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From ch. 2, "Light as Purposive"
pp. 10-11

The enigma of light

The heart of our story, like the beginning of creation, lies in the nature of light. Here we are confronted with mystery, and I say this not because of the perplexities of physics, b ut in view of what is the essential nature of light. Light, because it is primary, must be unqualified – impossible to describe – because it is antecedent to the contrasts necessary to description.

While the foregoing is essentially a philosophical statement, the physicists would have much the same report. For the physicist, light is unique in that, unlike everything else that exists in actuality, it has no mass (no rest mass). It has no charge and, as evidenced by the finding of relativity that clocks stop at the speed of light, it has no time.[1] While light in a vacuum has a "velocity" of 186,000 miles per second, this velocity is not motion in the ordinary sense since it can have no other value. Objects can be at rest or move at a variety of speeds. Light, on the other hand, has but one speed (in any given medium) and cannot be at rest. Even space is a meaningless concept for light, since the passage of light through space is accomplished without any loss of energy whatever.

Light involves us I a special kind of difficulty, the difficulty of knowing about that which provides our knowledge of other things. We might imagine a painter who wanted to paint the paintbrush, a problem I encounter when I want to repair my glasses: I cannot see without them; and light, by which we see, cannot be seen.

This sort of Zen paradox is not appreciated by the scientist, who likes to think of light as "just another kind of particle." This interpretation does not stand up under examination, for to call that which is outside of space and time, and which has no rest mass, "just another kind of particle" is a placebo for materialists rather than a correct description (see p. 6).

Light is not an objective thing that can be investigated as can an ordinary object. Even a tiny snow crystal, before it melts, can be photographed or seen by more than one person. But a photon, the ultimate unit of light,[2] *can be seen only once:* its detection is its annihilation. Light is not seen; it is seeing. Even when a photon is partially annihilated, as in scattering of photons by electrons, what remains is not part of the old photon, but a new photon of lower frequency, going in a different direction.

An ordinary object can be thought of as a carrier of momentum, or energy, which it can impart to another object. A hammer striking a nail exerts a force which drives the nail; a bowling ball conveys energy which knocks over the pins. In both cases, the hammer and the bowling ball remain after the work is done. With light, however, its transport of energy from one point to another leaves no residue. *Light is pure action*, unattached to any object, like the smile without the cat.

This light energy is everywhere, filling the room, filling all space, connecting everything with everything else. It includes much more than the light we see by, for *all exchange of energy* between atoms and molecules is some form of what used to be called electromagnetic energy, which extends over a vast spectrum and would be better named interaction. Visible light covers just one octave in that spectrum.

[1]The space-time path of light has zero length.
[2]The neutrino, if it exists, is no less insubstantial than light.

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The principle of least action

The difficult question is: what is *action*? This will become increasingly important as we proceed. Curiously, the notion of light as action was one to emerge quite early. It was observed in the 17th century that sunset occurred a little later than it would if light followed a straight line: light as it enters the atmosphere follows a curved path. This phenomenon is explained as due to the fact that the speed of light is reduced by the atmosphere.

[illustration]

What is remarkable is that the path followed by the light through the layers of atmosphere is precisely that which gets it to its destination in the shortest possible time. In driving from a point in the city to a point in the country, we can reduce the total *time* if we shorten the time spent in the city, even at the expense of going a longer distance. Fermat, the famous 17th century mathematician, was the first to solve this problem of the path for the minimum time.

[illustration]

Yet light, going from a denser to a rarer medium, follows just this path. As Planck himself said of the phenomenon:

> Thus, the photons which constitute a ray of light behave like intelligent human beings: Out of all possible curves they always select the one which will take them most quickly to their goal.[3]

This law, that light always follows the path taking the shortest time, is known as the *principle of least action*. According to Planck again:

> [It] made its discoverer Leibniz and soon after him also his follower Maupertuis, so boundlessly enthusiastic, for these scientists believed themselves to have found in it a tangible evidence for an ubiquitous higher reason ruling all nature.

[3]Planck, Max., *Scientific Autobiography and Other Papers* (p. 178). Translated by Frank Gaynor. New York: Philosophical Library, 1949; Greenwood Press, 1968 (reprint).

Consideration of light as purposive

As the reader is probably aware, the notion of purpose or teleology is forbidden in science, among biologists especially, who, while they must be strongly tempted to invoke it at every turn, avoid it as a reformed alcoholic avoids a drink. Physicists avoid it because their problems don't require it.

Yet we find one of the greatest physicists saying that:

> . . .the historical development of theoretic research in physics had led in a remarkable way to a formulation of the principle of physical causality which possesses an explicitly teleological character.[4]

But I do not wish to make an issue of this question of teleology here. Let us simply note one thing: that there is only one exception to the exclusion of purpose from science, and this exception is light, which these several scientists have seen fit to regard as having a purposive behavior. Let us also note that the purposiveness is associated with that aspect of light known as the principle of action (or least action).

[4]*Ibid*., p. 80

Importance of Planck's discovery that action comes in wholes

What did Planck add to this principle of action that was not already present in the ideas of Leibniz? It was the notion that action comes in *quanta* or *wholes*, and that this unit is constant. Note that despite the tendency to refer to energy as quantized – a habit which even good physicists are given to – it is n ot energy but *action* that comes in wholes.

Action = E x T (Energy x Time) = Constant *(h)*

Action is constant, energy is proportional to frequency. (*T* is the time of one cycle.)

So far, except for the reference to purpose, I have kept within the bounds of accepted science. Now I would like to go further to track down this notion of purpose which Planck, and before him Leibniz, felt was indicated by the principle of least action.

As we have noted, purpose is barred from science. As Bacon said: "Purpose like a virgin consecrated to God is (for science) barren."

But as Whitehead pointed out in his *Function of Reason*:[5]
"Scientists, animated by the purpose of proving they are purposeless, constitute an interesting subject for study." As Whitehead went on to say, we must distinguish "between the authority of science in the determination of its own methodology and the authority of science in the determination of the ultimate categories of explanation." Whitehead obviously wants to include purpose as an ultimate category of explanation.

How may we include purpose in cosmology (the ultimate categories of explanation) while still excluding it from the methodology of science?

We know that science builds its entire edifice on three measures: mass, length, and time, and their combination, and all scientific formulation can be expressed in these terms. Clearly, there is no evidence of purpose in any of these: it is not in mass, nor in length, nor in time.

The only suspicion of it, as we noted, occurs in the formula for action. Action has the measure formula *ML^2/T*. This *combines* mass (*M*), length (*L*), and time (*T*). Is it possible that there is something present in the whole that is not in the parts?

This is clearly the case here. Consider any device made of parts, say a bottle and its cork or a flashlight and its bulb. Is it possible to find the function of the device in the parts? Surely, no. Only when the device is put together can it express its function and its purpose, something its parts alone could never do.

It was Planck's epoch-making discovery that action *comes in wholes*, a discovery which in retrospect we an see to be true of human actions. We cannot have 1½ or 1.42 actions. We cannot decide to get up, vote, jump out the window, call a friend, speak, or *do* anything one-and-a-half times. *Wholeness* is inherent in the nature of action, or decision, of purposive activity. Planck's discovery about light touches home: it is true of our own actions. But we didn't really know this until the physicists had made this a principle.

[5]Whitehead, Alfred North. *The Function of Reason.* Princeton: Princeton University Press, 1929.

Light as first cause

Perhaps I should let it o at that. We are already pressing the mind beyond its limits. Nevertheless, let's go ahead and see what happens. Since purpose is in the whole and not in the parts, the whole must be greater than the parts. How can we account for this? Because the whole *cannot function when divided*. It follows that function is that aspect of "cause" which is not in the parts

and which science cannot deal with, because science deals with mass, length, and time, which are parts. This leads to a basic cosmological postulate: *the parts are derived from the whole*, and not the whole from the parts. In other words, the whole exists *before* the parts (see pp. 149-150).

We can now close our argument, for in showing that the parts arise from the whole we provide confirmation for *light as first cause*:

Light = quanta of action = wholes = first cause

An additional consideration that confirms the fundamental nature of action is that actions are *unqualified*. While mass is measured in grams, length in meters, and time in seconds, quanta of action are *counted* with no necessity of specifying the kind of unit. This implies their fundamental nature; actions *precede* measure, they are prior to the analysis which yields grams, meters, and seconds.

It might be objected that action has the measure formula *ML^2/T* and hence cannot be dimensionless. The answer is that, though action has the dimension *ML*^2/*T*, we are taking the position that this particular combination of dimensions (known as action) is the *whole* from which time, mass, and length are derived. The reasons are as follows:

1. Action comes in irreducible *quanta* or units.
2. These units are of constant, i.e., *invariant*, size.
3. The are counted, not measured.
4. Because indeterminate, they constitute the end point in the chain of causation and are therefore *first cause*.