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ADVANCES IN THE APPLICATION OF NUCLEAR ENERGY FOR PEACEFUL PURPOSES

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NIGERIA

1. Although the phenomenon of nuclear fission was discovered over 35 years ago, it is not yet fully understood. A crucial instrument for the understanding of this phenomenon is quantum mechanics.

2. An approach based on stochastic theory has been used in Nigeria to formulate the theory of quantum mechanical motion. In addition to providing a common base for quantum mechanics and stochastic theory, the new formulation is not limited to forces derivable from a potential. A non-linear dynamical law has been deduced which is distinct from the usual linear laws.

3. Many approaches have been adopted in order to formalize and extend the statistical concepts in quantum theory. One approach is von Neumann's, which is based on the hypothesis of repeatability of measurements. A major difficulty is obtaining the transformation of states due to the measurement of observables. For discrete observables, an operational approach was introduced by Schwinger and by Haag and Kastler.

4. Another approach relies on seeking an analogy between Kolmogorov's measure-theoretic formulation of classical probability theory and von Neumann's Hilbert-space formulation of quantum mechanics. What are supposed to correspond to "observables" in classical probability theory are the random variables, and the "states" of quantum theory are regarded as analogues of the probability measures.

Again, this approach faces fundamental difficulties. Basic physical quantities (e.g. joint probability distribution functions, conditional expectations) are realizable only under very restricted conditions, which is unnatural (e.g. conditional expectations exist if, and only if, the observable has a discrete spectrum; probability distributions exist if, and only if, the observables commute).

5. None of the conventional methods of quantum mechanics is capable of resolving fundamental problems in standard quantum mechanics (e.g. restriction to forces derivable from a potential). A more general formulation with a clear physical interpretation is therefore necessary. This is the purpose that the work done in Nigeria has served.

6. In order to give as clear a physical meaning as possible to the mechanics, the approach taken was one in which classical ideas still had meaning.

7. Several attempts to deduce quantum mechanics using classical concepts have been made. Either a Brownian model is used as the basis for the construction, or a semi-deductive stochastic approach is taken. The second approach is more comprehensive than the first. However, the crucial connection between the kinematic and dynamical quantities is missing, and thus important considerations, such as the effect of non-Markovian terms, cannot be taken into account. The lack of a general force-kinematics relationship, the inability to account for the non-Markovian terms, and the neglect of spin constitute some of the limitations in previous work.

8. Through the present work in Nigeria it has been demonstrated that a stochastic theory approach could be used as the foundation for quantum mechanics. The approach has the advantages of physical clarity and a minimum of postulates, in addition to not being limited to forces derivable from a potential. When the new formulation is used for extended rigid particles, a generalized Schrödinger equation for integral or half-integral spins is obtained. This formulation opens up new possibilities, particularly in the investigation of many problems not within the scope of standard quantum mechanics.