Testing Electrodynamics and Verification of the Results of Michelson and Morley by Laser Beam Aberration Measurement

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Abstract

The International Year of Light 2015 is a welcome opportunity to look back to observations and famous experiments that lead to revolutionary theories in physics around the phenomenon of light. The observed aberration of starlight and later the experiment of Michelson and Morley were in contradiction to the electrodynamic theory of light until the special relativity theory solved the conflict by proposing time and space effects in moving systems. Today, laser and CCD chip technologies enable much more precise measurements than in former times. The most accurate test of electrodynamics is achievable by aberration measurement of a laser beam because it offers an effect in the first order of v/c. The results of the experiment verify the findings of Michelson and Morley but are, surprisingly, in contradiction to electrodynamics and to special relativity theory. Our picture of the light's properties is still imperfect.

1 Historical and Theoretical Background

The aberration of the light of stars explained by Bradley [1] in 1728 forces scientists which believed in electrodynamics to the assumption that the earth is moving through an ether which is at rest itself, at least in respect to the solar system. The famous experiment of Michelson and Morley [2], conducted in the late 19^{th} century, intended to discover the motion of the earth through the ether which was supposed to be the carrier of electromagnetic waves. Michelson and Morley used a turnable interference apparatus. The effect was expected to show a very little shift in the interference patterns depending on the orientation of the interferometer relative to the earth's motion vector in the order of v^2/c^2 (10^{-8}), but nothing was found. To explain the null result, a number of physicists (p.e. Fitzgerald, Lorentz [3], Drude, Voigt, Poincaré, Einstein [4] et.al.) proposed special time and space effects in moving systems described by the so-called Lorentz transformations finally. If those effects were real – although they seemed to be very strange – the electrodynamic explanation of light could survive. In the early 20^{th} century, physics consequently accepted Einstein's special relativity theory as explanation and solution of the aberration problem which Fresnel [5] had regarded as the biggest problem in electrodynamics.

More than a hundred years later, it is interesting that laser and CCD technology gives us a much more precise instrument than the interferometer used by Michelson and Morley to test electrodynamics. For this purpose one may use a laser interferometer with high-definition CCD chip detectors or, what was done here, make a precise aberration measurement of a laser beam which is oriented in different angles to the earth's motion vector through the day using the earth's rotation. The benefit of the latter is a much simpler construction, a higher resolution and, in the end, a deeper insight in electrodynamic and relativistic theories.

While the Michelson-Morley experiment should detect runtime differences between the two orthogonal light beams (as a result of vectorial addition of velocities), the aberration experiment detects the deflection of a light beam in the moving system earth. The true measurement of runtime differences depends on the trustiness of clocks and scales in moving systems, which is difficult to verify. In contrast, the aberration of light is a steady effect in the first order of v/c (10^{-4}) and it is independent of clocks and – at least nearly – of scales, even whithin the special relativity theory. This is shown by the relativistic aberration formula for the case of orthogonal velocity vectors v and c:

$$\sin\alpha = v/c \tag{1}$$

$$\textit{or} \quad \tan\alpha = \gamma v/c \qquad \gamma = 1/\sqrt{1 - v^2/c^2} \tag{2}$$

$$\textit{(classical:} \quad \tan\alpha = v/c \textit{)}$$

Supposed an effective velocity of the earth of about 30 km/s on its orbit, the difference between the classic and relavistic formula is $1/20000^{\text{th}}$ only. In other words: relativistic aberration is time-independent and very little bigger than classical – non-relativistic – aberration.

The predication of the relativistic and classic formulae is, that a light beam oriented orthogonal to the velocity vector of a moving system is deviated by the angle α and no more orthogonal (as a result of vectoral addition of velocities). This is true for all light beams coming from outside the moving system, but also for all light beams inside the moving system, because in electrodynamics the propargation of light is independent of the motion of the light source. If any aberration of starlight is detected in a system, then it is a moving system and all light beams inside the system have to show – at least[1] – the same aberration. That is why the laser beam aberration experiment has to be regarded as the real *experimentum crucis* for electrodynamics.

Aberration is exactly what is shown in all diagrams of the Michelson and Morley experiment: Because the whole apparatus is moving with the earth's motion, the light beams of the source respectively the mirror have to be orientated slightly

[1]Theoretically, the value can even be bigger if the solar system is moving, too. While stellar aberration reveals those effects only that depend on the changes in the motion of the observer – because the real position of the star is unknown -, the aberration effect inside the moving systems has to show the value of absolute motion because the position of the light source is known exactly. If electrodynamics is correct, this would lead us to the concept of an apparatus nameable as "cosmometer" which detects laser beam aberration precisely and indicates the real, absolute speed of the moving system.

inclined by the angle α to reach the second mirror and to meet the other light beam:

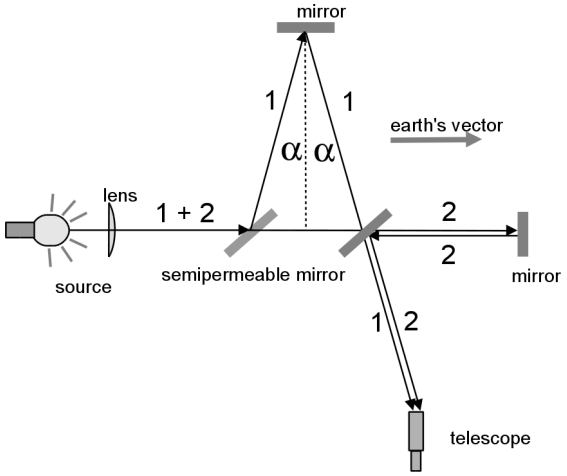

Figure 1: Schematic of the Michelson and Morley experiment.

Beams of most light sources are spread in different orientations and the light beam that reaches the moving observer has always the required inclination α. If source and observer have the same motion, the aberration effect is normally imperceptive, because planetary aberration (moving source) and stellar aberration (moving observer) perfectly compensate each other (see explanation given by Vogtherr [6]). But laser beams are much more focused and should show the predicted aberration effect (There is no doubt amongst star warriors that they have to train with their laser weapons by a certain correction angle to hit far, but fast moving targets similiar to conventional guns). In the moving system earth the maximum aberration angle is about 20.5", an easily detectable value. If the assumption of Michelson was correct, namely, that there is a vectoral addition of the velocity of the light and the velocity of the observer, and subsequently, if the relativistic interpretation of this experiment is true, namely, that time and scale effects occur in the moving system, then a laser beam oriented orthogonal to the earth's motion had to deflect 1mm per 10,000mm of beam length.

2 Experimental Concept and Results

The beam of a laser that is fixed stiff by concrete on a wall in the cellar of a very old farmhouse is sent over a distance of 7.95m to a rigidly mounted, but adjustable mirror on the rectangular wall. The reflected beam hits a screen nearby the laser. The screen is inclined to the laser beam with a ratio of 1:5, so the laser pattern on the screen is moving five times the lateral shift of the reflected beam. The total beam length is 15.95m. The theoretical effect gives a maximum shift of $\pm$1.595mm, resp. of about $\pm$8mm on the inclined screen. The experiment was conducted in Lindau, Germany, 47.6° north and 9.7° east. Therefore, an additional vertical shift occurs during one full rotation of the earth and the center of the pattern should move elliptically. Only the horizontal shift was of interest in this experiment, because it

should be nearly symmetric and independent of the actual season. The laser beam was oriented to 5.5° north and after reflexion to 186.5° south. Thus, the left maximal deviaton should happen at 13:45 MEZ, the right one at 01:45. At 07:45 and at 19:45 no horizontal aberration is expected (in summer: UTC = MEZ – 2 h).

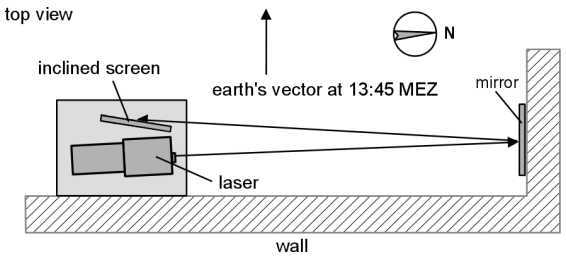

Figure 2: Schematic of the aberration experiment.

After some days of relaxation of the mountings and the mirror and refocusing it near the center of the screen, the following measurements were visually metered at different daytimes and documented by a digital camera. No part of the apparatus was touched except the power switch of the laser. The high precission of the experiment is demonstrated by the fact, that blowing breath into the laser beam let the pattern vibrate slightly sideways due to light refraction in warm and cold air, while without that, it showed a good stability. The temperature in the cellar was nearly constant at $10 - 12°$C.

The theoretical effect and the measured values versus daytime and date are presented in fig. 3 for the relevant x-axis (the difference between apparent solar time and mean solar time during the observation period was less than 1 minute and therefore neglegted):

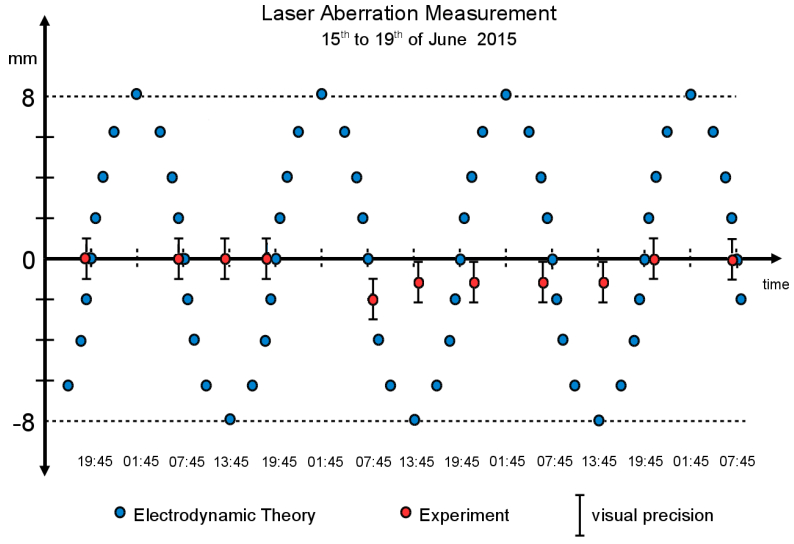

Figure 3: Results of the aberration experiment.

Although there is a slight variation in the measured values due to thermal or relaxation effects, no correlation exists between the experimental and the theoretical values. The reference frame of the isotropic light propagation conforms to the reference frame of the cellar respectivley of the earth and not to the solar system nor to any other system like the ether or vacuum as supposed by electrodynamics. The uncertainity in the visual metering was about $\pm$1mm. Electronic image evaluation might improve this value by at least two orders. The aim of the experiment was not to get the best accuracy, but to show that sufficent precission is possible using simple and cheap components. Thus, the experiment might be done and proved by almost everyone, even in schools.

3 Conclusions

The experimental results verify the Michelson and Morley experiment, but are in sharp contradiction to electrodynamical theory. The most surpring fact is not that there is no daily recurrent movement in the pattern of the beam on the screen, because the experiment of Michelson and Morley showed a similiar result by other means long time ago. The really surprising fact is that there is no possibility to explain the null result nor in electrodynamics neither in relativity. Both fail. Fresnel's aberration problem still exists if light is explained as an electromagnetic wave.

Applying the transformations of Lorentz the special relativity theory could explain the observation that any measurement of the light speed in moving systems gives the value of c, although it should be $c' = c - v$ according to electrodynamics. But it cannot explain the null result of the aberration experiment because it predicts a shift corresponding to formula (2). The aberration experiment falsifies both theories definitely. This rises the question what – maybe far-reaching – consequences have to be drawn in theoretical physics. In addition, the aberration experiment gives a hint that light has to be regarded more as an emitted and somehow oscillating particle than as a self-propagating wave. Probably, not only the source, but also the partners of (electromagnetic or gravitational?) interaction are defining the speed of light. This would explain deSitter's observations of the light from binary stars [7]. Potentially, photons possess an oscillation that cause interference and that may slightly change during the interaction processes which might explain the Doppler shift and the redshift of stars. Thus, cosmological modells are affected, too. There is much space for new speculations and possibly for a turnaround in physics.

Physicists are invited to do much more precise aberration experiments to determine the systems defining the light speed (e.g. source, surroundings, fields, masses) and the true character of light.

Private Note

I believe, if laser technology had been available in the late 19^{th} century yet, neither Lorentz nor Einstein, both brilliant minds, would have developed their space and time transformations.

References

[1] James Bradley: *A new apparent motion discovered in the fixed stars: the casue assigned, the velocity and equable motion of light deduced.* Proc.Roy.Soc.London 35, p.308-321, 1728.

[2] Albert A. Michelson & Edward W. Morley: *On the Relative Motion of the Earth and the Luminiferous Ether.* American Journal of Science 34, p.333-345, 1887.

[3] Hendrik A. Lorentz: *Versuch einer Theorie der electrischen und optischen Erscheinungen in bewegten Körpern.* Verlag E.J. Brill, Leiden, 1895.

[4] Albert Einstein: *Zur Elektrodynamik bewegter Körper.* Ann. der Physik 17, p.891-921, 1905.

[5] A. Fresnel: *Sur l'influence de la mouvement de terre dans quelques phenomènes d'optique.* Lettre á son frère Leonore, 4. Juillet 1814. Oeuvres complètes 2 (1814, p.820-824) and (1818, p.627), Paris, Imprimerie Impérial, 1868.

[6] Karl Vogtherr: *Über die Aberration irdischer und außerirdischer Objekte.* Zeitschrift für Physik A Hadrons and Nuclei, Vol.100, Issue 5-6, p.389-395, 1936.

[7] William deSitter: *Ein astronomischer Beweis für die Konstanz der Lichtgeschwindigkeit.* Physikalische Zeitschrift, Vol.14, p.429, 1913.