De Sitter's experiment scrutinized

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Abstract: De Sitter's theory, on which his experiment is based, has been scrutinized. His paper was aimed to prove the invalidity of Ritz's theory, but he failed due to a wrong interpretation of his crucial parameter α.

Introduction

The original text of De Sitter's paper: "A proof of the constancy of the velocity of light" can be found at [1]. A copy of this text is found at [2]. It is used here to reproduce this text in the analysis below. It has been checked against the original text. This original text will be analysed only, ignoring for example [3].

Analysis of De Sitter's original paper

1 " In the theory of Ritz light emitted by a source moving with velocity u is propagated through space in the direction of the motion of the source with the velocity $c + u$, c being the velocity of light emitted by a motionless source. In other theories (*LORENTZ*, *EINSTEIN*) the velocity of light is always c, independent of the motion of the source. Now it is easily seen that the hypothesis of RITZ leads to results which are absolutely inadmissible. "

Analysis of section 1:
De Sitter uses several times the word "velocity" without defining even once the reference for these velocities. The concrete examples are:

"...a source moving with velocity *u...".* Relative to what? The addition "through space" doesn't help, because vacuum cannot function as a reference. As a result the velocity $c + u$ is undefined too.

"....c being the velocity of light emitted by a motionless source." Motionless relative to what? Besides that, Ritz did mean that the velocity of the emitted light is exclusively c relative to its source, whatever the velocity of the source, relative to whatever reference, might be!

"....the velocity of light is always c, independent of the motion of the source." Always c with respect to what reference? But what is meant is: the velocity c of light is constant, relative to whatever reference!

The most magical property of a velocity ever created, but never validated as a result.

2 " Consider one of the components of a double star, and an observer situated at a great distance Δ. Let at the time t, the projection of the star's velocity in the direction towards the observer be u. Then from the law of motion of the star we can derive an equation:

$$u = f(t - t_0) \qquad (1)"$$

Analysis of section 2:
The velocity u is taken as the projection of the source its velocity in the direction towards the observer. No problem, except the lack of the reference of this velocity. Based on the second sentence only one reference can be thought of: the imaginary centre of the double star, from now on defined as R. The purpose of introducing the variable t_0 is not clear.

3 " The light emitted by the star at the time t reaches the observer at the time $\tau = t + \Delta/c - \alpha u$. In Ritz's theory we have, neglecting the second and higher powers of u/c, $\alpha = \Delta/c^2$. In other theories we have $\alpha=0$. If now we put $\tau_0 = t_0 + \Delta/c$, we have

$$u = f(\tau - \tau_0 + \alpha u) \text{ or } \qquad u = \varphi(\tau - \tau_0) \qquad (2)"$$

Analysis of section 3:
De Sitter states that the light reaches the observer at the time $\tau = t + \Delta/c - \alpha u$, which can also be presented as: the light reaches the observer after the time $\tau - t = \Delta/c - \alpha u$. He concludes: "In Ritz's theory we have, neglecting the second and higher powers of u/c, $\alpha = \Delta/c^2$." The question is why he concludes this. In Ritz theory the velocity of light is c relative to its source, so $c + u$ relative to R. If it is assumed that the observer does not move relative to R, the time for the light to reach the observer in Ritz's theory thus is $\Delta/(c + u)$. Because $u<<c$ the time $\tau - t$ can be approximated well by $(\Delta/c)\cdot(1 - u/c)$. Here too "the second and higher powers of u/c have been neglected". Rewriting this expression indeed results in $\Delta/c - \Delta/c^2 \cdot u = \Delta/c - \alpha u$.

4 " The function ϕ will differ from f, unless αu be immeasurably small. Therefore if one of the two equations (1) and (2) is in agreement with the laws of mechanics, the other is not. Now α is far from small. In the case of spectroscopic doubles u is not small, and consequently αu can reach considerable amounts. Taking e.g. u = 100 KM/sec, and assuming a parallax of 0".1, from which Δ/c = 33 years, we find approximately au = 4 days, i.e. entirely of the order of magnitude of the periodic time of the best known spectroscopic doubles.

Analysis of section 4:
De Sitter makes the following errors in this section:

- He states that α is far from small. The value of α in his example is 3.5 s^2/m. However, no variable is available to prove this claim, so his conclusion is irresponsible.
- The fact that he considers au = 4 days "entirely of the order of magnitude of the periodic time of the best known spectroscopic doubles" doesn't have anything to do with the judgement about α. Neither has his supplement: "In the case of spectroscopic doubles u is not small".
- The ratio: $\alpha u / (\Delta/c)$ = $3.3 \cdot 10^{-4}$ proves that αu is, even for $u = 10^5$ m/s, very small *relative* to Δ/c. That emphasizes the impossibility for the observer to decide whether Ritz's theory or the current theory is correct, certainly if Δ is only known roughly, as is normally the case.
- The ratio $\alpha u / (\Delta/c)$ equals u/c, showing in advance that is impossible to distinguish c from $c + u$. De Sitter should have mentioned this in his paper, or, even better, should have abstained from publishing his paper.

As a result De Sitter didn't find any evidence with his experiment (read philosophy) to reject Ritz's theory.

In addition, his philosophy demonstrates the ridiculousness of the current theory in the following situation where all velocities are unambiguously defined.

Suppose the emitting star moves with velocity $s(t)$ relative to the imaginary centre R of the double star and suppose the observer moves with velocity $o(t)$, also relative to R. Then the mutual velocity of source and observer is $s(t) + o(t)$. Obeying the current theory, saying that the velocity of light is c relative to whatever reference, light reaches the observer after Δ/c, *regardless of the value of* $o(t)$.
The inevitable, but at the same time most ridiculous and contradictory, consequence is that light must continuously match its velocity to that of the observer in order to achieve such a result.

Applying Ritz's theory would lead to a time to reach the observer of $\Delta/\{c + s(t) + o(t)\}$, with explicitly the following restrictions: $s(t)$ is the just defined velocity right *at the moment of emission* and $o(t)$ is *constant*.

Conclusions

1 De Sitter claims to have proven with his "experiment" that Ritz's emission theory has to be rejected, but he bases is pronunciation on multiple incorrect conclusions.
2 De Sitter implicitly concludes that Ritz's theory should be rejected in favour of the current theory, having the following properties:
   - The velocity c of light is *constant* with respect to any reference in whatever circumstances.
   - As a result light has to *adjust* its velocity continuously to the observer's velocity, in order to ensure that the time to reach that observer equals the distance Δ between observer and source at the moment of emission divided by c. Apart from the fact that such properties are individually already completely unnatural, they also strongly contradict each other.

Hopefully this observation will prompt further reflection.

References

[1] https://dwc.knaw.nl/DL/publications/PU00013063.pdf

[2] https://en.wikisource.org/wiki/Page%3ADeSitterConstancy1.djvu/1 and
https://en.wikisource.org/wiki/Page%3ADeSitterConstancy1.djvu/2

[3] https://en.wikipedia.org/wiki/Emission_theory