THE NON–ERGODIC INTERPRETATION OF QUANTUM MECHANICS AND NEUTRON INTERFEROMETRY

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ABSTRACT. The Non-Ergodic Interpretation of Quantum Mechanics is reviewed and a experimental test using neutron interferometry is described.

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I - REVIEW OF THE NON-ERGODIC INTERPRETAION

The Non-Ergodic Interpretation (NEI) of Quantum Mechanics is a local realistic theory which assumes a certain physical viewpoint of how particles behave in the microworld that is distinct from the usual interpretations of quantum mechanics (e.g., Copenhagen, Statistical, Bohm's, DeBroglie's, Nelson's, and Marshall-DelaPena's). It assumes neutrons which first pass through the interference region affect neutrons which later pass via memory effects in this region. Neutrons which first pass affect the interference region which then affects the neutrons which later pass through this same region. Here neutrons interfere with other neutrons, but only indirectly via hypothesized memory effects in an hypthesized medium (Here we may consider the medium to be the crystal itself). Two neutrons never need be in the apparatus simultaneously.

Consider the double slit experiment. The above type of indirect interaction permits one to say that a neutron passing through one slit knows if the other slit is open (closed) from this information being somehow recorded in the medium in their common path by neutrons which previously passed (didn't pass) the other slit. Here interference can only happen after a sufficient number of neutrons, m, have traveled through the apparatus and conditioned the crystal in the interference region. One might imagine that m neutrons[1,2] must pass to permit an equilibrium between the crystal and the state preparation, a kind of cooperative phenomena. This equilibrium might develop slowly, a little with each neutron, or abruptly as in the transition from a lamp to a laser.

One might also describe NEI by saying that it questions the ergodic type assumption that currently must be made in order to interpret both the existing low intensity interference experiments and the polarization correlation experiments as giving the true quantum mechanical ensemble averages. We recall, for example, that in the double slit experiment the conceptually correct quantum mechanical ensemble average for a one particle system should be made as follows. There should be many identical independent apparatus with exactly one neutron in each apparatus. All the neutrons must be prepared in the same quantum mechanical state. Then the interference pattern must be seen when the positions of all the neutrons in all the independent experiments are superimposed. Real laboratory averages are time averages out of necessity. In order to interpret these time averages as ensemble averages an ergodic type assumption must always be made.

NEI is a well defined alternative interpretation of quantum mechanics. It assumes the same Hilbert space formalism used in both the Copenhagen interpretation and any statistical interpretation in the sense of Ballentine except for the following. In these interpretations one associates the mathematical object, $\langle\Psi|A|\Psi\rangle$, representing the average of the observable A in the state Ψ, with the laboratory procedure of taking an ensemble average. Instead, NEI identifies this same mathematical object with the laboratory procedure of taking a time average (That is, with the way experiments are really preformed). This is the formal difference. Here we are making a different association between mathematical objects of the Hilbert space formalism and laboratory procedures. NEI always make the same numeric predictions as these interpretations but it makes them only for time averages and not for ensemble averages. NEI is not a physical theory since it does not offer a structure to explain the hypothesized medium with memory effects.

Further information about this view may be found in References (3 and 4). It's relation to Bell's Inequality is described in Reference (5).

II - AN EXPERIMENTAL TEST

We will call all the usual theories of quantum mechanics mentioned in the last section, ensemble interpretations (EI). It is clear that NEI is experimentally distinquishable from any EI in a wide variety of experiments since it predicts no interference whatsoever for a true ensemble average. Interference can only happen for a time average, i.e. when a sufficient number of neutrons consecutively pass through the crystal. We now very briefly describe the idea behind a seemly feasible experiment using neutron interferometry. Details may be found in Reference (3).

Consider the usual three ear neutron interferometer. Assume we have a shutter in the left arm which we may open and close at will. We want to examine the behavior of the initial neutrons when the configuration is changed from a two-arm to a one-arm experiment (and vice-versa). For example, assume one is seeing a good stable interference pattern at a two-arm configuration. Then quickly close the left arm. From the viewpoint of NEI the initial neutrons that then pass the interference region, which certainly must have gone through the unblocked arm, are fooled, so to speak, into acting as if it were still a two-arm experiment. This is because the crystal in the interference region, R, is still conditioned to a two-arm experiment. It only can become reconditioned to a one-arm experiment after a sufficient number of neutrons pass. The difference in the predictions between any EI and NEI for these initial neutrons is quite dramatic. In an ideal situation, one might have 100% of the neutrons arriving at one of the counters and none at the other counter at the two-arm configuration. When it is changed to a one-arm configuration any EI predicts that the counting rates must abruptly change from 100% and 0% to 50% and 50% at the two counters respectively. NEI predicts that the counting rates will not change abruptly but will change slowly from 100% and 0% to 50% and 50%.

III - REFERENCES AND FOOTNOTES

1. m must depend on various factors which include the beam intensity and coherence. In particular, we may assume that as you continue to reduce the neutron intensity then you may still obtain interference, but you must use more neutrons to do it. In the limit of infinitely low intensity you will need infinitely many neutrons.

2. J. Summhammer has kindly furnished the author with detailed information on the results of a rough experimental test of the non-ergodic interpretation. The experiment shows that m can be no larger than about 200 neutrons and probably significantly smaller. The intensity level of the experiment with both arms open was about 25 neutrons arriving at both counters per second and a $\Delta\lambda/\lambda$=.5%.

3. Buonomano, V., "Neutron Interferometry and the Non-Ergodic Interpretation of Quantum Mechanics", *Physics Letters A*. In revision, 1987.

4. Buonomano, V., "Quantum Mechanics as a Non-Ergodic Clasical Statistical Theory", *Il Nuovo Cimento*, 57B, 146, 1980.

5. Buonomano, V., "Bell's Inequality and The Non-Ergodic Interpretation of Quantum Mechanics", *Quantum Mechanics Versus Local Realism: The Einstein, Podolsky and Rosen Paradox*, Ed. F. Selleri, Plenum Press, 1987.