1937Obs....60..103H

Presumably therefore a considerable part of the cloud is now in molecular form. Then comes the further question whether the molecules will aggregate together. This involves questions of vapour pressure at low temperature. In view of the high boiling-point of water compared with other likely compounds, is it not likely that this would precipitate the most freely? Atoms of iron and other elements would adhere to the ice-crystals and be dissolved by them; and we might conjecture that, on approaching the Sun, the water evaporates leaving a residue to enter our atmosphere as a meteor. Perhaps my inclination to a "water theory" is influenced by the feeling that, inasmuch as the gas responsible for the mysterious light of the nebulæ has turned out to be just *common air*, it is fitting that the mysterious dark obscuring masses in the Galaxy should turn out to be just *common clouds*.

Important new developments are in progress through the discovery of additional interstellar lines by Merrill and Dunham, including some molecular lines as well as ionised titanium, and probably neutral calcium and potassium. But comment on this would be premature.

I wonder what our successors will have made of this great problem when the Centenary of the *Observatory* arrives?

AIRY'S WATER TELESCOPE.

By H. P. Hollis (Editor, 1893–1912).

This compilation is induced by a brief correspondence between the writer and the late Canon Ellison, well-known as an expert in optical matters, who made it clear that there is a very general misapprehension as to the actual purpose and rationale of this instrument in its bearing on the determination of the constant of aberration. As an episode in Greenwich history, the instrument is not within the period covered by the life of the Magazine, but still it is not so far distant that this may not be offered as a contribution to your Diamond Jubilee Number. Any opinion or statement of view that may be considered original is to be credited to Mr. Ellison.

In his Report to the Board of Visitors read in 1869 June, Airy wrote, "The question of dependence of the measurable amount of sidereal aberration upon the thickness of glass or other transparent material in the

© The Observatory • Provided by the NASA Astrophysics Data System

1937Obs....60..103H

telescope (a question which involves theoretically one of the most delicate points in the Undulatory Theory of Light) has lately been agitated on the Continent with much earnestness. I have calculated the curvature of the lenses of crown and flint glass (the flint being exterior) for correcting the spherical and chromatic aberration in a telescope whose tube is filled with water, and have instructed Mr. Simms to proceed with the preparation of an instrument carrying such a telescope. I have not finally decided whether to rely on zenith distances of γ Draconis or on right ascensions of Polaris". In the Report of 1870 he wrote :—" I alluded in the last Report to a telescope whose tube should be filled with water for examination of the coefficient of sidereal aberration where the pencil of light passes through a considerable extent of refractory medium. I have decided to use it in determining the apparent zenith distance of γ Draconis at the proper seasons of the year".

This note proceeded to say that the instrument which required some unusual arrangements was to be mounted in the South Ground of the Observatory, and was followed by information in the next Report, to the effect that some observations of the kind mentioned had been made in the spring, and that the bearing of these on the constant of aberration could not be pronounced with certainty until the autumn observations had been made, but that, so far as could be seen, it would be sensibly the same as with an ordinary telescope. The record of observations made was continued in the Reports for 1872 and 1873, and in the latter year results of observations of the zenith distance of the star made with the instrument in the spring and autumn of 1871 and 1872 reduced with the N.A. places to show the latitude were given, which agreed so nearly that no correction to the received value of the aberration constant could be suggested, and the instrument was dismounted.

This idea of the effect of water on the determination of the constant of aberration is due primarily to Boscovich (1711–1787), whose views on the subject are given by Lalande in his *L'Astronomie*, vol. iv. (Supplementary Volume), in paragraphs of which the following is a translation.

Boscovich wrote in 1766 that he had conceived a means of seeing if the velocity of light in air and in water is different. He proposed to place upon the same instrument

© The Observatory • Provided by the NASA Astrophysics Data System

1937Obs....60..103H

an ordinary telescope and one full of water from the objective to the reticule. This reticule would be a plate of glass on which would be lines to measure the distance of a star from the zenith. If the velocity of light is increased, its ratio to that of the Earth would be greater and there would be less inclination in the water telescope, due to the relative velocity of light and Earth and the aberration in the water telescope would be less. Since it appears according to Newton from investigations of refraction that the velocity of light in air and in water is in the ratio 3 to 4, the diameter of the aberration circle which is found to be 40 seconds by the use of an ordinary telescope should be 30 seconds as found with the water telescope.

To this Lalande adds that criticism has been made on the grounds that when the light left the water telescope it would lose the velocity it had acquired on entering, and that the effective light would be the light that passed between the eyepiece and the eye and thus would have the velocity of light in air. Against this Lalande urges that the direction of the star is determined when the ray reaches the reticule and that consequently it does not matter if the light does lose its additional velocity when it leaves the water telescope.

The scheme as attributed to Boscovich is the crude idea that comes into the mind of many persons when Airy's Water Telescope is spoken of, but actually the cause of its inception was much more refined, and was based as he said on a controversy of which the following are salient points :—

About 1864 Klinkerfues of Göttingen became absorbed in optical studies, more particularly as to the refrangibility of light as affected by the motion of its source, and made experiments as to this with no satisfactory results, and also as to the possible dependence of the constant of aberration on the passage of the light through a refracting medium placed in the telescope, and on the thickness of the object-glass, which met with only qualified success. In 1867 Hoek—investigating experimentally a theory due to Fresnel that the additional velocity of a luminous wave propagated in a medium which has a movement of translation u is $u(m^2-1)/m^2$, where m is the absolute refractive index of the medium—was able to accept the formula within small limits, but found that his result depended on the length of a tube of water through which

© The Observatory • Provided by the NASA Astrophysics Data System

1937Obs....60..103H

the light passed in the course of his experiment. It was these, and other investigations of the kind, that led Airy to make his determination of the constant of aberration with the instrument above described.

The Boscovich view, if we may call it so, appears in some text-books in the form of a diagram which illustrates the phenomenon of aberration by showing light passing through a telescope that has to be inclined forward so that the light may pass along its axis. This is apt to give the idea that aberration happens wholly in the telescope. But, looking at the matter broadly, the function of a telescope is merely to collect a bundle of light rays that are parallel and moving in a certain direction at its object-glass, and discharge them at its eyepiece still parallel, if object-glass and eye-lens are properly shaped and adjusted to suit the medium between; and it was this condition that Airy took care to fulfil. Has the telescope therefore any effect on the phenomenon of aberration, and are we confronted with a question that is implied in Lalande's addendum above quoted? Where does aberration take place? Is it in outer space, in the region where the light enters the Earth's atmosphere, or is it in the eye of the observer, or in some region intermediate to these? The question is akin in its elusiveness to that in the general knowledge paper:—Is there a picture in the looking-glass when we are not looking at it?—or in others about the rainbow.

The splash of the raindrop on the window of the railway carriage, stationary and moving, seems incontrovertible as an illustration of the principle of aberration: but it assumes that the elements are independent; that the raindrop is not carried by the air through which it passes, nor is the air carried by the railway carriage. These assumptions, though credible for material substance, may not—and, in fact, do not—hold for light as conceived by the undulatory theory. On that theory, light is a state of the ether through which it moves, and according to certain experiments the ether is carried by the Earth, and consequently both of the assumptions above specified fail. In his erudite work, 'Aberration and the Electromagnetic Field'*, Sir Gilbert Walker describes an experiment by Röntgen with a rotating glass disc from which he (Sir Gilbert) says we may infer that the earth carries the ether with it, and that the explanation of stellar

* Adams Prize Essay, 1899.

© The Observatory • Provided by the NASA Astrophysics Data System

1937Obs....60..103H

aberration has yet to be found, or, alternatively, that Fresnel's law above mentioned does not correspond with facts. It appears therefore that an explanation in terms of the undulatory theory is still wanting. There can be no doubt of the existence of aberration as a numerical fact, but whether Bradley was rightly guided to its cause by the flag on the mast-head of the boat is less certain.

[It is, of course, one of the triumphs of the Special Theory of Relativity that it gives a logical and satisfactory explanation of this and similar experiments, notably Fizeau's water-tube experiment (*Phil. Mag.* **2** (Fourth Series), 568, 1851). This experiment preceded Hoek's, mentioned by our contributor above, by some sixteen years. Water was made to circulate round a rectangular path, and two beams of light were passed through two of the long sides in such a way that one beam travelled with the water and one against it. These beams were then brought together and formed an interference pattern such that the fringes would shift if there was a difference of velocity in the two beams. Fizeau found a shift proportional to the velocity of the water, agreeing with Fresnel's formula which Mr. Hollis quotes above. The hypothesis which was advanced at the time to account for this phenomenon, that the ether was *partly* carried along by the water, seems peculiarly cumbrous at the present time. There is a concise account of the phenomenon from the Relativity standpoint on p. 21 of Eddington's *Mathematical Theory of Relativity*. In Relativity theory, Airy's experiment is trivial, as the observer is at rest relative to the telescope.—EDITORS.]

CORRESPONDENCE.

To the Editors of 'The Observatory'.

Eclipse Colour Photography and Coronal Spectrophotometry.

GENTLEMEN,—

On examining the very interesting first reproduction of natural colour photograph of a total eclipse of the Sun *, it occurred to me that in this field lies a means of spectrophotometric investigation worth testing.

* Irvine C. Gardner, 'National Geographic Magazine,' Feb. 1937. The illustration referred to is a reproduction in colour of one of a series of natural colour photographs on Dufay plates taken by Dr. Gardner on June 19, 1936, at Ak Bulak, Siberia.

© The Observatory • Provided by the NASA Astrophysics Data System