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Nobel Prize in Physics 1953

Frits (Frederik) Zernike

The Nobel Prize in Physics 1953 was awarded to Frits Zernike *"for his demonstration of the phase contrast method, especially for his invention of the phase contrast microscope"*.

RESEARCH INFORMATION:

The Royal Academy of Sciences has this year awarded the Nobel Prize for Physics to Professor Frits Zernike, Groningen, for the phase-contrast method devised by him, and particularly for his invention of the phase-contrast microscope.

Zernike's discovery falls within that part of optics in which one operates with the notion of light as a wave motion. From this it follows, amongst other things, that light may be extinguished by light through interference, and is diffracted and scattered by small particles such as the microscopic objects. All this, as far as the principles involved are concerned, belongs to a closed chapter that is generally referred to as classical physics.

When on this occasion a Nobel Prize is awarded for contributions in classical physics, the fact is so remarkable that we must go back to the very earliest Nobel Prizes to find a counterpart. All later Nobel Prizes, with the exception of a couple of awards where the stress was rather upon the technical aspect, have been awarded for discoveries in atomic and nuclear physics, the physics of this century.

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It would scarcely be an exaggeration to claim that the microscope is one of our most important instruments of research. Every improvement, even a slight sharpening of this eye towards the microcosmos, may pave the way to great advances in the natural sciences, medicine, and the technical sciences.

Probably no other instrument has been the object of so much technical and theoretical study as the microscope. The thorough theoretical foundation that we owe to the genius of Ernst Abbe of the famous Zeiss concern was followed at the end of the last century by a development of the microscope that brought its optical and illumination system very close to perfection.

But even Abbe's theory had a gap, for it took into account only those conditions in which the microscopic objects appear against the background as a result of their contrasts in colour and intensity. Many microscopic objects, however, micro-organisms such as bacteria and cells, are colourless and transparent, and for this reason difficult to distinguish from their surroundings. Attempts have been made to overcome this difficulty with various methods of staining or with a special illumination system, the so-called darkfield illumination. The staining methods are not always suitable, as for example when we are dealing with living objects; and dark-field illumination easily leads to a misinterpretation of the finer details in the structural picture.

It was this gap in Abbe's theory that in the 1930's led Zernike to re-investigate the refraction processes in the light that give rise to the image in a microscope. Even if the eye is not able to discern the change undergone by a beam of light when it passes through a transparent object, the change does nonetheless exist as a phase-difference of a quarter of a wavelength relative to the direct beam that does not pass through the object. The problem was thus to transform these otherwise imperceptible phase differences to visible contrasts in intensity. Zernike was able to show that this was possible, thanks to the fact that the two rays of light take different routes through the microscope before being reunited in the image. By interposing in the paths of the direct ray a so-called "phase-plate" which either further increases the phase-displacement to half a light-wavelength or smooths it out

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completely, Zernike attained the desired effect, so that the two rays either extinguish or reinforce each other. In this way the formerly invisible particle appears in dark or light contrast to the surroundings.

I have deliberately dwelt upon the description of the phase-contrast microscope as the result of Zernike's method which is, so far, the most valuable. The phase-contrast method has, however, many other and increasingly important applications in optics. In addition to its capacity to render colourless and transparent objects visible in the microscope, it also enables one to detect slight flaws in mirrors, telescope lenses, and other instruments indispensable for research. In this connection, Zernike's phase-plate serves as an indicator which locates and measures small surface irregularities to a fraction of a light-wavelength. This sharpness of depth is so great that it penetrates to the point at which the atomic structure of the substance begins to become manifest.

<u>For more details please visit:</u>

http://www.nobelprize.org/nobel_prizes/physics/laureates/1953/press.html