Completeness in Physics.

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Abstract.

Here it is intended to raise some questions surrounding the whole notion of completeness in physics. This does, of course, have bearing on issues raised by the well-known paper by Einstein, Podolsky and Rosen[1].

Introduction.

The questions about the completeness of quantum mechanics as a physical theory have been discussed at length ever since the famous paper by Einsteiun, Podolsky and Rosen first appeared[1]. Many experiments were carried out in attempts to both prove and disprove the assertions contained therein and a great deal of thought went into the theoretical investigations of Bell. All the references to this work may be found in the collected papers by Bell on quantum philosophy[2]. Less well-known is the resolution of the paradox advanced by Santilli in 1998[3]. Recently, however, the matter has resurfaced with the announcement of experimental results supporting the EPR assertions at Basel[4]. This has provoked further thoughts on this whole issue of completeness and just what it really means.

Thoughts from Thermodynamics and Probability.

For a moment consider the situation in thermodynamics. In traditional classical thermodynamics there are no uncertainties; all the variables, for example the internal energy, possess values. However, when systems composed of a large number of particles, for example, are to be considered, the methods of statistical mechanics have to be employed due to our present state of knowledge. As a consequence, when incorporated into thermodynamics, the realm known as statistical thermodynamics is entered. This is, in some crucial ways, totally different from classical thermodynamics because the introduction of statistical techniques has introduced uncertainty into the picture. No longer is there a definite value for the internal energy; rather an average value is considered. This average value, as with the average values of other thermodynamic variables, can fluctuate in this new regime. Hence, a degree of uncertainty is introduced which leads to the derivation of thermodynamic uncertainty relations[5]. It is important to note, though, that these relations have been introduced via the recourse to statistical methods to describe details of the system under consideration. They have been introduced because, in a system composed of a large number of particles, it is not possible to write down all the equations of motion of the individual particles and solve the resulting set of simultaneous equations. The uncertainty, therefore, has been introduced as a result of our inability to solve the exact problem; there is no inherent uncertainty in the original system. This reasoning follows for all statistical thermodynamic theories and indicates a very difference between classical and statistical thermodynamics.

Indeed, the same reasoning may be seen to apply to many, if not all, problems considered utilising probability theory. For example, in introducing probability, it is popular to consider the tossing of a coin. If the coin is simply tossed, the outcome when it lands – head or tails – is totally uncertain. However, this is not so if someone is in possession of all the initial conditions pertaining to the toss. If the initial speed is known, the height to which the coin rises may be found as may the time taken to reach that height. Similarly, the time taken to fall back to a given level may be found. If the rate of rotation is also known, that, together with the total time of flight, should enable the state of the coin on reaching the desired level to be ascertained. Hence, the uncertainty associated with this problem really arises through a lack of knowledge of the initial conditions in the problem; it is not an inherent property of the system.

It may be seen, therefore, that neither statistical thermodynamics nor probability may be termed complete theories in the sense that neither provides exact solutions to problems. In both uncertainty is introduced as a result of inability to write down and solve a set of exact equations and/or a lack of knowledge of initial conditions.

Possible Implications for Quantum Mechanics.

Recent rereading of some books on quantum mechanics would seem to indicate a similar situation existing in that branch of physics as well. For example, in Heisenberg's well-known book *The Physical Principles of the Quantum Theory*[6], the initial derivation of the uncertainty relations relies on an obvious approximation which might raise a few minor queries but the slightly later, more rigorous, derivation draws on notions from probability. Indeed the ideas of probability are closely associated with the wave function as is seen from discussions of Schrodinger's equation and its wave function. Once probability enters any discussion we contend that an element of uncertainty must follow in the subsequent theory. Hence, one must wonder if the uncertainty relations of quantum mechanics are a product of the theory rather than a natural property of the systems the theory is purporting to portray? However, the very fact that probabilistic ideas enter the subject at all must surely indicate that the theory cannot be complete? Here the idea of a theory being complete is intended to indicate that the theory is capable of describing any relevant physical system exactly without any degree, however slight, of uncertainty. That may, or may not, be the notion put forward in the famous EPR[1] article but that is the meaning adopted here and, in that sense, neither statistical thermodynamics nor quantum theory may be adjudged complete.

Some Final Thoughts.

As a follow-up to these comments, it might be worth raising the question of the presumed boundary between classical and quantum mechanics. Precisely when is something small enough to warrant the use of quantum mechanics to describe it? Is this boundary clear cut or does the transition evolve over what might be termed a blurred region in which either or both apply?

It might be wondered if the reintroduction of an aether could help in the resolution of many of these difficulties. For example, the uncertainty in the position and speed of a very small particle could be accounted for by the presence of a boundary layer between the said small particle and the aether. It is certain that, if the existence of an aether is true, then such a boundary layer must exist and, if the ideas put forward by Thornhill[7] concerning an aether are valid, then the size of aether particles would be extremely small and small in comparison with the size of recognised elementary particles. Obviously this situation would not apply so obviously to macroscopic bodies because their individual size would far outweigh that of the proposed aether particles.

These are all speculative thoughts but, nevertheless, thoughts which have materialised over years and lead to questions, at least, which need carefully considered answers in order to serve the cause of the advancement of scientific knowledge well.

References.

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