in search of Raman. During a reception party Asuthosh Mukerjee asked " Professor Raman, what next?"

Answer was spontaneous " why, of course NP itself."

Day and night were spent by Raman and his students in the lab from 1924 onwards. Towards the end of the hectic period the mood was in climax as explicitly seen from KS Krishnan's diary.

### **Feb2, 1928, Thursday**

The previous three-four days were spent to study fluorescence. This may open up the door to an extensive fields of research. Professor along with Venketeswaran is studying the fluorescence from a number of organic compounds. Surprisingly fluorescence from some liquids are polarized.

### **February 7, Tuesday**

All pure liquids exhibit weak fluorescence. Interestingly all are polarized, When I said this to Professor he did not believe. Whwn the experiments were repeated results reproduced. Professor briskly paced in the length and breadth of the laboratory repeatedly asking himself " most astonishing result. Five years ago why it escaped from our observations?"

After dinner, me and Venketeswaran were chating in the upstairs room of the lodge ( about night 9o'clock).. Unexpectedly somebody called us loudly . When reached below we saw Professor who was highly excited. He told" I just came to say that what we discovered was the phenomenon we were looking for as per Kramer-Heisenberg theory. Hence we will call this as " Modified light scattering"

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### **February 9, Thursday**

Set up was ready to study the effect in gases. Before completing the experiment, Professor had to go to College since it was time fro the class. By 3 o'clock when professor returned I told him the result of the experiment. There was still some sunlight for professot to look and confirm himself. He walked to and fro in the laboratory repeatedly saying " most wonderful discovery." During the class hours, professor was quite restless since he had to stop the experiment in between in the morning.

### **Feb 16, Thursday**

At higher temperature, the existence of polarized modified scattering of light in pentane gas was confirmed beyond doubt. A note was sent to Nature under the title " A New type of Secondary Radiation."

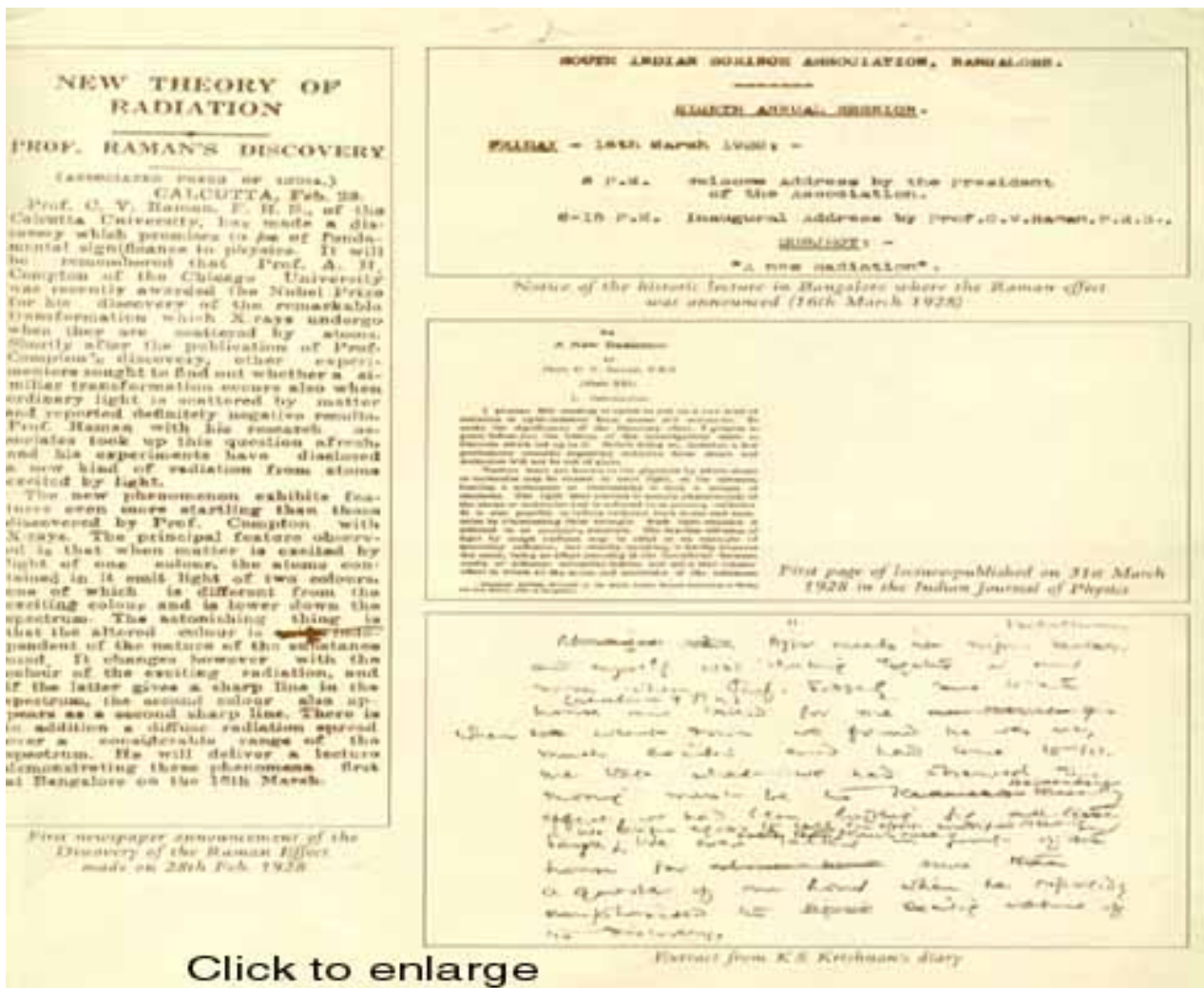


### Feb 17, Friday

Professor confirmed the polarization nature of fluorescence emission in pentane gas. My left eye was giving some trouble. Professor asked me to take rest and told that he himself will take observations.

### Feb 27, Monday

Went to the Association in the afternoon. Professor ws there. Started studying the effect of incident light wavelength on the ne scattering effect. Astonished to see that the scattered radiation has wavelength different from the incident one - wavelength higher and shrter than that of the incident radiation.



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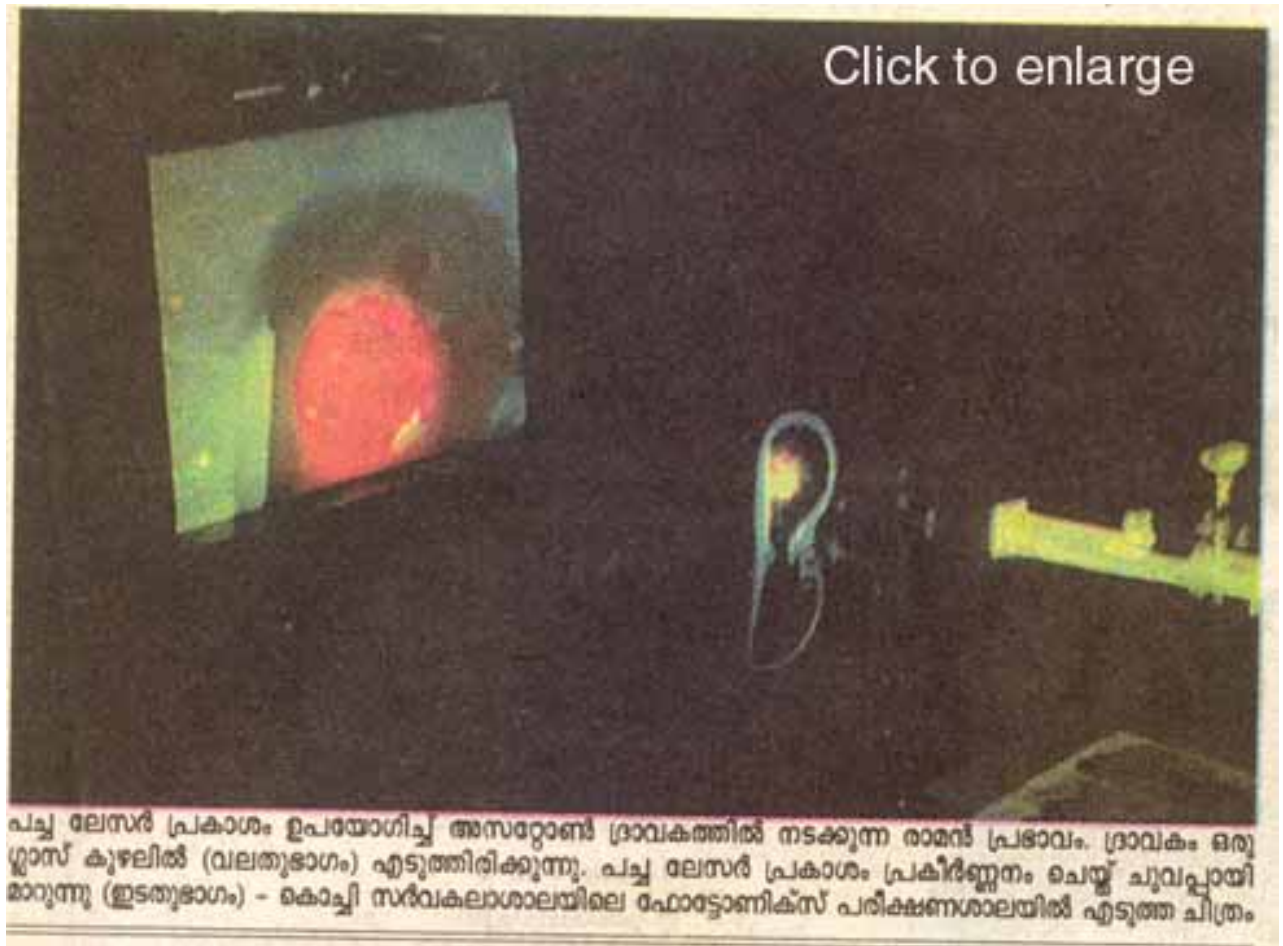
We see the breath-taking pace and expetations of a great discovery from Krishnan's diary. Let us see the reason for this new scattering effect which later on known as Raman Effect.

World knew about the discovery of RE in February 29. Next Sunday, in front of the overflowing gathering of South Indian Science Academy at Bangalore, Raman repeated the experiment. 1000 copies of the speech entitled " New Type of Radiation" were printed overnight and sent to scientists all over the world.



Somebody mentioned about Compton effect during the meeting. Raman replied. "right, but my effect will act deeper roles in the study of chemistry and molecular structure." Time proved the correctness of this prophecy.

Why was Raman showed this much eagerness to make this discovery known to the world as fast as possible? He was pretty sure that they were on competition.



From 1913, two Russians, Mendelsram and Landsberg were carrying out studies in the same direction as that of Raman . From 1925, they converged such studies in pure quartz. Quartz are plenty in Russia. However they were cheated by shopkeepers by selling low quality quartz passing for pure. Impure quartz will not show the light scattering as expected. At last in 1928 they got a batch of pure quartz. In February 21, they observed for the first time the phenomenon similar to that observed by Raman.

Luck was not with Russians. Due to lack of self confidence, they did not publish the result. Instead, they presented the results in an Academy meeting. Nobody in the audience beloved them. When Raman published his results, then only the Russians realized that they also observed same phenomenon. In May, they send their paper for publication. By that time about 16 pppers including Raman's appeared from different labs all over the world.

The NP of Raman was an eye sore for Russians. In the beginning they referred the phenomenon as Mandelstraum effect instead of RE. Later on as Mandelstram -

Raman Scattering. Now the Russians also accepted the name Raman Effect. Time is the great healer of wounds.

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C.V. Raman and the other Nobel Prize winners of 1930 (From Pictorial, Karl Lundström and Niklas Lönn)



Everybody believed that the 1928 NP will go to Raman. However the British scientist Richardson was the winner on that year. Same was the case in 1929 also when Louis de Broglie was awarded the prize. In July 1930 an inner voice urged Raman to book two tickets to Europe for Dec 1930 (one for him and the other for his wife). NP of 1930 went to C V Raman. The NP ceremony took place at Stockholm on 10th Dec 1930 between 4 and 7.30 pm. Since two Americans were also in the list, State advisor of USA were also present in the hall. He wrote to USA:

"Of all the Nobel Laureate much attention was focused on to Sir Venketaraman, the Indian winner. After receiving the prize from the king, C V Raman returned to his seat visibly moving with emotion. Tears streamed down from his eyes. During the dinner, Raman's speech was a masterpiece. Everybody in the hall gave a big applause to CVR after his speech. The only one annoyed at least a little was the British ambassador near my seat since Raman referred to his friend in jail who send greetings to him telegraphically."

Now listen Raman's words:

" On returning to my seat I saw the ocean of white faces all around me. Here, I, a loner, an Indian with the coat and turban. really felt to be representing my country and my people. I felt humble while receiving the prize from King Gustav- moments of up tide of emotion- I controlled myself. Then, I turned around. I was sitting below the Union Jack. On realizing this I remembered my poor country. India does not have even her own flag. This realization broke my self control."



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Even though C V Raman had written a number of valuable articles, he has not written any book - except a monograph called " molecular scattering of light" He gives the reason " it may be while writing that sudden burst of idea takes shape in the mind. Immediately goes to lab spending days immersed in a variety of experiments. This causes breaks in the flow of writing. Then I abandon the idea of writing the book.."

As mentioned earlier lasers gave a resurrection to RE during the sixties. Even now new phenomena related to Raman are being discovered from the labs world over.

Along with the fame dark clouds of jealousy and intolerance started condensing in the atmosphere of IACS as well as the Calcutta University. It was at that time that Tata founded a Science & technology institution at Bangalore, which later on became Indian Institute of Science. From the beginning itself, directors of the institute were British. In 1933, the institute was looking for a director and the



committee contacted Rutherford in England. He asked " Since in India itself has the most appropriate person why waste time searching in England?" In 1933 Raman became the first Indian to become the director of the Tata Institute. Raman founded and nurtured the Physic dept at the institute, which shoot up to international famous within a short span of time.



Once again the black forces started playing the pre-scripted roles. Within three years, Raman had to resign from the Director's post. However, he continued to be the head of the Physics dept till his retirement in 1948. Raman's coming to Bangalore made it the academic capital of India. Calcutta's loss was the gain of Bangalore.

Raman molded outstanding physicists in Bangalore also. To cite examples, Nagendranath, Pncharatnam, PRPisharoty, R S krishnan, G Ramachandran. One of the important discoveries during this period was Raman - Nath effect which has recently applied in FEL. Phenomenon of geometrical phase in polarized light discovered by Pancharatnam has recently rediscovered by Michael Berry and is now commonly referred to as Berry's Phase.

2nd world war made scientists to leave Germany. Raman wanted to bring stalwarts like Born, Schrodinger, Oppenheimer etc to India. In fact Born stayed in Bangalore as a guest of Raman for some time. However, the adverse atmosphere prevailing in the Institute and in the country made Raman to fail in this mission. Otherwise, India could have been the gravitational center of Modern science and could have regained the ancient glory.

Raman effect is an important tool to study the geometrical symmetry of crystals and molecules. Symmetry is also the language of beauty not only in flowers,

crystals, and animals but also in natural laws and natural phenomena.



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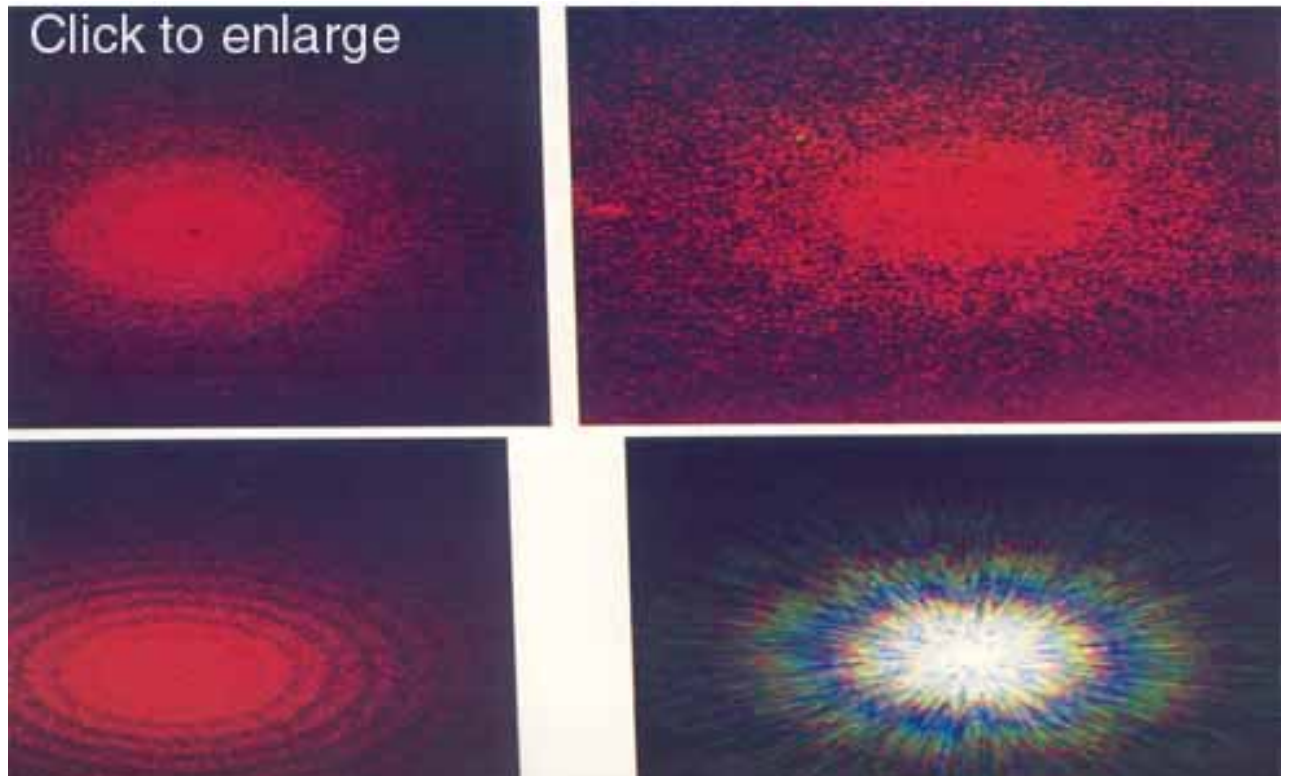


In 1934, Raman established the Indian Academy of Sciences. During 1934-54 periods, the Indian Academy Proceedings were considered to be one among the top research journals all over the world. Majority of Raman's papers appeared in this proceedings.

When retired from service, Raman lost all his savings including the NP money since he deposited the money in a private Bank. This bank was liquidated thereby sinking the lifetime savings of C V Raman.

With the help of the Maharajah of Mysore and his own friends, Raman established a research laboratory, which is now called Raman research lab in Bangalore. The RRI is in perfect blend with surrounding trees and bushes and is an important landmark of Bangalore. RRI's future expansion should be without destroying its rhythm with nature, thus wrote Raman in his will. Trees are dissolved into the

soul of RRI. At present an Optics lab is being constructed in the campus centered on a grand old tree treating it as a valuable gift of Nature. There is no other mode of payback more appropriate than this gesture of the present administration to Raman who had been a lifelong lover of science and nature.



Towards the twilight of his life, Raman was melancholic and sad. He used to say that in life he was an utter failure. In the evening he used to take around the children in RRI campus in which he found immense pleasure.

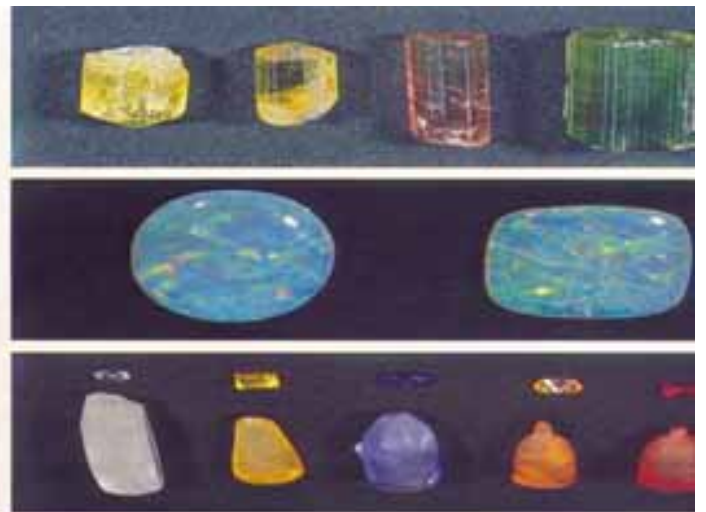
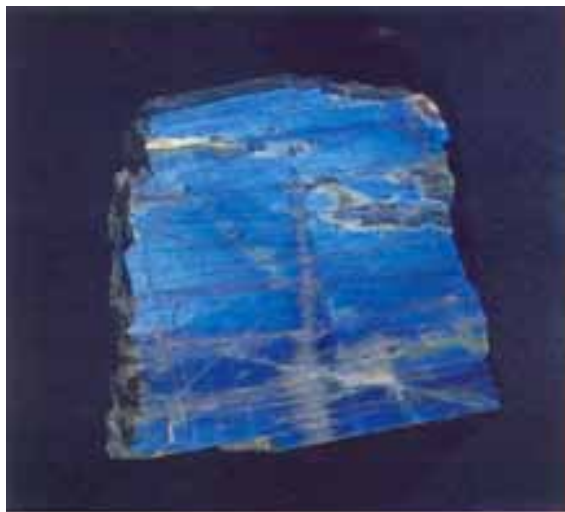
Every year Raman gave Gandhi Memorial lecture on Oct 2 through the AIR. 1970, Oct 2 as well as the country saw the last of Gandhi Memorial lecture delivered by Raman. In an evening of Nov 1970, Raman fell unconscious in his lab. After two weeks, in Nov 21, 1970 he got dissolved in to the *Varnaprapancha* -the universe of colour- leaving about 310 varieties of diamonds gems and stones to the future generations.

It might have been the starting point of *Mahaprasthan* - the great journey- of a pure soul. As per his wish the compound of RRI became the resting place of Prof C V Raman- the final resort of the great son of India - sans celebration, sans memorials sans anything except a lone tree on the green Spread, standing upright looking directly above waiting for the mild wind flowing often and embracing it....





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*The Lawn in RRI. The lone tree*

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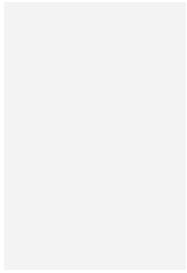


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