

Natuurkundig Laboratorium
der Rijks-Universiteit
te GRONINGEN
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Onze ref. HG 857-57.

MBP-
Please make
1 photo copy for
me; send
this to HEIII
Jtw 15 Apr

Hugh - Do you want to
draft a reply that I
could review before
it is sent off? See

GRONINGEN, 1 April 11th 1957.

You soon! - John Wheeler

Dr. Hugh Everett, III and Professor
John A. Wheeler
Palmer Physical Laboratory
PRINCETON New Jersey

U.S.A.

Dear Dr Everett and Professor Wheeler,

very inter.
are proceeding
to be available? { Just returning from the Colston Symposium at Bristol on "Observation and interpretation", where during 4 days from early in the morning until late at night we have been fighting on the foundations of quantum mechanics, I find your 2 papers dealing with just the same subject. Thank you for sending them. If I were going to give my full comments and criticisms, I could do no better than completely rewriting and enlarging my MS on "Quantum Measurements", which I provisionally wrote down last year in Copenhagen and of which I have sent you a copy. Until now I only have rewritten a few sections of it (in particular sections 2 and 4) and I am afraid that in the near future I will not find time to revise it in the way I have mind. Therefore I now have to restrict myself to some very crude general remarks without the detailed arguments and reasoning and which I only make quite hastily and with much hesitation and reservation.

Compared with the MS on "Wave mechanics without probability", which I borrowed last summer, I find the present abstract much improved, but with regard to the fundamental physical and epistemological aspects I must say that I still profoundly disagree. Let me just briefly outline some of my main objections and comments in a number of short points (which are not independent).

1) All physical observable quantities may ultimately be expressed in statistical relations between results of various measurements. These relations may be expressed with merely the unitary operators representing the motion and the projection operators representing the various possible measuring results and without wave functions (or more general statistical operators). The statistical relations may be expressed in the form of conditional probabilities of certain measuring results (which e.g. have not yet been read, so that no information has yet been obtained about them) with respect to other measuring results (which e.g. already have been read, so that information has been obtained about them). Now one can introduce the statistical operator, which just represents in a very efficient way all the information which already has been obtained and which may be used to calculate the conditional probability (with respect to this information) of other information which still may be obtained or used. Thus also the statistical operator is conditional and depends on the standpoint from which the system is described. It is relative like the coordinate frame in relativity theory. It seems to me that this conditional character has been overlooked in your papers (as well as in many others).

2) I fully sympathize with the idea of describing the measuring process on purely physical systems without including living observers. So the "measuring chain" has to be cut off. But it is extremely fundamental that off is made after the measuring result has been recorded in a more

X wrong!
won't work
for approx. mass.

on contrary, there is
useful descriptive in
field papers. In fact is
at very basis of "relativity
of states".

nonsense.
whole idea not to cut off
till after final observ.

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Onze ref. HG/857-57. 2nd page

GRONINGEN, April 11th 1957.

Dr Hugh Everett and Prof. Wheeler
PRINCETON.

no meaning in Q.M.
QM. says it effected
just like macrosystems
where this magic
occurred?

The very basic idea is
to avoid this necessity,
which is a serious
difficulty in our view.
?

What process does? (It is corrected in field theory). The influence of the measuring instrument
can obviously not be represented in this way. I agree that in a certain way
yes, in ordinary it could be represented by applying process 2 to the combined object and
interference. It is however measuring systems. But this is not sufficient, because one has also to
take account for the destruction of the coherence between those Hilbertsubspaces,
which are to be distinguished by the measurement. (It should be observed
that coherence only has a statistical meaning). There are various effects
which lead to such a destruction, one of them being the macrophysical
character of the recording system. I do not see that this destruction of
coherence, which is very essential in the measuring process, has been dealt
with in your theory. → nor in the usual theory either in a consistent manner.

Not so. To assert
this is to be exposed
to the "For what?"
embarrassment.

Briefly
what is done
in the theory
(in detail in
first version)

not necessarily
ideas with you precisely
wave mechanics doesn't
give this answer,
where does it come from?

misunderstanding
what ensemble?
why not?
?
?

permanent way, so that it no longer can be essentially changed if it is
observed on its turn (i.e. if the chain is set forth). This recording has
to be more or less irreversible and can only take place in a macrophysical
(recording) system. This macrophysical character of the later part of the
measuring chain is decisive for the measuring process. I do not think that
it can be left out of consideration in its description. It does not seem to
act an essential part in your considerations.

3) "Process 2" is only an approximation in as far as the influence of other
(external) systems is represented by a classical external field. In many
cases of elementary quantum mechanics this is a satisfactory approximation.

4) On one hand the combined object and measuring systems are considered from
the microphysical quantum mechanical point of view. So far one could not
even speak of a measurement. On the other hand the later part of the meas-
uring chain and in particular the recording system is regarded from the
macrophysical classical point of view. A satisfactory theory of measurement
has to relate these two aspects to each other. Only some very preliminary
attempts of a microphysical quantum mechanical foundation of a macrophysi-
cal description of macrosystems have as yet been made. In such
a theory destruction of coherence has to play a fundamental part.

5) After the measuring result has been recorded it may be read by an ob-
server outside the system considered so far. The recording is not essential-
ly changed by the reading. On the ground of the information obtained from
the reading the observer (or his associate theoretician) may assign a new
(conditional) statistical operator to the object system. On the other hand
he may for a great number of similar measurements statistically test the
conditional probabilities, which had been calculated for these measuring re-
sults.

6) Now I guess that your "memory of the observer" corresponds somehow with
the ensemble of all the recording systems, but I do not see how your auto-
matical observer included in the described combined systems also could be
used for describing the activities of reading the recorded measuring result
and of assigning statistical operators to the object system on the ground
of the obtained information. In a certain way the "disturbance" of the
object system under the influence of the measuring instrument could be
described in the combined systems, but I do not see how that could also
be done for the description of the object system, which does not "disturb"
it at all.

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{ 6) Now I guess that your "memory of the observer" corresponds somehow with the ensemble of all the recording systems, but I do not see how your automatical observer included in the described combined systems also could be used for describing the activities of reading the recorded measuring result and of assigning statistical operators to the object system on the ground of the obtained information. In a certain way the "disturbance" of the object system under the influence of the measuring instrument could be described in the combined systems, but I do not see how that could also be done for the description of the object system, which does not "disturb" it at all.

7) It seems to me that the relation between the object system and the observer (who not only "observes" the object system, but also describes it with some theory and "interprets" if you like) is a rather delicate one, which should be analyzed very carefully and that neither of them could even be formulated without the other one.

8) Because all observable quantities may ultimately be expressed in statistical relations between measuring results and the latter are represented by essentially macrophysical recordings, the former ones may ultimately be expressed in macrophysical language. That does of course not mean that the formalism, which serves as a tool for calculating these statistical relations could also be expressed in macrophysical language. On the contrary in this field the macrophysical language is liable to loose its original more or less unambiguous meaning.

9) A similar loss of the meaning of the language and of our notions might occur under the extension of the described physical system to the entire universe and the inclusion of the observer, who not only observes, but also theoretically describes the system.

10) In many existing considerations of the foundations of quantum mechanics the non-recognition of the conditional character of the statistical operator (or wave function) and also of the statistical character of notions like interference a.o. and the neglect of the macrophysical features of the later part of the measuring chain (in particular of the recording) introduces all kinds of paradoxes (e.g. cat paradox; Einstein-Rosen-Podolsky paradox a.o.). I do not see how in your theory these paradoxes could be avoided.

I am quite clear that this haphazard hasty collection of points without the necessary arguments cannot be clear at all. All I could do in these few lines was perhaps to point out that in various aspects I cannot follow your arguments and that I fail to see that your theory would give a deeper insight into quantum mechanics. I regret that I have no opportunity to discuss these things with you in all detail. I am really much interested in your points of view and in case copies with the full text of Dr Everett's text might be available, I should be glad to read it. My impression that problems in this field recently regain interest and highly puzzle various people was strongly fortified at the Bristol symposium last week. Also that in various aspects our understanding of them is still far from satisfactory.

Haa!

Yours sincerely,

(H.J. Groenewold).