

atoms and molecules in a magnetic field. The result of the experiment described above is now published in the hope of attracting attention to this difficult but important problem.

The experiment was carried out in the Davy-Faraday Laboratory of the Royal Institution, and my thanks are due to the Director, Sir W. H. Bragg, for placing the necessary facilities at my disposal.

The Davy-Faraday Laboratory,  
20 Albemarle Street,  
London, W. 1.  
January 7th, 1926.

CVI. *On the True Signification of Fizeau-Zeeman's Experiments.* By CHARLES L. R. E. MENGES\*.

THE purpose of the present communication is to discuss the signification of the result obtained in a former paper of the writer †. I have shown that the *usual interpretation* of Fresnel-Fizeau's experiment is essentially erroneous on account of two subtle errors, which depend on each other and which we formerly unconsciously introduced. It seems I have not sufficiently emphasized the importance of my correct interpretation, as it was misunderstood.

The development and signification of Einstein's Relativity Theory is treated by Professor Dr. J. D. van der Waals, jr., in a very interesting way in two volumes ‡. The first one, issued in 1921, being an introduction to the second one, deals with those points, which, according to the author, lead to Einstein's theory. Fresnel's coefficient and Fizeau's experiment are discussed, obviously with the intention to refer thereto in the second volume in the usual sense as being the decisive experimental confirmation of Einstein's theory. However, in *the second volume the reference expected is not to be found.*

That second volume appeared in 1923. In the meantime, it resulted from my paper on Fresnel's coefficient § that the

\* Communicated by the Author.

† "On Kinematics," *Phil. Mag.* xlix. p. 597 (March 1925).

‡ Dr. J. D. van der Waals, jr., 'Over den Wereldether' (1921); 'De Relativiteits-Theorie' (1923); 'De Erven F. Bohn, Haarlem.

§ *Comptes Rendus*, clxxv. p. 574 (1922).

true interpretation of Fresnel-Fizeau's experiment is essentially different from that formerly generally attributed to it. Professor van der Waals's opinion is obviously that the said experiment can no longer be regarded as decisive between Einstein's theory and the older theories and that it may be left out of consideration now.

Apparently this is also the actual prevailing opinion, for Fizeau's experiment was not even mentioned in last year's extensive discussion on Professor Dayton C. Miller's results obtained on Mount Wilson in repeating Michelson and Morley's so-called æther drift experiment. According to a communication from Professor Einstein to "Science Service"\* , he admits now that his theory rests essentially on Michelson and Morley's experiment only, therefore he likewise abandons what he himself repeatedly stated to be the "*experimentum crucis*" or decisive experiment for his theory.

I cannot share that new opinion, as if Fizeau's experiment had no longer any importance in the matter now. The immediate result of Fizeau's experiment is quite certain; in this respect it very much surpasses Michelson and Morley's experiment. This depends on the velocity of the Earth in an hypothetical way; that velocity is a circumstance outside the laboratory, quite beyond our control, not changeable, not reversible. In Fizeau's effect, on the contrary, its main cause and all details are well controllable, exactly determinable, and they may be changed and reversed at will.

Professor Dayton C. Miller claims a result for his repetition of Michelson and Morley's experiment, which is only 30 per cent. at most of the calculated effect. Certainly, Professor Miller observed an effect of the said magnitude, but the question remains: is it due to the alleged æther wind? There is no incertitude of this kind in Fizeau's experiment. This experiment therefore maintains its character as "*experimentum crucis*" (decisive experiment) quite independent of what it proves or disproves, which depends on the *interpretation* of the result.

For more than a century Fresnel's formula and Fizeau's experiment concerning light transmitted by moving substances formed a problem which scientists have tried to solve in different ways. The main point in the problem is the fact that a solution resting on certain well-established

\* 'Science,' lxii. Supplement, p. 8 (July 31, 1925).

bases (see below) could not be obtained. Therefore, the generally admitted inferences were :—

1. The solution of the problem on said bases is impossible; to solve the problem any particular hypothesis, suitable to lead to the solution, must be added.

2. The said bases are only approximately, but not essentially, true.

In this sense the last alleged solution is that by means of Einstein's theory, which was originally given by Professor von Laue.

That formerly admitted insight in the question is now wholly null and void in consequence of my solution.

The fact is: *on the said bases, and without introducing any particular hypothesis, I established the formula for the experiment.*

Any formula may be made to fit a particular experiment by means of a suitable chosen so-called constant. However, under different circumstances, it generally will not suit. Only when the formula is correctly based on true general physical laws, will it give with the same constant correct results over a wide range. Especially when the formula proves to be true under the most different circumstances—which is just the case here, as I point out below—then the laws as well as the constant are well confirmed.

To test the validity of physical or other laws, the well-known way is to calculate, according to those laws, the result of experiments and compare it with the actual experimental result. Of course, the calculation must be correct, that is, *all formulæ used must be strictly consistent with the laws to be tested.*

Unconscious deviations from this logical law led to the hitherto encountered difficulties. It is by strictly avoiding such deviation that I arrived at *quite new results*, free from difficulties, free from any old or new doubtful hypothesis.

I emphasize this to avoid my communication being mistaken as analogous with the attempts to refute Einstein's theory, which all mainly aim at reverting to older theories, as, for instance, in Professor E. Gehrcke's controversy with Dr. M. Born\*, and in Professor P. Lenard's polemic pamphlets against Einstein's theory.

In the question I here discuss, it is the old idea of a "dragging coefficient" which led to Einstein's theory. *According to my new result the true interpretation of the experiment is radically different to that old idea.* As a

\* 'Die Naturwissenschaften,' i. pp. 62, 92, 170, 191, 338.

consequence then, it follows that Einstein's theory cannot be maintained.

In the same way I treat electromagnetic theory in my books 'Nouvelles vues Faraday-Maxwelliennes' and its 'Supplément—Sur la Propagation de la Lumière' (Gauthier-Villars & Cie, Paris, 1924). I refer thereto concerning the connexion of the actual subject with electromagnetic theory.

I established my formula for the experiment on light transmitted by moving substances, namely for the actual observable shift of the interference fringes, on the following bases :—

1. The laws of Kinematics. For the case in question the result of the velocity  $v$  and another velocity  $\mp w$  in the same direction is the velocity

$$u = v \mp w.$$

2. The aforesaid laws are generally true, without any exception; they hold also when one of the velocities, say  $v$  is  $c =$  the velocity of light in vacuo; the velocity obtained by compounding  $c$  with  $\mp w$  is

$$c' = c \mp w.$$

3. The refractive index of a substance is the ratio of the velocity of light outside the substance to the velocity of light inside that substance, both velocities calculated relatively to the substance, according to 1 and 2.

The formula I established on said bases (see my Phil. Mag. paper, and, for further details, my books above referred to) is confirmed by Professor P. Zeeman's experiments\*. I particularly mention Zeeman's experiments, as his results are undoubtedly the most accurate so far obtained. *They confirm my equation practically to 100 per cent.* Moreover, his experiments do not only concern moving water, as in former experiments, but also quartz and moving glass. The experimental results with such different substances being in so close accordance with my formula, *they form the decisive confirmation of the fundamentals, as stated under 1, 2, and 3.*

*The validity of 1 is the immediate disproof of the formula for compounding velocities in Einstein's theory.*

*The validity of 2 is the immediate disproof of what Einstein's theory admits as its basis.*

\* P. Zeeman, *Verslagen Akad. Amsterdam*, xxi. p. 245 (1914); xxiv. p. 18 (1915); xxvii. p. 1453 (1919); xxviii. p. 1462 (1919); xxix. p. 1252 (1920).