The Light Principle and Notions of Heisenberg and Feynman

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Abstract

Einstein claimed that one pillar of his edifice of special relativity was what he referred to as the Light Principle. After it is stated, we will follow up with comments regarding its meaning by Werner Heisenberg and Richard Feynman.

1 Introduction

Einstein claimed to have founded his theory of electrodynamics on just two fundamental principles: The *Light Principle* and the *Principle of Relativity*. In this paper I want to address just what we should understand this Light Principle to be. I'm not going to claim that my conclusion is necessarily what Einstein himself had in mind when he published his paper in 1905.

> The special theory of relativity is an adaptation of physical principles to Maxwell-Lorentz electrodynamics. From earlier physics it takes the assumption that Euclidean geometry is valid for the laws governing the position of rigid bodies, the inertial frame, and the law of inertia. The postulate of equivalence of inertial frames for the formulation of the laws of Nature is assumed to be valid for the whole of physics (special relativity principle). From Maxwell-Lorentz electrodynamics it takes the postulate of invariance of the velocity of light in a vacuum (light principle).
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> Found in: "Fundamental ideas and problems of the theory of relativity," in Gerald Tauber's Albert Einstein's Theory of General Relativity, Crown Publ., 1979, p. 53.

2 Notions of Heisenberg and Feynman

The meaning of the Light Principle is tied to a measurement. Einstein referred to his relativity as a principle theory, rather than a constructive theory – the terms are his own, from what I can tell. He wanted very much to emphasize the different nature of his theory compared to Lorentz's ether theory, which is 'constructive' by Einstein's definition. Unfortunately, his imprecise wording of the Light Principle belies his true desire in what he wanted it to convey: a measurement constraint upon any would-be theories consistent with special relativity. Heisenberg clarified this when he wrote:

> Already a few years after Planck's discovery, the significance of a second "measurement constant" was understood. Einstein's special theory of relativity made it clear to physicists that the velocity of light did not, as had previously been supposed in electrodynamics, describe the property of a special substance—"ether"—that supported the propagation of light, but that a property of space and time was involved, that is, a general property of nature not related in any way to particular objects or things in nature. Thus, the velocity of light can also be considered as a measurement constant of nature.
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> Found in: "Planck's discovery and the philosophical problems of atomic physics," Werner Heisenberg, *On Modern Physics*, Heisenberg et al, Clarkson N. Potter, Inc./Publisher, New York, c. 1961, pp. 7–8.

It's ironic that the principle that was meant to hammer down the meaning of the speed of light to the value c actually opened up its interpretation to incredible mental fancies. In other words, light can theoretically do nearly anything thinkable, so long as all the theory's predicted measurements of the speed of light is the fixed value c in all inertial reference frames in a vacuum.

This flight to fancies is precisely what Feynman did in his *QED*.[1] But I must first set the stage:

> However, I can guarantee you (otherwise the examples I'm going to show you would be misleading) that every phenomena about light that has been observed in detail can be explained by the theory of quantum electrodynamics, even though I'm going to describe only the simplest and most common phenomena.
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> Found in: Feynman, *QED*, Princeton Science Library, p. 38.

Feynman goes onto say that his weird theory allows for light to actually travel from the source to the detector point by reflecting off of every part of the mirror (sum of all paths). Feynman refers to Poincare's claim that light is in

[1] QED is the standard acronym for quantum electrodynamics.

a conspiracy against humans to know it completely and its supposed absolute rest frame (see, *The Feynman Lectures on Physics*, Vol. 1, p. 15-5).

He claimed even more:

> You found out that in the last lecture that light doesn't go only in straight lines; now, you find out that it doesn't go only at the speed of light.
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> Found in: Feynman, *QED*, Princeton Science Library, p. 89.

Let's throw in one more:

> Throughout these lectures I have delighted in showing you that the price of gaining such an accurate theory has been at the erosion of our common sense. We must all accept some very bizarre behavior: the amplification and suppression of probabilities, light reflecting from all parts of a mirror, light travelling in paths other than a straight line, photons going faster or slower than the conventional speed of light, ...
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> Found in: Feynman, QED, Princeton Science Library, p. 119.

Feynman's theory would be impossible if he were constrained to model light as always traveling at the speed c in a given reference frame! This is a perfect example of why I emphasize why the light principle is about measurement.

3 Conclusion

So, does light really act as crazy as Feynman's QED suggests? Who knows? I take the instrumentalist view of physical theories: They are about what works to describe what happens in the natural realm; they are not about what really happens at the deepest levels of metaphysics. If you've found a theory that makes good measurement predictions, be satisfied (or at least happy) with that much success.