THE RAMAN EFFECT

S. BHAGAVANTAM
Indian Institute of Science, Bangalore

PROFESSOR RAMAN started working on the scattering of light by matter in 1921. In 1922, he wrote a monograph entitled *Molecular Diffraction of Light*, which was published by the Calcutta University Press. By 1924, he made such noteworthy progress that he was invited to open a symposium on the subject at a meeting of the British Association in Toronto. In 1928, he discovered the phenomenon that now bears his name—the Raman Effect. In 1930, he was awarded the Nobel Prize in Physics. Thus, it took him just nine years to climb to the top, starting from the scratch.

During the presentation speech, the Chairman of the Nobel Committee for Physics said: "the Raman Effect has already yielded important results concerning the chemical constitution of substances; and it is to foresee that the extremely valuable tool that the Raman Effect has placed in our hands will, in the immediate future, bring with it a deepening of our knowledge of the structure of matter." That, during the forty and odd years that have since gone by, many thousands of papers have been published by scientists working in several countries and in widely varying disciplines, that numerous problems of importance have been solved and that some unexpected ramifications of the subject have come to light in recent years is a most gratifying fulfilment of such an anticipation, pronounced so soon after the discovery and in such a forthright manner. Today, the Raman Effect stands as the pinnacle of India's contribution to world science.

It was known for a long time that light is diffused laterally with varying degrees of intensities by matter in all states of aggregation. When a beam of white light is condensed by means of a lens into the centre of a large glass bulb containing a dust-free liquid like benzene, an observer who shields himself from the direct rays of the source and views the track in the liquid in a transverse direction, will at once see a magnificent blue scattering. This rather easily performed experiment was always explained by attributing the blue colour to a relative enhancement of what is already present in the source. It was never expected that during the process of scattering, it was at all possible that in addition to what is present in the source, light of frequencies not present in the source can be generated and therefore detected in the scattered beam. Professor Raman, by using a simple device of inserting appropriate filters in the paths of incident and scattered beams in the beginning and by using monochromatic sources later, discovered that some new frequencies not present in the incident light appear in the scattered beam as a result of, so to say, interaction between molecules of the radiated substance and the incident radiation. Thus, in the spectrum of the light scattered by a substance, the Raman Effect discloses itself by the presence of new lines adjacent to the original lines of the incident light. The effect may be briefly defined as follows: when a transparent substance is radiated with monochromatic light, a portion of the incident radiation is scattered by the substance in all directions. While a large part of the light thus scattered possesses the same frequency as that of the incident radiation (Rayleigh scattering), a small fraction thereof consists of light which has undergone a change of frequency (Raman scattering), the extent of change being characteristic of the substance.

It is best to quote here what Professor Raman himself wrote, nearly 40 years after the discovery, about how he was led to make the discovery.

"Later, I became aware of the remarkably brilliant monochromatic illumination which could be obtained by the aid of the commercially available mercury arcs sealed in quartz tubes. Towards the end of February 1928, I took the decision to make use of such lamps for all further studies in the field of light-scattering. The success which attended this forward step was immediate and highly gratifying. Experience in working with sunlight indicated the techniques necessary for the observation of extremely weak phenomena, viz., the rigorous exclusion of stray light and the conditioning of the observer's vision by a prolonged stay in darkness. On setting up the apparatus and making these preparations, I found that the light of the mercury arc diffused by various materials when examined through a direct vision spectroscope showed

the presence, besides the lines of mercury, also of other lines the positions of which varied with the substances under study. Amongst the numerous materials thus examined was a large block of clear ice. This showed sharp displaced lines in the spectrum of the scattered light in approximately same positions as the rather diffuse bands observed with pure water. Within a few days of the discovery, photographic spectra were successfully recorded in which the additional lines showed up very clearly."

Today, intense sources of radiation and powerful spectrographs are available for Raman studies. Techniques have been greatly improved and automatic recording devices pressed into service. The discovery of Laser action and Laser sources has introduced a new dimension to the phenomenon. The Raman spectrum of a new substance has now come to be regarded as its signature and is invariably studied.

It is of particular significance that the equipment which Professor Raman employed consisted of three items, namely, a mercury lamp, a flask of benzene and a direct vision spectroscope, all of which would be regarded as crude instruments at the present time. Even at that time, these would by no means qualify for being classed as sophisticated or expensive items. On the contrary, they were available to many physicists all the world over in every laboratory worth its name. Great discoveries always appear incredibly simple, but alas only after some devoted individual has made the discovery.

PROFESSOR RAMAN, "THE SCIENTIST-SAVANT" I ADMIRED

T. S. SADASIVAN

Director, Centre for Advanced Studies in Botany, University of Madras

WHO can write a near complete appreciation of our most colourful and dynamic personality of the community of scientists of modern India? Who, indeed, could dare attempt to fathom the intellectual brilliance of a unique personality India lost on that fateful day, November 21, 1970? To many, he was just Sir C. V. Raman, a venerable figure full of honours and the tallest among Indian scientists of this century, but to some of us who were admitted into his 'inner court' he was THE PROFESSOR which conveyed everything that the title signified. Whether we belong to diverse discipline of biology, physics, mathematics or the earth sciences, he was our guiding star and we looked upon him not only as a Nobel Laureate in Physics but also as a sole representative of a fast dwindling group of scientists who could be called Naturalist-Philosophers. For, who could have the courage to enter into fields like the Physiology of Vision or Floral Pigments (he coined a word 'Florachrome') or the colour of the sky or the oceans and make significant contributions?

Ever since he built his own Institute, Professor Raman's wide interests in science became more apparent than ever. His collections of natural objects ranged from colourful minerals to diamonds, rubies and sapphires; every type of musical instrument from the mridangam to the violin; from birds, beetles and butterflies to the finest collection of roses, bougainvilleas and jacarandas; stately trees from the common eucalyptus to the rare mahogany—indeed, he was literally surrounded by a fantastic array of biological materials. I can never forget the way he laid two similarly dressed ores of copper and gold in the palms of the late Prime Minister Pandit Jawaharlal Nehru when he visited his Institute and switched on the ultra-violet light and asked the Prime Minister as to which was copper and which gold. The brighter piece under the ultra-violet light was promptly named gold by the Prime Minister and Professor Raman in his inimitable way burst out: "Mister Prime Minister, all that glitters is not gold."

Professor Raman had some very definite views on fundamental research as Society's soundest investment for the future. He, nevertheless, conceded that while technological innovations had their own marketplace importance, the future of science unquestionably demanded a high place for fundamental research and the scientific community would have to understand the rationale of it all and make science play a positive role in our society than ever before. While he did not deprecate the interdisciplinary approach in many new fields of specialization, Professor Raman made no