Editor and Advisory Board

SCIENCE BULLETIN

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QUESTION BOX

Question:

What is Huyghens's theory of the transmission of light? What objections to this theory have been advanced? How have these been met?

Answer:

For the sake of concreteness in thinking of this question draw an arc or other line, A B, to represent the wave front of an advancing wave of light. Take a small length, r, as radius, and with points a, b, c, d, & c. on A B as centers, draw arcs on the side of A B toward which the wave is advancing. Draw a line A' B' tangent to these arcs. Then A' B' represents the wave front after the wave has advanced a distance, r, from A B.

According to Huyghens each point on a wave front, as a, b, c, d, & c. on A B, becomes in effect a new point of origin of light. The disturbance then spreads from each of these points as a secondary wavelet. In a homogeneous isotropic medium the wavelets are spherical. The new wave front is the surface which is tangent to all the wavelets, that is, their envelope.

By Huyghens's construction the wave theory gave a ready explanation of the phenomena of reflection and refraction of light. In this it had a decided advantage over the corpuscular theory, supported by Newton. Various objections to the wave theory have been made, however, on other grounds. One of the first of these was the observation that light travels in straight lines, and casts sharp shadows. It was contended that if light is a wawve phenomenon, propagated as suggested by Huyghens, it should bend around obstacles as sound and water waves do. Sharp shadows should be cast only if light is corpuscular. Now closer observation has revealed that light does in fact bend around obstacles just as sound and water waves do. But the amount of bending is very small. It has been found that this is due to the extreme shortness of light waves. The nature of the action is the same as in the other cases mentioned. This departure from exact rectilinear propagation, even though small, could not be explained by the corpuscular theory, but was readily explained by Huyghens and Fresnel on the basis of waves.

A second objection to the Huyghenian construction is to the effect that if each point on the wave front becomes a new point of disturbance this disturbance should spread in every direction, and not merely forward as it is observed to do. There should be a backward wave as well as a forward one. In explanation of this Huyghens assumed that it is only the apex of each wavelet that is effective, thus begging the question. Stokes, however, has shown that the effect of a wavelet at an external point varies as $(1+\cos x)$. The factor $(1+\cos x)$ becomes equal to zero for an angle of 180 degrees, that is, for the back wave. In other directions, except in the forward one, the wavelets destroy each other by interference. A qualitative view of the case would show that unless the conditions of the medium are the same behind the centers of the wavelets as in front of them, that is, unless subjected to the same stresses and possessed of the same velocities, no back wave need necessarily be expected. These factors might well be such as exactly to neutralize the backward directed effects of the wavelets.