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QUANTUM THEORY, INFORMATION AND THE MIND-MATTER RELATION.

by

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Quantum Theory, Reality and Consciousness.

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QUANTUM THEORY, INFORMATION AND THE MIND-MATTER RELATION.

(1) What are the MAIN LESSONS we learn from QUANTUM PHYSICS?

(2) How RADICAL must we become to SATISFACTORILY account for QUANTUM BEHAVIOUR?

BOHR:-
If we are not profoundly disturbed by quantum phenomena, we have not begun to appreciate its implications.

BUT HOW RADICAL?

Interpretations:

Standard interpretation, Copenhagen interpretation, Statistical interpretation, Many-worlds interpretation, Bohm-de Broglie interpretation, Bohm Ontological interpretation, Consistent histories interpretation, Transactional interpretation, Many minds interpretation, Modular interpretation.......

Why so many?

They are all limited.

We CANNOT maintain the REDUCTIONIST, MECHANICAL position.

Even for the PHYSICIST the

CARTESIAN DREAM IS DEAD!
What is the most important novel feature?

Will not dwell on:-

(1) Wave-particle duality.
(2) Discreteness of energy.
(3) Uncertainty relations.
(4) Indeterminism or uncontrollability.

These emphasise how QM is NOT in Newtonian tradition.

The CENTRAL role played by the OBSERVER or his PROXY, the OBSERVING INSTRUMENT.

BOHR:-
"The INDIVISIBILITY of the quantum of action implies that it is not possible to SEPARATE the OBSERVER (or the OBSERVING INSTRUMENT) form the SYSTEM."

VON NEUMANN:-
"Indeed experience only makes statements of this type: an OBSERVER has made a certain (SUBJECTIVE) OBSERVATION: and never : a PHYSICAL QUANTITY has a certain VALUE."

WIGNER:-
"Consciousness was needed to complete quantum mechanics."

STAPP (based on Heisenberg):-
CLASSICAL MECHANICS strives to and SUCCESSFULLY KEEPS the observer and his mind out of physics,
QUANTUM MECHANICS tries, but FAILS TO KEEP the observer and his mind out of physics.

If you want to understand mind and consciousness you cannot do it using classical physics alone.
Freeman Dyson:-

I cannot help thinking that our awareness of our own brains has something to do with the process which we call "observation" in atomic physics. That is to say, I think our consciousness is not a passive epiphenomenon carried along by the chemical events in our brains, but is an active agent forcing the molecular complexes to make choices between one quantum state and another. In other words, MIND IS ALREADY INHERENT IN EVERY ELECTRON, and the processes of human consciousness differ only in degree but not in kind from the processes of choice between quantum states which we call "chance" when they are made by electrons.

[Disturbing the Universe, p.249, (Harper & Row, New York, 1979)].

David Bohm:-

The REMARKABLE POINT-BY-POINT ANALOGY BETWEEN THOUGHT AND QUANTUM PROCESS would suggest that a hypothesis relating these two may well turn out to be fruitful. If such a hypothesis could ever be verified, it would explain in a natural way a great many features of our thinking.

[Quantum Theory, p. 171, (Prentice Hall, Englewood Cliffs, 1951)]
WHAT ABOUT THE BOHM ONTOLOGICAL (OR CAUSAL) INTERPRETATION?

Nature participates in nature

Classical Potential---Reducible and controllable.
Quantum Potential--Irreducible and uncontrollable.

The Bohm approach to quantum processes is NOT MECHANICAL.

Bohm suggested it should be called QUANTUM NONMECHANICS.
[Bohm, Quantum Theory, p. 167, Prentice-Hall, 1951]
An Ontological Interpretation.

Very simple idea.

Write \[ \psi(r, t) = R(r, t) \exp\left[\frac{i S(r, t)}{\hbar}\right] \] in the SCHRÖDINGER EQUATION, separate into real and imaginary parts and find:

Real part:-

\[ \frac{dp}{dt} + \nabla[V(r, t) + Q(r, t)] = 0 \]

[NEWTON'S equation of motion]

Where

\[ V(r, t) \] is the CLASSICAL POTENTIAL.

and

\[ Q(r, t) = -\frac{\hbar^2}{2m} \frac{\nabla^2 R(r, t)}{R(r, t)} \]

is the QUANTUM POTENTIAL.

Imaginary part:-

\[ \frac{dp}{dt} + \nabla.(Pv) = 0. \]

[CONSERVATION OF PROBABILITY]
APPLICATIONS OF BOHM APPROACH.

1. Stationary states in atoms.
2. Frank-Hertz experiment.
3. Two-slit interference.
4. Barrier penetration.
5. Transmission through wells.
6. Aharonov-Bohm effect.
7. Neutron interference effects.
8. Neutron spin interference experiments.
10. Wheeler delayed choice experiment.
12. EPR paradox.
14. Quantum transitions.
15. Dirac equation.

EXTENSION TO FIELD THEORY.

1. Photoelectric effect.
2. Compton effect.
3. Photon interference effect.
5. EPR effect using photons.

EXTENSION TO STOCHASTIC QUANTUM MECHANICS.

1. Non-relativistic particle theory.
2. Pauli theory.
3. Dirac spin theory.
The QUANTUM Potential as an INFORMATION Potential.

Nature of quantum potential TOTALLY DIFFERENT from classical potential.

(1) It has no **EXTERNAL SOURCE**.

The PARTICLE and the FIELD are aspects of the SAME PROCESS.

**SELF-ORGANISATION.**

(2) The QP is NOT changed by multiplying field $\psi$ by a constant.

\[
\text{[because } Q \propto \frac{\nabla^2 R}{R} \text{ ]}
\]

**STRENGTH of QP is INDEPENDENT of FIELD INTENSITY.**

QP can be large when R is small.

(3) Effects DO NOT necessarily fall off with distance.

QP depends on FORM of $\psi$, NOT INTENSITY.

**NOT LIKE MECHANICAL FORCE.**

(4) The Newtonian potential DRIVES the particle.

The QP ORGANISES the FORM of the trajectories.

**POST-MECHANISTIC ORGANIC VIEW.**
(5) The QP carries INFORMATION about the particles ENVIRONMENT.

e.g., in TWO-SLIT experiment QP depends on:-
(a) slit-widths, distance apart, shape, etc.
(b) Momentum of particle.

QP carries INFORMATION about the WHOLE EXPERIMENTAL ARRANGEMENT.

BOHR'S WHOLENESS.

"I advocate the application of the word PHENOMENON exclusively to refer to the observations obtained under specific circumstances, including an account of the WHOLE EXPERIMENTAL ARRANGEMENT."

The QUANTUM POTENTIAL acts like an INFORMATION CONTENT.

[To inform means literally to FORM FROM WITHIN]
The Meaning of INFORMATION.

As with many words in the English language, the word "information" has both Greek and Latin roots. The Latin informatio bears direct and obvious structural similarities to our modern "information". The prefix (in) is equivalent to the English "in", "within", or "into"; the suffix (tio) denotes action or process and is used to construct nouns of action. The central stem (forma) carries the primary meaning of visible form, outward appearance, shape or outline. So informo (or informare) signifies the action of forming, fashioning or bringing a certain shape or order into something, and informatio is the noun from which signifies the "formation" thus arrived at. The Greek terms which are analogous to the Latin forma are morphe and eidos - translated as appearance, constitutive nature or form.

[Miller, PhD Thesis, Rutgers University, 1987]
THE ACTIVE AND PASSIVE ROLE OF QUANTUM INFORMATION.

With particle in CHANNEL I, the Quantum Potential, $Q_I$, is ACTIVE in that channel,

while the QP in CHANNEL II, $Q_{II}$, is PASSIVE.

If INTERFERENCE occurs in the output channel, we need information from BOTH CHANNELS.

INFORMATION IN THE 'EMPTY' CHANNEL BECOMES ACTIVE IN THE OUTPUT CHANNEL.
[It cannot be thrown away.]

Does INFORMATION ever become INACTIVE?

Once an IRREVERSIBLE process has taken place the information becomes INACTIVE

There is NO COLLAPSE, but it behaves as if a collapse has taken place.
TWO PARTICLE SYSTEM.

Wave function:-

\[ \Psi(r_1, r_2, t) = R(r_1, r_2, t) \exp\left[ \frac{i S(r_1, r_2, t)}{\hbar} \right] \]

Substituting into Schrödinger's equation gives:-

\[ \frac{\partial S}{\partial t} + \frac{(\nabla_1 S)^2}{2m} + \frac{(\nabla_2 S)^2}{2m} + V(r_1, r_2, t) + Q(r_1, r_2, t) = 0, \]

where

\[ Q(r_1, r_2, t) = -\frac{\hbar^2}{2m} \left[ (\nabla_1^2 + \nabla_2^2) R(r_1, r_2, t) / R((r_1, r_2, t) \right] \]

(1) As \( \Psi(r_1, r_2, t) \) evolves in time, the movement of the particles are correlated so that they move together even when \( V(r_1, r_2, t) = 0. \)

They are TOGETHER YET APART.

NON-SEPARABILITY.

(2) The QP does NOT necessarily vanish as \( |r_1 - r_2| \to \infty \)

Can meaning be given to SEPARATE and INDEPENDENT PARTS?
(3) If you measure a property of particle one, then the two particles fuse with the apparatus to form a WHOLE with a combined wave function $\Psi(r_1, r_2, r_y, t)$, no matter HOW FAR particle two is from the APPARATUS.

**QUANTUM NON-LOCALITY.**

This offers an EXPLANATION of the Einstein-Podolsky-Rosen experiment.

"From our point of view we now see that the wording of the above mentioned criterion of physical reality proposed by Einstein, Podolsky and Rosen contains an ambiguity as regards the meaning of the expression "without in any way disturbing a system." Of course there is no question of a mechanical disturbance of the system under investigation during the last critical stage of the measuring procedure. But even at this stage there is essentially the question of an influence on the very conditions which define the possible types of predictions regarding the future behaviour of the system."


**QUANTUM INDEPENDENCE.**

How do we get independence?

Wave function written as a simple product:-

$$\Psi_1(r_1, t) \Psi_2(r_2, t) \Rightarrow Q_1(r_1, t) Q_2(r_2, t)$$
POST-MECHANISTIC ORGANIC VIEW.

"The concrete enduring entities are organisms, so that the plan of the whole influences the very characters of the various subordinate organisms which enter into it."

"The molecules may blindly run in accordance with general laws, but the molecules differ in their intrinsic characters according to the general organic plans of the situation in which they find themselves."


Group A \[\Psi_1(r_1,\ldots, r_N, t)\] has \[Q_1(r_1,\ldots, r_N, t)\]

Group B \[\Psi_2(r'_1,\ldots, r'_M, t)\] has \[Q_2(r'_1,\ldots, r'_M, t)\]

These groups do NOT see each others QPs

Quantum potential INFORMATION is PRIVATE.

NOT ONLY NON-LOCALITY

BUT NON-BOOLEAN aspect.

CANNOT be simulated by CLASSICAL PHYSICS.
QUANTUM FIELD THEORY.

\[ r \leftrightarrow \phi(r,t) \quad p \leftrightarrow \pi(r,t) \]

\[ \psi(r,t) \leftrightarrow \Psi(\phi(r,t)) \]

\[ \frac{\partial S}{\partial t} + \frac{(\nabla S)^2}{2m} + V + Q = 0 \leftrightarrow \frac{\partial S'}{\partial t} + \frac{1}{2} \int \left[ (\frac{\delta S'}{\delta \phi})^2 + (\nabla \phi)^2 \right] d^3r + Q = 0 \]

\[ Q = - \frac{1}{2m} \frac{\nabla^2 R}{R} \leftrightarrow Q = - \frac{1}{2} \int \frac{\delta^2 R}{(\delta \phi)^2} / R \ d^3r \]

Fields ORGANISED by SUPER-QUANTUM POTENTIAL

Particles ORGANISED by QUANTUM POTENTIAL.

\[ \Rightarrow \]

Particles are CREATED, SUSTAINED and ANNIHILATED

INFORMATION gives rise to QUASI-STABLE, SEMI-AUTONOMOUS FORMS.
IMPLICATIONS FOR MIND.

THOUGHT.

About ORGANISATION of FORMS and STRUCTURE NOT SUBSTANCE.

For this we need INFORMATION

(i) ACTIVE INFORMATION: To develop new meaningful structures.

(ii) PASSIVE INFORMATION: Information we are aware of but judge to be irrelevant.

(iii) INACTIVE INFORMATION: Information we have forgotten, unaware of etc.

"Mind may be regarded as a field in the accepted physical sense of the term."

[Margenau, The Miracle of Existence, p. 97]

"Mind may be regarded as a non-material field carrying little energy that can change the probability of synaptic vesicular emission".


Does the approach through the QUANTUM POTENTIAL provide a way to examine the relation between Mind and Matter?
WHERE DO WE LOOK FOR CONNECTIONS WITH MIND?

(a) General structure of thought? Mind & Matter different aspects of same process?

(b) Direct application to physical processes in the brain?

At what level could the quantum features appear?

(1) Molecular level.
    Synaptic changes. Eccles & Beck.

(2) Neuron level.
    Microtubules. Penrose & Hameroff.

(3) Many neuron level. Collective modes.
    Dendritic fields. Pribram & Yasue.
    Corticons. Umezawa.
    [Analogy to phonons, magnons, etc.]

    Phase coherence in DENDRITIC fields?
    Holography. Schempp.

The quantum field (super quantum potential) organises different groups of neurons to behave in a co-ordinated way.