On Cause and Effect in Quantum Physics

Abstract

The supposition of proportionality between energy (*hn*) as intrinsic 'cause' and its effect 'momentum', connected by the constant *c*, leads to some new aspects of the Planck-Einstein-deBroglie equations and Heisenberg's indeterminacy relations which seem to corroborate realism.

Introduction

New research on the physics of Galileo and Newton has shown that their system was set up on the principle of proportionality of cause (impressed motive force, or impetus) and effect (change of motion, or motus = momentum), connected by a constant of proportionality *c* of dimensions [L/T] [1]. Now, the efficiency of this principle in quantum physics will be demonstrated by transferring it to the relation of energy $E = hn$ and momentum $p = h/l$, and to the Heisenberg indeterminacy relations $\Delta E \times \Delta t \geq h$; $\Delta p \cdot \Delta l \geq h$.

Planck's concept of energy

When Planck defined the proportionality of energy *E* and frequency *n* in 1900 a step was taken, the meaning of which seems still not to be fully realized in physics. For, if energy is regarded as cause and frequency as effect, the law of proportionality of cause and effect as law of causality (not of determinism!) had thus returned to the very heart of physics, from where radical proponents of the Enlightenment, such as d'Alembert, had tried to banish it 150 years before, as a consequence of their analytical and antimetaphysical approach to rational mechanics[2]. Moreover, Planck's step included a new concept of energy which is in a linear relation to another entity (namely frequency), while in analytical mechanics *E* is related to *the square* of another entity (namely velocity). Schrödinger had an inkling of this change in the meaning of energy as early as 1926 [3]. From the proportionality between energy and frequency resulted Planck's constant *h* which plays a chief part in modern physics and philosophy as a supposedly ultimate information, though it should be noted that *h* is only a consequence of Planck's purely empirical approach without any meaning *a priori* [4] .

Planck's *h*, and the proportionality between energy and momentum

To be sure, an *a priori* principle is provided by the law of proportionality between energy as cause and momentum as effect, connected by the constant *c*, and it is at the bottom of modern physics, as can be shown in the following (regarding photons only) :

$$E/p = h \times n/h/l = ln = c \; ; E = p \acute{} c \; ; E \propto p \; . \qquad (1)$$

Obviously the effect of the cause *E* which is proportional to *E* is not ν but *p*, and the constant that connects cause *E* and effect *p* is not *h* but *c* [L/T], in agreement with the Newtonian law of cause and effect mentioned in the introduction, and also with Einstein's equation $E = mc^2$, when it is interpreted as a proportion between energy and momentum of photons ($E/mc = c$; mc = momentum of the photon). From eq. (1) and Planck's $E = h \acute{} n$ we get

$$p \times c = h \times n \; ; \quad p = h \times n/c = (h/c) \times n \; . \qquad (2)$$

In this case (still regarding photons), the geometrical dimension of the constant quantity *h/c is* [L], which might be Heisenberg's elementary length *l*, and the momentum then is expressed by

$$p = l \times n \qquad (3)$$

while

$$h = l \times c \; , \qquad (4)$$

which shows that Planck's constant is a product of two more basic constants, namely *c* and *l* . Using eq. (4) and deBroglie's $p = h/l$, *p* can also be expressed by

$$p = (l/l) \times c \qquad (5)$$

which gives information on microphysical reality, as it indicates that the electromagnetic momentum *p* becomes a maximum if the wavelength λ becomes a minimum that is equal to

some elementary length l , since in this case $l/l = 1$, and $p = c$ (consequently $E = c^2$). Considering the effect p of an electromagnetic energy E to be $l \times n$ (equation (3)), we can infer that this effect is the oscillation of a real entity characterized by an elementary length l , oscillating with frequency n. As a particle cannot oscillate with a wavelength that is smaller than the radius of the particle, p and E reach a maximum when l converges to l (l being the active radius of the particle).

Consequently, the oscillating entity of characteristic length l seems to be a constituent of the electromagnetic field, which field can be identified with space itself. If we only accept again Newton's absolute (i.e. *real*) space as an immaterial entity, this substantial space can be realized as, and can be identified with the concept of the ether as carrier of the electromagnetic and gravitational phenomena, that is the fluctuating vacuum or *subvac* [5] recently created by theoretical physicists who unnecessarily establish a difference between the vacuum, the carrier of the electromagnetic field, and space itself.

Pressure of light, photoelectric effect, and photon theory

Let a ray of light (energy $E = h \times n$) produce electrons with momentum $p = m \times v$. In this case, the proportionality between energy and momentum yields the equation

$$E/p = h \times \nu / m \times v = c \text{ [L/T]}; \quad E = m \times v \times c \ . \qquad (6)$$

This notion of E has already shown its validity as an elementary part of Born's proof of Einstein's mass-energy proportion[6], and it corresponds with the interpretation of Newton's law of cause and effect mentioned in the introduction. At this point it should be stressed that E, according to equation (6), must be a vector, and this marks another important difference between this concept of energy and that of analytical mechanics. Equation (6) once more yields a derivation of electromagnetic momentum $p = l \times n$ (as in eq. (3)), since the equivalence of energy $E = h \cdot n$ and energy $E = (mv) \times c$ leads to

$$h \cdot n = m v c \qquad (7)$$

and this equation (7), divided on both sides by c , brings to light an equivalence of electromagnetic momentum and momentum (mv) of a moving body. Recalling that the quotient h/c is a constant length l, we arrive again at eq. (3), and for the electromagnetic energy we get

$$E = (l \acute{} n) \times c \quad . \qquad (8)$$

Heisenberg's indeterminacy relations

The Heisenberg relations $\Delta E \times \Delta t \geq h$; $\Delta p \times \Delta l \geq h$ bear a heavy weight of philosophical interpretations which are all due to the orthodox interpretation of h. Since h is now demonstrated to be a product of the more basical constants l and c , a simpler and hitherto hidden principle underlying Heisenberg's formalism is needed, and this is again the law of causality (proportionality between cause and effect) as can be shown thus: Let the product $\Delta E \times \Delta t$ equal h, and the product $\Delta p \times \Delta l$ as well. In this case, Δt and Δl may symbolize the ultimate smallest particles of time and space, and one can write the products

$$\Delta E \times \Delta t = \Delta p \times \Delta l \quad . \qquad (9)$$

Now, the proportion corresponding to equation (9) reads

$$\Delta E/\Delta p = \Delta l/\Delta t \qquad (10)$$

or, since $\Delta l/ \Delta t$ in this case is a constant quotient of constants that coincides with c (vacuum velocity of light),

$$\Delta E / \Delta p = c \; ; \Delta E = \Delta p \times c \; ; \Delta E \propto \Delta p \qquad (11)$$

wherein c once again plays the role of the constant of proportionality that connects energy as cause with momentum as effect. So we can see that it is the law of causality which, as an elementary information on reality (or as a synthetic *a priori*in the sense of Kant[7]), works behind the formalism of quantum mechanics.

Conclusion

It should be stressed that the law of causality, i.e. the proportionality of physical effects to their immaterial causes, whether these be called 'forces' or 'energies', holds good for a unification of the new interpretation of Newton's second law ($F = \Delta(mv) \times c$) with the essentials of quantum physics. The epistemological account that encouraged this approach was pointed out by Jammer, who has emphasized that physical entities do not do what they do because they are what they are, but are what they are because they do what they do[8] (namely, produce proportional effects, as is demonstrated of the quantum physical concept of energy in this paper).

References

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