

**PHYSICS AND THE STUDY OF CONSCIOUSNESS:
DOES TRANSCENDENTAL MEDITATION INDUCE
A MACROSCOPIC QUANTUM STATE
IN THE NERVOUS SYSTEM?**

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For almost fifty years physicists have been aware that quantum mechanics, in its measurement theory aspect, gives a unique place to human consciousness. E.P. Wigner in his famous analysis (1) of this relationship, called for a search for new experimental means to scientifically investigate consciousness directly, if this aspect of physical science is to make satisfying progress.

A physicist intending to study consciousness might, after his habit, wish to find a state of human conscious awareness which is as simple, isolated, and elementary as possible — free of the complexity and activity of our ordinary mental states. Does such a state of 'pure consciousness' exist, and if so, is it available for study?

The technique of Transcendental Meditation as taught by Maharishi Mahesh Yogi (2) has been systematically and uniformly learned by over 300,000 people in the past five years. The technique consists of a definite, easily learned procedure in which the meditator is given a 'mantra' or special sound and then specific instructions how to use it properly. The result is a consistent and repeatable state of mind which precisely satisfies the description 'pure consciousness'. Offered simply as a new educational technology, Transcendental Meditation has attracted a great deal of scientific attention (3). Upon examining the results of these studies in physiology, neurology and psychology, the physicist finds a pattern of behaviour so strikingly simple and profound that the phenomenon seems in some ways more akin to the usual subjects of the physical than the biological sciences. Moreover, certain features of Transcendental Meditation seem directly suggestive of macroscopic coherent quantum phenomena.

Transcendental Meditation induces a consistent pattern of physiological changes, all in the direction of extraordinarily deep physical rest but with mental wakefulness fully retained. Wallace, Benson and Wilson (4) found that metabolic rate decreased by 20% during a few minutes practice, more than during eight hours of deep sleep. Banquet found in EEG studies (5) that this deep metabolic quiescence was accompanied by a unique formal coherence in the brain waves. The frequency spectrum of EEG developed persistent narrow peaks in the theta (6 Hz.) and beta (20-40 Hz.) regions, along with phase coherence between the back and front of the brain, and between the left and right cerebral hemisphere. According to Glueck (6) this degree of temporal and spatial wave coherence is unique in EEG studies. The implication is of a total synchronous brain state implying long range order among vast arrays of neurons.

Together with these objective findings, subjective mental experience reported during TM (7) is extremely interesting. Meditators report that the use of the mantra spontaneously leads to experience of 'finer, more undeveloped' stages of thought and then, at certain intervals during the 20-minute meditation, the 'finest stage of thought is transcended' and there is a sudden transition to a state described as 'pure consciousness without thought, infinitely expanded in space and time, unbounded, eternal, perfectly silent, freely flowing'.

This dramatic experience of pure consciousness with its physiological correlate of extreme rest and neurological coherence may be described by constructing a psychological analogy to the third law of thermodynamics (lower temperature implies lower entropy, zero temperature brings zero entropy). Defining a 'mental temperature' as the level of thought activity, TM systematically de-excites the physiology and nervous system (while maintaining conscious awareness), and along with this brings increased mental and physical coherence. Then, in certain intervals, the 'mental temperature' is low enough to cause a sudden phase transition to a new state of very much lower entropy. Because biological systems are characterized by order in motion rather than order in space, we take the transition of 'pure expanded consciousness' to be analogous not to a crystalline phase, but to a superfluid, arising from wave coherence.

This state of pure consciousness, expanded, without thought, with minimum physiological activity, is clearly an excellent candidate for the simple 'hydrogen atom' of conscious awareness required by the physical scientist. Furthermore, we might find — if helium atoms could talk — that an entirely similar subjective description in terms of separateness, infinite expansion, timelessness and perfect order might apply to a transition to the macroscopic quantum ground state in superfluidity.

It is interesting to speculate whether this analogy can be taken seriously, opening the possibility that conscious awareness is in general a quantum wave function phenomenon and that the state of pure consciousness actually represents the macroscopic quantum ground state of the total electrophysiological system which gives rise to conscious awareness. A phase transition bringing a sudden expansion of the wave function through correlation among many neurons could then account for the subjective experience of 'unbounded pure consciousness'.

To construct a more concrete model for this speculation it is necessary to recognize that the orderliness maintained in living systems is not well described by the third law and superfluidity, but rather by the non-equilibrium statistical mechanics developed by Prigogine (8) to analyze stable coherent states of open systems maintained far from equilibrium. In this context Prigogine has pointed out (9) the analogy between a living system and a laser.

The laser is perhaps the most appropriate physical analogy to TM, and in these terms pure consciousness is seen as a simplified, amplified and purified version of the basic physical process which characterizes life generally — an appropriate description from the point of view of Maharishi also (7). Further, the actual technique of Transcendental Meditation involving the use of an individually assigned sound to systematically de-excite and order the nervous system

is remarkably reminiscent of the quantum process of stimulated emission which induces macroscopic coherence in laser light.

The suggestion that macroscopic quantum (superfluid) states may be relevant to biology was first made by F. London (10) with respect to the macromolecules of biochemistry. Following this idea, we might ask whether superconductivity within some macromolecular constituent of nerve cells could become continuous from cell to cell. Dimensional arguments suggest that superconducting currents extending for about 1 cm. would be associated with electromagnetic frequencies in the EEG range (10 Hz.).

A more recent biological proposal for a possible macroscopic quantum mechanism on the cellular level was suggested by H. Frohlich (11), who examined the possibility of single mode excitations of longitudinal electrical fields in cell membranes, falling in the microwave frequencies.

Nerve cells are not directly connected, but normally interact by the diffusion of chemicals across synaptic gaps of about 200 Å width. If some form of superfluid state occurred either at the level of the macromolecule or at the cellular membrane, it is possible that intercellular coherence would take the form of quantum tunneling across the synapse in place of molecular diffusion. It is interesting that induced tunneling across an insulating gap — the AC Josephson effect (12) — is the precise macroscopic analogue of stimulated emission in the case of atoms, which we related earlier to the use of the mantra in TM. The occurrence of Josephson junctions among neurons would imply the possibility of extremely sensitive biological magnetometers. Recently R. Adey (13) and others have observed sensitivity to fluctuating magnetic fields as small as 10^{-5} Gauss in human and animal nervous systems.

Further experimental work to examine the hypothesis of a zero entropy expanded ground state underlying pure consciousness should focus on the brief subperiods of 'transcendence' within meditation periods, when we would expect EEG signals of extreme spectral purity to appear. Intercellular electrical correlations should be measured directly if possible. D. Cohen's technique (14) of measuring the magnetic field of brain (with a Josephson effect magnetometer) might show especially simple fields during TM if a coherent state is present.

Whether these detailed speculations on the ground state of the mind bear fruit or not, it remains clear that TM is an important scientific discovery which provides science for the first time with a systematic means to investigate directly the nature of consciousness in a simplified form. In view of the structure of quantum mechanics, this promises significant contributions to fundamental physical theory.

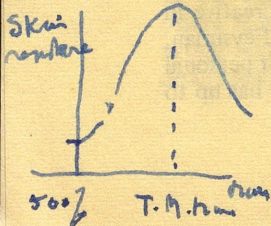
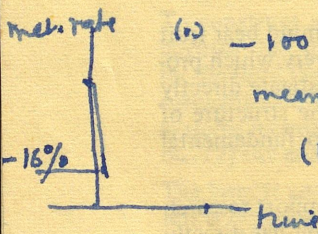
Finally, there is an entirely different aspect of TM which can support research in physics — the subjective effect which the practice of meditation has directly on the physicist's own mind and on his ability to be successfully creative in understanding nature. The greatest physicists, such as Einstein or Feynman, display as their chief characteristic a profound inner intuition, a direct personal feeling of inner contact with the working of nature. This capability has up to

(2) Remarks about analogy re: conscious (3) Superconductivity & biological phenomena
 Ref to London - DNA & superconductivity - Lighter molecules having superconductivity
 at higher temperatures, more like biological molecules (DNA?) - Such a DPO job

now been regarded as an admirable but mysterious gift. If, however, we fully understand Maharishi's description of the mind (7), we realize that depth of intuition is to be equated with purity of consciousness - and that this can be systematically developed through TM. Heisenberg (15) wrote that the mathematical laws of quantum physics deal 'no longer with the particles themselves but with our knowledge of the particles' and to this we add Maharishi's aphorism that 'knowledge is structured in consciousness'.

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(1)
 (2) - 100 theoretical results of physical & psychological experiments
 measuring ^{bioactive} factors (re. anxiety) with twin of T.M. - Expts on
 (1930) Brain measurements re: intensity of brain activity - spectrum
 analysis of signals (amp vs ν) -
 Peak at 8 to 10 - δ waves etc -
 Coherence in high frequency region -
 spatial coherence in brain signals -
 $8-10 \text{ Hz}$ - As 3^{rd} law of Thermodynamics S decreases
 $S = 0$ at 0°K - mental temperature - fluid to superfluid
 Properties of He^4 (Boson) - δ Superconductivity - analogy
 with facets of T.M. & metaphysics - Analogue