Award Ceremony Speech

Presentation Speech by Professor H. Pleijel, Chairman of the Nobel Committee for Physics of the Royal Swedish Academy of Sciences, on December 10, 1930

Your Majesty, Your Royal Highnesses, Ladies and Gentlemen.

The Academy of Sciences, has resolved to award the Nobel Prize in Physics for 1930 to Sir Venkata Raman for his work on the scattering of light and for the discovery of the effect named after him.

The diffusion of light is an optical phenomenon, which has been known for a long time. A ray of light is not perceptible unless it strikes the eye directly. If, however, a bundle of rays of light traverses a medium in which extremely fine dust is present, the ray of light will scatter to the sides and the path of the ray through the medium will be discernible from the side. We can represent the course of events in this way; the small particles of dust begin to oscillate owing to electric influence from the ray of light, and they form centres from which light is disseminated in all directions. The wavelength, or the number of oscillations per second, in the light thus diffused is here the same as in the original ray of light. But this effect has different degrees of strength for light with different wavelengths. It is stronger for the short wavelengths than for the long ones, and consequently it is stronger for the blue part of the spectrum than for the red part. Hence if a ray of light containing all the colours of the spectrum passes through a medium, the yellow and the red rays will pass through the medium without appreciable scattering, whereas the blue rays will be scattered to the sides. This effect has received the name of the "Tyndall effect".

Lord Rayleigh, who has made a study of this effect, has put forward the hypothesis that the blue colours of the sky and the reddish colouring that is observed at sunrise and sunset is caused by the diffusion of light owing to the fine dust or the particles of water in the atmosphere. The blue light from the sky would thus be light-scattered to the sides, while the reddish light would be light that passes through the lower layers of the atmosphere and which has become impoverished in blue rays owing to scattering. Later, in 1899, Rayleigh threw out the suggestion that the phenomenon in question might be due to the fact that the molecules of air themselves exercised a scattering effect on the rays of light.

In 1914 Cabannes succeeded in showing experimentally that pure and dustless gases also have the capacity of scattering rays of light.

But a closer examination of scattering in different substances in solid, liquid, or gaseous form showed that the scattered light did not in certain respects exactly follow the laws which, according to calculation, should hold good for the Tyndall effect. The hypothesis which formed the basis of this effect would seem to involve, amongst other things, that the rays scattered to the sides were polarized. This, however, did not prove to be exactly the case.

This divergence from what was to be expected was made the starting point of a searching study of the nature of scattered light, in which study Raman was one of those who took an active part. Raman sought to find the explanation of the anomalies in asymmetry observed in the molecules. During these studies of his in the phenomenon of scattering, Raman made, in 1928, the unexpected and highly surprising discovery that the scattered light showed not only the radiation that derived from the primary light but also a radiation that contained other wavelengths, which were foreign to the primary light.

In order to study more closely the properties of the new rays, the primary light that was emitted from a powerful mercury lamp was filtered in such a way as to yield a primary light of one single wavelength. The light scattered from that ray in a medium was watched in a spectrograph, in which every wavelength or frequency produces a line. Here he found that, in addition to the mercury line chosen, there was obtained a spectrum of new sharp lines, which appeared in the spectrograph on either side of the original line. When another mercury line was employed, the same extra spectrum showed itself round it. Thus, when the primary light was moved, the new spectrum followed, in such a way that the frequency distance between the primary line and the new lines always remained the same.

Raman investigated the universal character of the phenomenon by using a large number of substances as a scattering medium, and everywhere found the same effect.

The explanation of this phenomenon, which has received the name of the "Raman effect" after its discoverer, has been found by Raman himself, with the help of the modern conception of the nature of light. According to that conception, light cannot be emitted from or absorbed by material otherwise than in the form of definite amounts of energy or what are known as "light quanta". Thus the energy of light would possess a kind of atomic character. A quantum of light is proportionate to the frequency of rays of light, so that in the case of a frequency twice as great, the quanta of the rays of light will also be twice as great.

In order to illustrate the conditions when an atom emits or absorbs light energy, we can, according to Bohr, picture to ourselves the atom as consisting of a nucleus, charged with positive electricity round which negative electrons rotate in circular paths at various distances from the centre. The path of every such electron possesses a certain energy, which is different for different distances from the central body.

Only certain paths are stable. When the electron moves in such a path, no energy is emitted. When, on the other hand, an electron falls from a path with higher energy to one with lower energy - that is to say, from an outer path to an inner path - light is emitted with a frequency that is characteristic of these two paths, and the energy of radiation consists of a quantum of light. Thus the atom can give rise to as many frequencies as the number of different transitions between the stable paths. There is a line in the spectrum corresponding to each frequency.

An incoming radiation cannot be absorbed by the atom unless its light quantum is identical with one of the light quanta that the atom can emit.

Now the Raman effect seems to conflict with this law. The positions of the Raman-lines in the spectrum do not correspond, in point of fact, with the frequencies of the atom itself, and they move with the activating ray. Raman has explained this apparent contradiction and the coming into existence of the lines by the effect of combination between the quantum of light coming from without and the quanta of light that are released or bound in the atom. If the atom, at the same time as it receives from without a quantum of light, emits a quantum of light of a different magnitude, and if the difference between these two quanta is identical with the quantum of light which is bound or released when an electron passes from one path to another, the quantum of light coming from without is absorbed. In that case the atom will emit an extra frequency, which either will be the sum of or the difference between the activating ray and a frequency in the atom itself. In this case these new lines group themselves round the incoming primary frequency on either side of it, and the distance between the activating frequency and the nearest Raman-lines will be identical with the lowest oscillation frequencies of the atom or with its ultrared spectrum. What has been said as to the atom and its oscillations also holds good of the molecule.

In this way we get the ultrared spectrum moved up to the spectral line of the activating light. The discovery of the Raman-line has proved to be of extraordinarily great importance for our knowledge of the structure of molecules.

So far, indeed, there have been all but insuperable difficulties in the way of studying these ultrared oscillations, because that part of the spectrum lies so far away from the region where the photographic plate is sensitive. Raman's discovery has now overcome these difficulties, and the way has been opened for the investigation of the oscillations of the nucleus of the molecules. We choose the primary ray within that range of frequency where the photographic plate is sensitive. The ultrared spectrum, in the form of the Raman-lines, is moved up to that region and, in consequence of that, exact measurements of its lines can be effected.

In the same way the ultraviolet spectrum can be investigated with the help of the Raman effect. Thus we have obtained a simple and exact method for the investigation of the entire sphere of oscillation of the molecules.

Raman himself and his fellow-workers have, during the years that have elapsed since the discovery was made, investigated the frequencies in a large number of substances in a solid, liquid, and gaseous state. Investigations have been made as to whether different conditions of aggregation affect atoms and molecules, and the molecular conditions in electrolytic dissociation and the ultrared absorption spectrum of crystals have been studied.

Thus 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.

Sir Venkata Raman. The Royal Academy of Sciences has awarded you the Nobel Prize in Physics for your eminent researches on the diffusion of gases and for your discovery of the effect that bears your name. The Raman effect has opened new routes to our knowledge of the structure of matter and has already given most important results.

I now ask you to receive the prize from the hands of His Majesty.