Does Quantum Mechanics Imply the Concept of Impetus ?

Abstract

This paper shows a close correspondence between the quantum mechanical concept of the energy of light and the concept of *impetus*, as it was used, according to the author, for "cause of uniform straight-lined motion" by Newton (*vis inertiae*, that is the force of inertial motion, in contrast to mere *inertia* as a property of matter). Both concepts are identified as *causal* via the common factor of proportionality c . Since the product " momentum $\times$ c " stands for "cause", the terms pc (light) and (mv)c (matter) are seen as true mathematical equivalents of the quantum mechanical concept of energy $E = hn$, in contrast to the incompatible *squared* energy-momentum relation $E = mv^2/2$. The identification of the *linear* $E = hn$ and the *squared* $E = mv^2/2$, upon which Schrödinger's equation is based, is shown to be the reason why the Schrödinger quantum mechanics appears as a noncausal and nonlocal theory of motion.

What does impetus mean? Up to the time of Galileo impetus meant the *cause* or *force* of motion, *proportional to* the generated *motion*. Even in Newton's *Principia* of 1687 a concept of impetus was still present as a fundamental part of the theory of motion: in "definitions" III and IV he speaks of *a force innate in matter* which he calls "matter's inertial force", and this force is defined as the cause why a body maintains its uniform straight-lined motion in the absence of external acting forces *able to change* this motion[1]. However, in analytical mechanics, as it was established after Newton mainly on Leibniz's concept of energy (*vis viva)* by d'Alembert and others, this concept of *impetus* was lost in favour of merely "inertia" not as a force, not an (immaterial) entity of its own, but only a property of matter itself. As a result of this materialistic departure from Newton's true theory, uniform straight-lined motion, now bereft of its former cause *impetus*, appeared as a "causal paradox" [2]. I feel that it might be worth reintroducing the concept of impetus not only to remove this paradox, but also because I believe that it serves as part of the foundation of quantum mechanics. One should also appreciate its explanatory power in the still unsettled task of understanding the principles upon which quantum mechanics, in contrast to classical mechanics, is based.

The Platonic-Newtonian concept of *proportionality* between real physical quantities of different kinds (i.e. incommensurables), mainly between quantities of "force" (as *cause of*

motion) and the *generated motion* itself, is a key to this author's research. The ontological difference between *force* and *motion* requires a *constant of proportionality* if both are put proportional to each other. This constant will consequently bear *a definite dimension* of its own. If one then analyses basic equations of modern physics with respect to this concept of proportionality, one will understand where true *causal* relations between true natural causes of motion and the effected motions work, and where *noncausal* relations, say mere *functional* and, consequently, *instantaneous* or *nonlocal* relations work. I would not consider the latter descriptions of a reality of nature, but only rational working models for applied physics. In general, my method rests on a decided Platonic conviction of the mathematical structure of the laws of true nature.

In the following I will employ Newton's concept "impetus proportional to uniform straight-lined motion". Expressing this motion through our concept of momentum, $p = mv$ (which is the same as Newton's), we obtain $impetus \propto p$, or

$$impetus / p = constant, \text{ or} \qquad (1a)$$

$$impetus = constant \times p \quad . \qquad (1b)$$

As a matter of fact, quantum mechanics employs concepts of energy that show a mathematical structure analogous to this concept of impetus. I refer to

$$energy\ E = vacuum\ velocity\ of\ light\ c \times p \qquad (2)$$

which is an equivalent of the quantum mechanical concept of energy $E = hn$, as can be seen in the concept of momentum of light [3] $p = hn/c = E/c\ ;\ E/p = c\ ;\ E \propto p$. Obviously this proportion corresponds to the above proportion "$impetus \propto p$ " , and the correspondence would be perfect if the constant of proportionality were *c* in both cases.

Now this depends on the definition of *impetus* only. If the relation between impetus and momentum is seen as *causal* (as we presented it earlier), where "momentum" means *the effect* of the "impetus" as its *generating cause*, it is very reasonable to identify the constant of proportionality, linking the cause with its effect, as *c*, that is the vacuum velocity of light, in accordance with eq. (2), and, consequently, to see eq. (2) also as a cause-effect relation

between energy and momentum. The general reason for this interpretation is that *c* (as we have learned from special relativity) indeed means that *finite* velocity with which, in a causal relation, effects follow their causes, since effects cannot follow their generating real causes *instantaneously*, rather *successively in time and space,* following a set pattern. Consequently, we may introduce *c* as constant of proportionality into eq. (1b), thus obtaining a complete causal relation between impetus and momentum, in perfect correspondence with the quantum mechanical eq. (2). And the operation should be the more admissible since I have identified the constant *c* (dimensions "space over time") as part of Newton's true concept of impetus [1]. So we may say that the quantum mechanical concept of energy $E = hn = pc$ means the cause of a momentum $p = E/c = hn/c$ as its effect, as well as impetus means the cause of a momentum $p = mv$; and this causal view of an energy-momentum relation means a considerable further development in the understanding of physics, so we should not shy away from it only because it sounds rather strange from the view of standard physics to think of the energy of a photon as the cause of its momentum.

The proportion between momentum *p* as effect and some other concept or entity which may be called "impetus" or "energy" as cause, connected through the constant *c* (vacuum velocity of light) could well serve as a most basic concept of physics, since it can also be identified in special relativity. Just look at the relativist concept of the energy of light which is $E/mc = c$ (with *mc* = momentum of light). Even an *E*-over-*p* relation which makes use of the *orthodox* relativist concept of energy, $E = mc^2\gamma$, and $p = mv\gamma$, with $\gamma = (1 - v^2/c^2)^{-1/2}$, results in something quite similar, since γ reduces, and what remains is

$$E/p = mc^2/\mathrm{mv} = (c/v) \times c \text{ ; or } E(v/c) = p \times c \ , \qquad (3)$$

Which differs from our $E/p = c$ paradigm only in a factor *v/c* (which is merely a scalar number). Moreover, Einstein established an equivalence of the momenta of light and material motion [4], $hn/c = mv$ which, since it yields

$$hn = E = (mv) \times c \ , \qquad (4)$$

also corroborates the $E/p = c$ paradigm. However, eq. (4) for a time did not become part of the foundation of quantum mechanics, since the material motion of particles, due to the concept of classical *kinetic energy*, $E = mv^2/2 = p^2/2m$, seemed to obey not a *linear*, but a

squared relation to p ; and this *squared* energy-momentum relation became the basis of the new (Schrödinger) quantum mechanics from 1926 on.

It is quite obvious that the concept of kinetic energy (i.e. the squared energy-momentum relation) for the present is incompatible not only with eq. (4), but with *any* of the *linear* energy-momentum relations $E = pc$, namely $E = hn$, $E = (mv)c$, as introduced above. However, from the foundations of the Schrödinger equation we learn how Schrödinger's quantum mechanics handles this issue. Indeed, Schrödinger's equation rests on

$$hn = pc = mv^2/2 \quad ; \qquad (5)$$

and the above stated incompatibility of both hn and pc with $mv^2/2$, as it comes to the fore if we write (with $mv = p$)

$$p \times c = p \times v/2 \qquad (6)$$

is only removed by a purposeful introduction of the condition $c = v/2$; purposeful because the term $v/2$ as a *variable* is meant to represent the *phase velocity* of the so-called *Schrödinger wave*, in contrast to orthodox wave theory, where the phase velocity is always constant. Obviously, the Schrödinger wave is not a *real* wave, rather a mere mathematical construction.

Now we understand for the first time how and why the present formalism of quantum mechanics implies the concept of a *noncausal* or *instantaneous* theory of motion or *action* (action at a distance): it is only a result of the elimination of the causal linear energy-momentum paradigm $E = pc$ in favour of the merely functional, time-dependent concept $E = mv^2/2$, an it is achieved through the elimination of the causal parameter c in favour of a variable term $v/2$. Indeed, the latter step replaces the space-time distinction between cause and effect, as guaranteed by c , through a mathematical space-time *identity* between energy and (the square of) momentum (divided by $2m$): $E = p^2/2m$. And from this concept the intrinsic nonlocality or noncausality of quantum mechanics in its Schrödinger formalism originates.

How might this reasoning benefit us? I believe that understanding the how and why of quantum-mechanical nonlocality can help to prevent any unrealistic, mystifying, and subjectivist interpretations of this purely mathematical property of a certain technical tool; I

also believe that an understanding of the realistic structure of a causal energy-momentum relation will help to conceive a future real and true causal unified theory of motion.

The above considerations are not standard physics. That is clear. As a matter of fact, they are a true novelty, namely a first application of the geometric theory of proportions of incommensurables to the foundations of quantum mechanics. Hitherto nobody has identified the $E/p = c$ relation (which has been known for a long time since it can be derived from Maxwell's equations) as a *proportion between incommensurables*, and nobody has designated the constant c a *factor of proportionality.* Another aspect of this work is how this constant works as part of Newton's original causal theory of motion (as demonstrated in ref. 1). The incompatibility of the *linear* energy-momentum relation $E/p = c$ and the *squared* one, $E = p^2/2m$, has not been understood before, nor has it been recognized that the linear paradigm lies at the basis of Newton's true theory of motion, of special relativity, and as well of quantum mechanics.

However, the validity of this geometric approach to the foundations of physics goes far beyond these findings, as indicated in ref. 3. For instance, the noncommutativity of certain quantum mechanical operators can now for the first time be understood as a algebraic representation of the *originally geometric* topic of transforming a quaternary proportion of incommensurables into an equation of products (cf. ref. 3, eqs. (9), (10), (11)). Consequently, I appraise this geometric approach as *new* and *promising*, which decisively might improve our knowledge of real (microscopic and macroscopic) nature.

References

1) Ed Dellian, Inertia, The Innate Force of Matter - a Legacy from Newton to Modern Physics, in: Newton's Scientific and Philosophical Legacy, edited by P.B. Scheurer and G. Debrock (Dordrecht 1988), p. 227; cf. Isaac Newton, Mathematische Grundlagen der Naturphilosophie, edited by Ed Dellian (Hamburg 1988), p. XXXI.
2) Cf. C.F. von Weizsäcker, Aufbau der Physik, (München 1984) pp. 234, 243.
3) Ed Dellian, Spec. Sci. Tech. 12, 45 (1989).
4) Albert Einstein, Phys. Z. 121 (1917).