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A peep into Raman's world

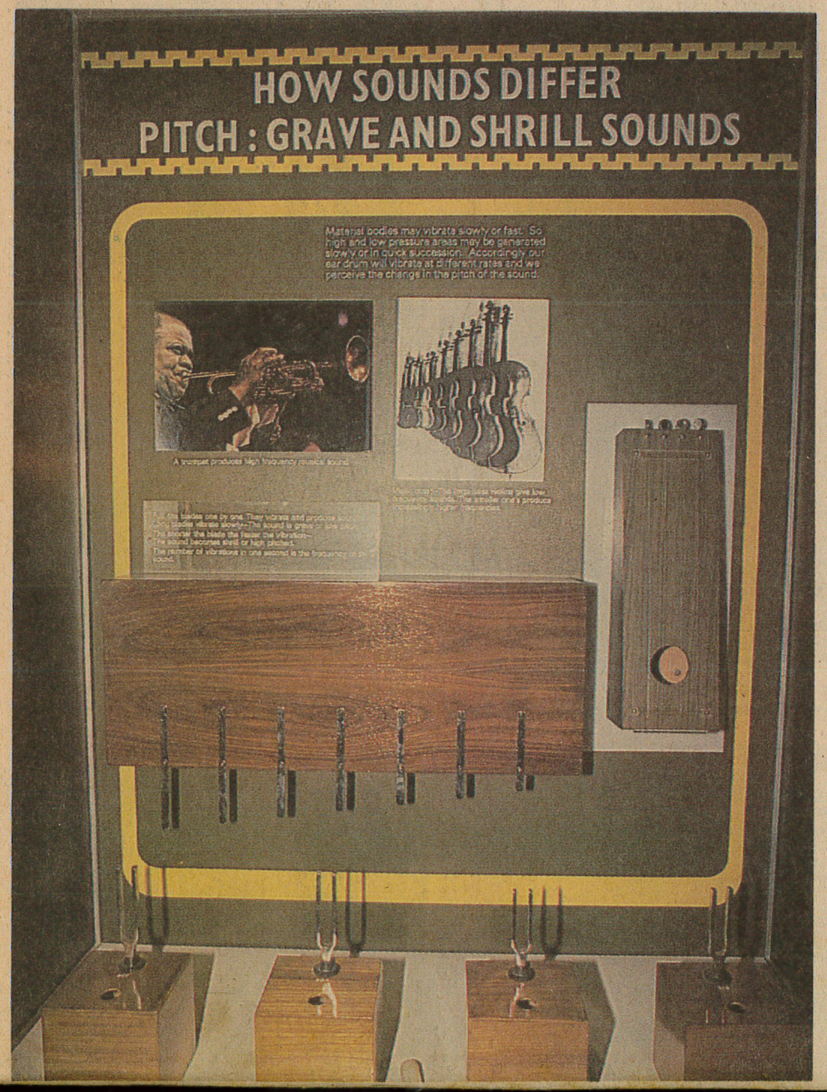
The Birla Industrial and Technological Museum in collaboration with the Raman Research Institute, Bangalore, has set up an exhibition on C. V. Raman's areas of research.

THE year 1988 marks the birth centenary of the greatest Indian physicist and father of modern experimental physics in the country, Sir Chandrasekhar Venkata Raman. Last year, as a prelude to the centenary celebrations that are being held all over the country, the Prime Minister, Mr. Rajiv Gandhi declared February 28, the date on which Raman made his historic discovery on the scattering of light now called the Raman Effect, as the 'National Science Day'.

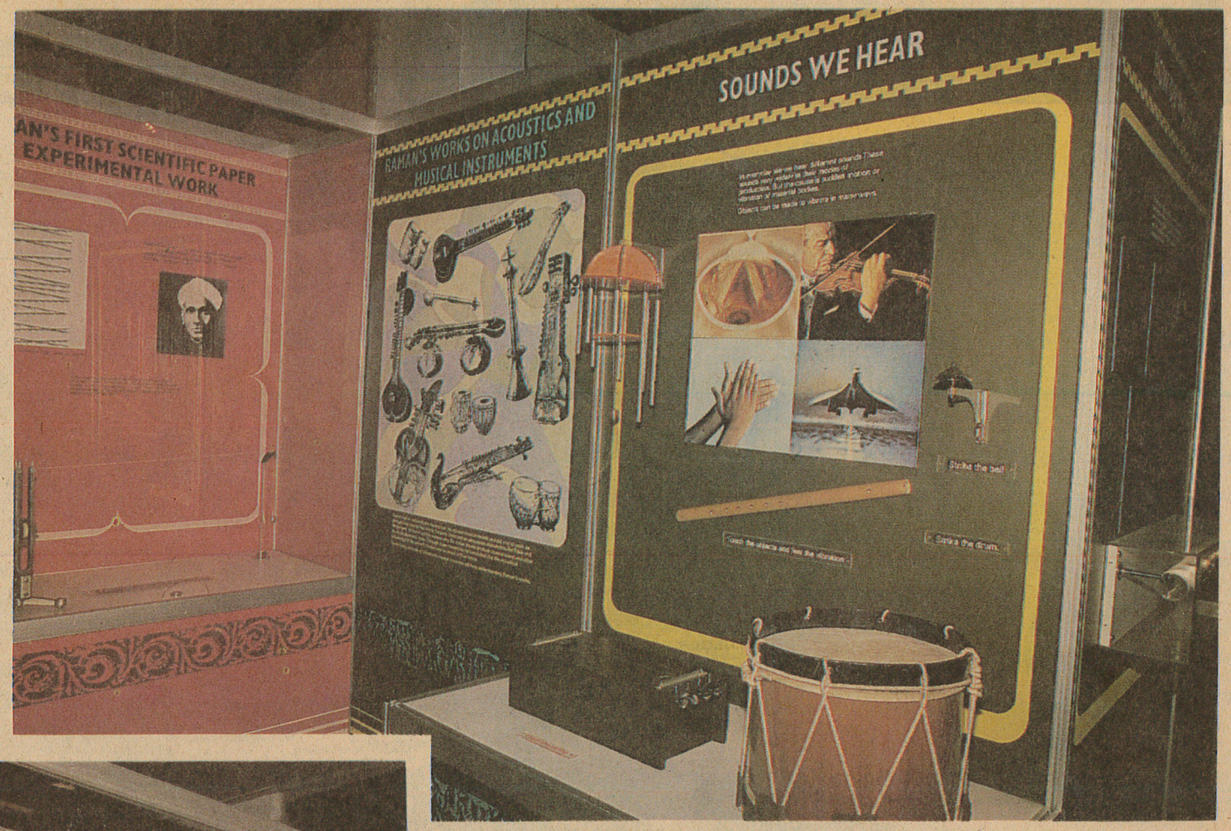
It is, however, a sad commentary on the science education system in the country that Raman's science is yet to make way into school and college textbooks even though his science was simple and beautiful. In fact, apart from the mere information that Raman got the Nobel Prize, very often a school student is exposed to the name of Raman through prose text books in the English language courses where one of the favourite pieces is the brilliant essay by Raman on water called 'The Elixir of Life'. There is no denying that Raman's English was as expressive and simple as his science was but even such popular writings on scientific topics by Raman have failed to make way into the science curricula of Indian schools, let alone the hard science of his research work that spanned nearly seven decades.

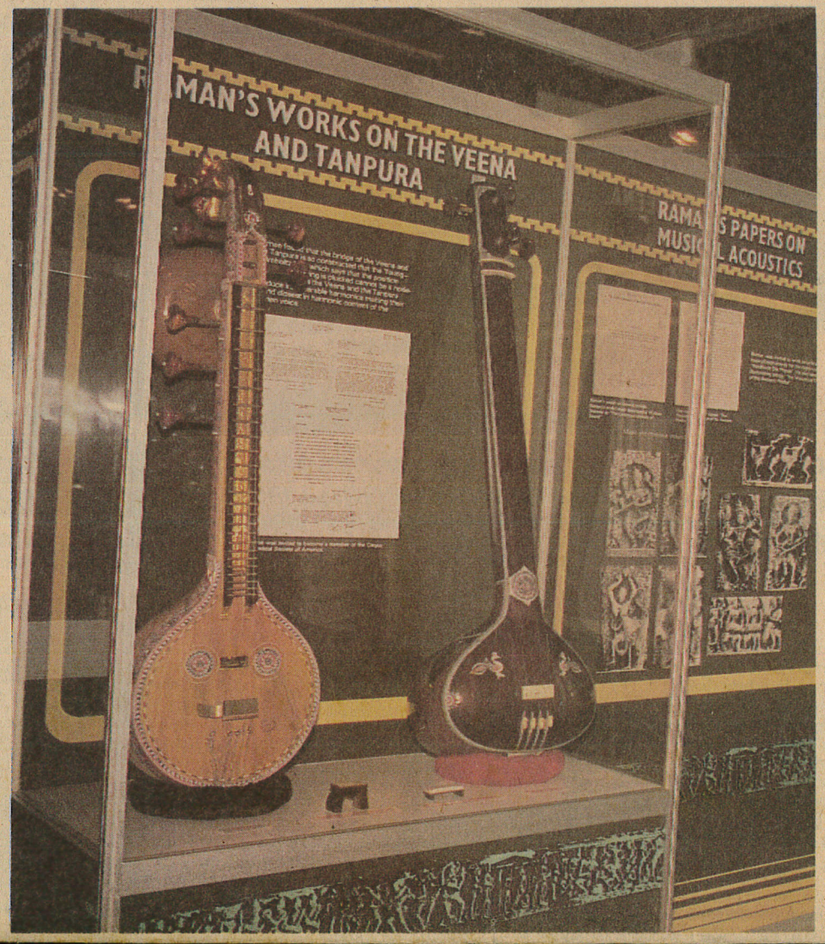
What gave Raman's science the stature and ranked it with the best of science around the world during his days is the remarkable insight and ingenuity of approach that he brought to bear on any topic he took up whether it be optics or acoustics, musical instruments or church halls, sea or sky, flowers or birds, rocks or diamonds. At the same time he thought it necessary to make his science accessible. The clarity of his expression was such that even a layman could understand what his findings meant.

The centenary celebrations provide a good opportunity to expose school and college students of science to Raman's world. And even today his approach to scientific research is relevant and can serve as an inspiration to the young aspirants. What better way can one think of to get a feel for Raman's science and his experimental ingenuity than through a science museum with working models and demonstrations.



Raman carried out extensive research on acoustics. Pictures on this page and the next show musical instruments displayed at the exhibition which can be handled by visitors to observe the effects discovered by Raman.





The Birla Industrial and Technological Museum (BITM), in association with the Raman Research Institute (RRI), Bangalore, has set up an extremely imaginative exhibition on the Life and Works of Raman which is now simultaneously on at Calcutta and Bangalore and later will move to various parts of the country with the assistance of the National Council of Science Museums (NCSM).

What makes the exhibition worthwhile for every one is that it has been designed with the inquisitiveness of the spectator in mind. The experimental set-ups are interactive in nature in the sense that they can be handled by the visitor so that he or she can physically see the effects that Raman observed. The credit for the conceptualisation of the exhibition and the various demonstration apparatuses therein goes to Mr. D. K. Phatak and his colleagues at the BITM, Calcutta. There are also a large number of rare photographs which the BITM has diligently collected from various original sources. Many institutes and societies as well as individuals have contributed their material for the exhibition. These include the RRI; the Indian Association for the Cultivation of Science (IACS), Calcutta; the BARC; the Royal Society, London; the Optical Society of America; the Franklin Institute, USA; the Catgut Acoustical Society, USA; the Nobel Foundation; California Institute of Technology, USA; Niels Bohr Institute, Denmark, the Tamil Nadu Science and Technological Centre, Madras; the Science Museum, London; the American Institute of Physics; and Dr. Tapen Roy of the Jadavpur University, Calcutta.

It is true that scattering of light and other related aspects formed a bulk of Raman's research but he carried out extensive investigations in acoustics and, in particular, musical instruments. This is largely not known to science students and even in courses on sound at higher levels Raman's theories on bowed string instruments, plucked instruments and struck instruments are not always taught. The fact that Raman was awarded the Nobel Prize for his work on light adds to this impression even though his work in acoustics is of equally high order if not better. It is only that (quantum) effects of light electromagnetic radiation, in general enjoyed a pre-eminent position in the research activities of that period with quantum theory trying to establish it-

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self. It is unfortunate that in the University Science College, Calcutta, several equipment that Raman used for his acoustic experiments are lying in an abandoned state even today. These include, it is believed, a violin set-up, a piano, Helmholtz resonators etc. The sonometer that Raman used was being used in the laboratories of the Science College for many years after Raman left Calcutta. Efforts on the part of the BITM, it is learnt, have not been fruitful in retrieving these for preservation.

It is, therefore, only appropriate that a considerable section of the exhibition is devoted to Raman's research on musical instruments and acoustics.

One of the very interesting findings of Raman on percussion instruments was that Indian drums like the tabla and the mridangam produced musical sounds whereas Western drums produced noise. This he showed was because of the fact the vibrating membrane of the Indian drums had 'ring loading' or 'step loading' in six or seven steps symmetrically from the centre. This was achieved by the application of a flexible material composed of charcoal, iron oxide, starch and glue on the surface. Because of this step loading the sound of Indian drums consist of harmonics whereas the Western drums produced random frequencies resulting in noise. The way this experiment has been set up is that loud speakers, by forced vibrations, cause the drums to be excited at their fundamental frequencies. Lycopodeum powder sprinkled on the membrane gets aligned in patterns characteristic of the various harmonics. The visitor can fiddle around adjusting the frequency of the speaker and see the patterns.

Raman also demonstrated that some established laws on vibration of strings are violated by Indian stringed instruments like the veena and the tambura. He showed that unlike many other stringed instruments veena produced all the harmonics like the human voice. We are all aware that in Indian music the sound of the veena is the closest to the human voice. This would seem to be against the Young-Helmholtz law but Raman demonstrated that the curved bridge in the veena allowed the node of vibration not to be fixed at the point of contact of the string with the board but to have small motions and this gave rise to all the harmonics. One can see and experience these effects on the veena and the tambura which have been specially set up at the exhibition.

Raman's theory of bowed strings is, of course, a landmark in acoustics. One of his hypothesis was that the energy input in a bowed string was such that the fundamental frequency of the string could not be maintained and it very quickly passed over to a situation where the octave is dominant. The situation then reverts back to the fundamental frequency mode and a kind of oscillation between the two situations takes place in the vibration of the string. The energy input view still remains one of contention. But the basis of discussion till today continues to be what Raman stated in his theory of bowed strings. He was also interested in struck strings which led him to investigate the problem of impact where he made some significant advances. Some of his findings are described in the exhibition.

Light scattering experiments of Raman, of course, get their due share at the show. As is well known Raman's explanation of the 'Colour of the Sea', disproving Lord Rayleigh's explanation that it was due to the reflection of the sky, came after he performed the simple but ingenious experiment aboard the deck of the ship in which he was returning from England. Raman's experiment was to look at the reflected light through a polaroid prism and quench the reflected light by setting it at the so-called Brewster's angle. When he did so to his astonishment he found that the blue would not go and so he concluded that Rayleigh was wrong. You too can rotate the polaroid and obliterate the reflection and see the genuine effect at the exhibition. The blue of the sea is due to the predominant scattering of light by the sea in the blue region. On display are experiments that demonstrate the related optical effects like the colour of the sunset etc.

It is this experiment that led to Raman's monograph entitled 'Molecular theory of scattering of light' and this laid the foundations for Raman's extensive investigations into scattering of light by media culminating in the Raman Effect. There is a modern version of Raman Spectrograph using a helium-cadmum laser and the frequency shift of the incident laser light after it's scattered, the Raman Effect, can be viewed in this exhibit.

One sometimes hears, that Raman never believed in the quantum theory. This would be a gross misjudgment of Raman because, even before the quantum theory was formulated by Dirac and Heisenberg, Raman in the above mentioned book states that the (classical) theory of Electrodynamics based on Maxwell's Equations needed to be modified to explain light scattering at the molecular and atomic levels. Well, this is what quantum theory of electrodynamics of today is all about. In fact, the Raman Effect is in itself a demonstration of the quantum effect which led Einstein to remark 'Raman was the first to recognise and demonstrate that the energy of a photon can undergo partial transformation within matter.'

The exhibition has a section on the atomic structure and the quantum theory. Although a bulk of Raman's work was classical physics the section actually falls into place because Raman's work on the scattering of light is actually demonstrative of a quantum effect and the student would do well to appreciate this link. It is also important to emphasise that, like Rutherford whom Raman admired, this path breaking research was done using apparatus which cost Raman less than Rs. 500.

The study of solar coronae and light halos was an obsession with Raman which never left him. These studies gave rise to his finding of the so-called 'speckle phenomenon' or the appearance of coloured streamers when we look at a light source. A demonstration of this effect can be seen at the exhibition. Raman deduced that this was due to the diffraction corona formed by the imperfections in the refraction medium of the eye. This takes us to Raman's interest in the physiology of vision. A section of the exhibition deals with this work of Raman.

Nature abounds in colours and Raman was fascinated by them. He sought to explain their preponderance through his scientific investigations. Colours of gem stones, bird plumes, flowers etc. attracted his scientific curiosity particularly during the last days of his life. He maintained a fantastic collection of various kinds of stones that included a multitude of beautiful specimens like marbles, alabaster, gypsum, feldspar, moonstones, labr'dorites, jades, opal etc. which displayed extraordinary optical effects. He felt that many of these properties were essentially due to fine crystallites of one phase imbedded inside an isotropic form to give rise to a birefringent medium.

To Raman birds were beautiful and hence subjects for serious study. He gave dozens of public lectures on the subject and one of his favourite titles used to be 'Birds, beetles and butterflies'. The brilliant colours of the plumage of birds were the subject of many of Raman's studies. The interest was all the more as the optical characteristics and distribution of colours were so different on different parts of the the same bird, in different specimens and different species that no single explanation would suffice. Every phenomenon known to optical scientists had to be invoked. He also carried out studies on the kingfisher and the plebian parrot. The section on birds has some fascinating pictures from Raman's personal collection. As has been pointed out by someone, Raman was perhaps the only Nobel Laureate who ran around catching butterflies with a butterfly catcher.

One may say that there are many more things that could have been included. Raman's canvas was so extensive that a museum could be set-up just based on his work. But given the limited objective of this exhibition, as a birth centenary tribute, the limitations of space and also to keep the spectator from losing interest the size is just right and gives a very good feel for Raman as not only a scientist but also one who loved nature intensely. This odyssey into nature as Raman saw can be recommended without any reservations.

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