Einstein at Leyden

Standards for clocks and rods in relativity

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Albert Einstein – unlike frequently cited authors such as John Wheeler (who writes: “The Principle of Relativity rests on emptiness” [14]) – ultimately understood and acknowledged that there is an underlying reality to special relativity. In his 1920 lecture at Leyden, Einstein speaks at length about Mach's notions of an object's relationship to the universe at large. [15]

Quoting Einstein from that lecture:

“To deny the ether is ultimately to assume that empty space has no physical qualities whatever. The fundamental facts of mechanics do not harmonize with this view; for the mechanical behavior of a corporeal system hovering freely in empty space depends .. on its state of rotation, which physically may be taken as a characteristic not appertaining to the system [within] itself. [thus,] .. the modern physicist .. comes back once more, if he follows Mach, to the ether, which has to serve as medium for the effects of inertia.”

Einstein continues:

“Mach's idea finds its full development in the ether of the general theory of relativity. According to this theory the metrical qualities of the continuum of spacetime differ in the environment of different points of spacetime, and are partly conditioned by the matter existing outside of the territory under consideration.”

Einstein summarizes:

“Space without ether is unthinkable; for in such space there .. would be .. no possibility of existence for standards of space and time, [specifically] our measuring-rods and clocks, nor therefore any [space and time] intervals in the physical sense.”

In fact, as early as 1911, Einstein pointed out that there was “no satisfactory answer” to the phenomena of a spherical mass – under no local influence of gravity – becoming ellipsoidal upon setting it to rotation other than the explanation offered by Mach, which is that an object's inertia is determined by totality.

Einstein went on to state: “The only satisfactory answer must be that the physical system consisting of S_1 and S_2 reveals within itself no imaginable cause to which the differing behavior of S_1 and S_2 can be referred. The cause must therefore lie outside this system .. The mechanical behaviours of S_1 and S_2 are conditioned [quite essentially] by distant masses.” [16]

Note that it would be nonsensical to limit the “matter existing outside of the territory under consideration” to anything other than the entirety of the interconnected universe. In fact, Einstein's general theory encompasses the entirety of the cosmos – not just a limited portion of it – just as Mach saw it: Recall that, in GR, an imaginary clock “at infinite distance”, free of all gravitational influence, serves as the baseline for non-kinematical clock-rates. And all properties are communicated at the speed of light of course, rather than instantaneously.

The fact that we can see galaxies – and clusters and superclusters of galaxies – proves that the entire universe is interconnected. The seeing is dependent on the connectedness. That is all one reasonably needs to consider to prove that Mach was correct in asserting that an object's physical properties, including its inertia, is dictated by totality.

The contrast

The preceding statements of Einstein's are in sharp contrast to his treatment of 1905 (and 1916), wherein he claimed that [an ether broadly speaking] would prove to be superfluous to his treatment.

In his initial wording, his second postulate states that “light is always propagated in empty space with a definite velocity c which is independent of the state of motion of the emitting body.” [17]

With the word "definite", Einstein implies that light has an absolute (actual) speed in reality, though he doesn't explicitly state that there is a physically defined universal reference frame against which light has this definite velocity.

Three pages later, when he restates this postulate, he uses conceptually different terminology which fundamentally changes the meaning:

“Any ray of light moves in the "stationary system" of coordinates with the determined velocity c, whether the ray be emitted by a stationary or by a moving body.” [18]

Here he replaces "definite" with "determined" and uses quotes around stationary system. With this new wording, he abandons the absolute character of his postulate as initially worded, indicating he is already preparing (*with an eye on the results he anticipates*) to abandon the very reference frame that could have brought clarity to his treatment. Instead (and in keeping with experimental evidence of the day), Einstein proceeds to simply *assume* symmetrical assessments across inertial frames, without any means for diagramming the process.

The "peculiar" consequence

At the conclusion of Einstein's kinematical section, where he deduced the "peculiar" time-keeping differential between reunited clocks, he should have realized that his clock synchronization method was obscuring the reality underlying the symmetrical measures across inertial frames.

That is, an absolute frame of reference was not superfluous to his treatment after all.

Thus, Einstein's second postulate is so replaced in our absolute approach. Or we might say we are restoring Einstein's initial wording of his second postulate, which is in lock step with his strongly worded description of space years later in his Leyden lecture.

The consideration of photons being massless particles, along with the consideration that mass and energy are interchangeable, serves as the basis for postulating that light has an absolute speed and is also the limiting speed, with the photon having the property of existing in the form of pure energy.

The preceding properties of photons and matter were actually known prior to Einstein's theory. Einstein himself, following the lead of Max Planck, introduced the notion of light existing in the form of a quanta of energy.

An actual difference in clock rates follows immediately from this postulate of the absolute nature of light, provided of course that one assumes that photon activity is the maker of every relationship (specifically here, the regulator of atomic functioning; but also the carrier of force information and our means for perceiving events).

The Machian notion of a particle's relationship to totality, along with absolute light speed, combine with the need for atomic synchronization to explain actual length contraction. It is the equivalent of the Michelson-Morley paradigm, but on the atomic scale. Implicit here, is that particles have both a translatory relationship with the universe (with an ether so associated), and a rotational/orientational relationship with their translatory path, in the Machian sense.

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Citation and annotation for the book *Relativity Trail*

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15. Einstein, A. Ether and the Theory of Relativity. English translation from the German. (1922). Methuen & Co. Ltd, London. https://mathshistory.st-andrews.ac.uk/Extras/Einstein_ether/
16. Einstein, A., Lorentz, H.A., Minkowski, H., and Weyl, H. (1923). Arnold Sommerfeld. ed. The Principle of Relativity. Dover Publications. Mineola, NY. pp. 112-113.
17. Einstein, A., Lorentz, H.A., Minkowski, H., and Weyl, H. (1923). Arnold Sommerfeld. ed. The Principle of Relativity. Dover Publications. Mineola, NY. p. 38.
18. Einstein, A., Lorentz, H.A., Minkowski, H., and Weyl, H. (1923). Arnold Sommerfeld. ed. The Principle of Relativity. Dover Publications. Mineola, NY. p. 41