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Light Postulate

In the preceding chapter we examined the relativity postulate, the first of the two basic premises of special relativity. We will now turn our attention to the second basic premise, the light postulate, which deals with the constancy of the velocity of light. Immediately after announcing the relativity postulate in the introduction of the 1905 paper Einstein says that he is also introducing a second postulate *which is only apparently irreconcilable* with the first. The 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.* It will be noticed that the postulate consists of two parts. The first says that light velocity is constant, the second that it is source-independent.

That the velocity of light is a physical constant was generally accepted by 1905 when Einstein announced his postulate. The elevation of an empirically derived measurement to an axiom did not add anything to physical knowledge. Neither did it provide any new philosophical insight into the nature of light. In terms of Newtonian theory it was an unnecessary and arbitrary manoeuvre. The purpose of axiomatising the constancy of the velocity of light was to endow light with absolute qualities in the mathematical scheme of things, without having to justify it, and to create the required basis for the subsequent development of the theory.

The second part of the postulate asserted that the velocity of light is independent of the motion of the emitting body. The meaning of this phrase and its implications will be discussed in the next chapter. However, two things have to be pointed out at this stage. Firstly, while the constancy statement could be associated with well-founded physical evidence, the independence statement represented one of several possible assumptions suggested to explain the behaviour of the velocity of light in the Michelson-Morley experiment. Secondly, contrary to the requirement that motion must always be relative to something, Einstein is now introducing the idea of the motion of light relative to nothing. Previously the light medium was considered to be the hypothetical stationary aether. Einstein specifically excludes it from his theory and maintains that *the introduction of a "luminiferous aether" will prove to be superfluous inasmuch as the view here to be developed will not require an "absolutely stationary space".* In physical terms Einstein's proposition of source-independent motion relative to nothing is less attractive than the idea of the aether and absolutely

stationary space. Einstein is avoiding any discussion about the nature of the medium between inertial systems. His solution to a difficult problem is to pretend that it does not exist.

In the 1905 paper Einstein offers also a second version of the light postulate: *Any ray of light moves in the "stationary" system of co-ordinates with the determined velocity c, whether the ray be emitted by a stationary or by a moving body.* This formulation is probably closer to what Einstein really wants to say than the first one, namely that the velocity of light is the same in all inertial systems. Although this situation appears to be equivalent to the Newtonian position, we are, in fact, no longer within the realm of Newtonian physics since inertial systems are Einsteinian creations subject to the Einsteinian relativity postulate. The use of the word "stationary" in the expression *"stationary system"* is also noteworthy. Einstein is not correct in telling us that it is used purely for convenience or, as he puts it, *in order to render our presentation more precise and to distinguish this system of co-ordinates verbally from others.* Without the concept of the stationary system the Einsteinian argument would not be able to proceed. It is an absolutely necessary concept. We will see later that the derivation of his transformations requires that the notions of rest and motion be allocated in a specific and non-reciprocal way to the two systems of the Einsteinian doublet. In the quoted second version of the light postulate the expression "stationary" performs an additional function. It restricts the application of the full light postulate temporarily to light rays in the stationary system. Light rays in the moving system are not subject to this restriction during the crucial stages of the argument.

Einstein's reference to the *apparent irreconcilability* of the light postulate with the relativity postulate will become clear if the real meaning of the latter is considered. In the preceding chapter it was suggested that the proper wording of the postulate should be as follows: If a state of relative motion exists between two inertial systems, physical measurements made by an observer in respect of a particular situation within his own system will differ from measurements made by the same observer in respect of the same situation in the other system. The application of this postulate in relation to the propagation of light would mean that Einstein's hypothetical observer measuring the velocity of light in his own and in the other system would obtain different values because, as we will see later, measuring rods and clocks will not agree if a state of relative motion exists between two inertial systems. Since Einstein plans to use the propagation of light as a fundamental ontological category and the means by which physical action is communicated between inertial systems, he has to issue a decree, overriding the relativity postulate, to the effect that although measurements referring to physical quantities may be affected by the state of relative motion between inertial systems, those referring to the velocity of light will not be affected. This is a completely arbitrary decision. By a stroke of the pen Einstein exempts the velocity of light from his relativity postulate and elevates it to the status of an absolute.

The velocity of light is a fundamental physical constant not because Einstein announced a postulate to that effect, but because the physical

evidence is pointing in that direction. The evidence is based on the convergence of empirical observations, on a series of measurements and associated theoretical considerations made over a long period, using various approaches and methods, and achieving mutually corroborating and progressively more precise results. These can be summarised in the following table indicating the year when a significant experiment was performed, the name of the experimenter, and the value of the velocity of light in a vacuum (in km/sec) which has been obtained:

1676	Römer	302,000
1727	Bradley	299,000
1849	Fizeau	314,000
1862	Foucault	298,000
1876	Cornu	300,400
1902	Michelson	299,880
1926	Michelson	299,796
1949	Bergstrand	299,792.7
1958	Froome	299,792.5
1974	Terrien	299,792.458

The degree of precision has now reached the metre level, and if the presently adopted value of the velocity of light is considered as sufficiently certain, it can serve as a basis for the definition of the standard metre. We have reached a stage when it appears possible, and adequate for practical purposes, to ascribe to a particular value of the velocity of light an absolute significance and then use it as a standard for the quantitative definition of length. However, it would be impractical to use the velocity of light at the same time as a standard for the determination of time. Either we improve our methods of measuring time and then determine distances with a greater precision, or we can try to improve our measurement of length and then derive a higher resolution of time. There is no point in doing both with the aid of the velocity of light. The proposal to use the velocity constant for the determination of the standard metre is a consequence of the fact that time measurement processes have achieved a higher resolution than length measurement processes. The velocity of light offers a fixed ratio between units of time and units of length. The frequency of a particular, sharply defined radiation, such as a laser emission stabilised on a methane absorption line, has been determined with great precision, and its wavelength has also been measured, but with less precise devices. The velocity of light constant thus obtained can be used to improve length measurement standards.

Any considerations associated with the determination of the velocity of light indicate quite clearly that there is no method by which the velocity of light could be measured directly, by one single process or measurement. It is wrong to imply that this is possible or that it may be possible. Although there is absolutely no foundation for such assumption, relativistic texts appear to say that because Einstein has declared the velocity of light to be an absolute constant there is no longer any need to worry about the two components of the velocity, time and length, and their definition. It is

needless to say that Einstein's declaration has in no way affected the necessity of time and length measurements in order to obtain the value of the constant. The velocity of light is a composite physical quantity. It represents a ratio of two more fundamental physical categories. It may well be that the ratio is fixed and permanent, but it is a ratio nevertheless and not a fundamental quantity in its own right. The fact which is so unpalatable to relativists is that the constancy of the light velocity, embodied in Einstein's light postulate, requires necessarily the existence of constant time and imperturbable space. Einstein's light postulate is devoid of meaning and substance without Newtonian constant time-flow and rigid space, and the assertion that special relativity has abolished or modified the Newtonian concepts of space and time is one of the more obvious contradictions in the theory. How can it abolish concepts which are part of its logical basis? Einstein's theory has not abolished absolute time and space, it has firmly incorporated them as its fundamental premises.

The extent to which Einsteinian theory presupposes and uses Newtonian concepts in order to reject them is a subject about which most relativists prefer to remain silent. But the fact is that relativity requires full support from Newtonian propositions in order to get off the ground and to sustain its arguments. And it is ironical that without this support relativity would not be able to claim subsequently that the very same propositions are inappropriate. No wonder the light postulate was considered a thorn in the side of relativity by some of Einstein's contemporaries and friends, e.g. Petzoldt, Frank, Lampa and others. Petzoldt in particular was disturbed by the light postulate as it axiomatised an absolute. It seemed wrong to him that one of two basic principles of a relativity theory proclaimed the motion of light to be an absolute, derived, as it could not be otherwise, from absolute space and time. Petzoldt tried to argue with Einstein, but he had no success. It was not possible to modify the theory by making the light velocity non-absolute without destroying the whole edifice.