Chapter 5

The Quantum-Brain

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Introduction

The decades following the flowering of quantum theory during the late 1920s have witnessed much speculation over the possibility of a linkage between the theory -not to say, the mystery- of quantum mechanics and the phenomena of consciousness. The appeal is manifold, but perhaps the major attraction is the way in which the 'alternation of generations' seemingly involved in the flow of consciousness appears to mirror that of the alternation between the 'resting' (actually diffusing) wave function and its sudden collapse into the 'concrete' reality of the particle. The conscious odyssey familiar to us all is chiefly one in which a fuzzy, diffused reticulum of concepts constituting 'memory' (or more broadly, 'dispositional' mind) ejects actual articulate instances, as dictated by internal initiatives and the external circumstances holding at the time. It is one of an alternation between generality and particularity, that between the 'synthetic invariant' of dispositional and the covariant envelope of instances which flow from it. So also, it might seem, of events disclosed by quantum physics, in which a very informationally-dense complex vector Hilbert space collapses instantaneously into the very 'real' entity of the particle.

A second characteristic of quantum theory seeming to echo the mental world is the uncertainty and unpredictability with which the wave function collapse is invested. Despite the fact that such uncertainty is rigidly constrained within characteristic stochastic envelopes, an intriguing possibility is raised, that under appropriate circumstances and conditions –perhaps dependent upon some threshold of complexity (some analogue of 'critical mass) being exceeded, a metamorphosis may occur in which mere unpredictability transmutes into the putative free will and directedness so seemingly characteristic of mind in action. As Eccles and Beck [ ] have pointed out, Maxwell's demon may become operative without violating the principle of conservation of energy because, unlike classical waves, those of Schrödinger's equation are devoid of energy. In a classical waveform, the square of its amplitude has the dimensions of energy, whereas an equivalent operation performed upon quantum waves yields not energy, but a probability density function.

Thirdly, the 'delocalisation' characteristic of the wave equation seems to offer itself as a tailor-made substratum for that everyday aspect of conscious experience which has come to be known as the 'binding' attribute. This is most directly experienced in simple visual perception. What one witnesses is not merely the details of the configuration, as directly offered by the sentences, but further, that these are grasped immediately and holistically, and not by some derivative process of scanning or program of intercomparisons of one part with another. These

latter may sometimes be required as an after thought should something in the scene be baffling or call for special treatment; to the contrary, the integral overview is thee at the start. As William James put it a century ago:

> "…...One of the obscurest (notions).is the assumption that our mental states are composite in structure, made up of smaller states conjoined. This hypothesis has outward advantages which make it almost irresistibly attractive to the intellect, and yet it is inwardly quite unintelligible."
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> "…...In other words, no possible number of entities -call them as you like, whether forces, material particles, or mental elements can sum themselves together. Each remains in the sum what it always was."
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> "……Take a sentence of a dozen words and take twelve men and tell to each one word. Then stand the men in a row, or jam them in a bunch and let each think of his word as intensely as he will. Nowhere will there be a consciousness of the whole sentence. Atoms of feeling cannot compose higher feelings any more than atoms of matter can compose physical things." William James.
>
> "…...Aggregations are wholes only when they behave as such in the presence of other things. A statue is an aggregate of particles of marble, but as such it has no unity. no summing up of parts can make an unity of a mass of discrete constituents unless this unity exist for some other subject, not for the mass itself." Royce, quoted by James.

The delocalisation of the wave-form of a particle extends over arbitrarily great distances, in which direct and instantaneous communication is maintained with all other particles which it has encountered (and become 'entangled' with) during its history. This kind of 'out-reach' has seemed to some physicists –such as Chris Nunn [ ] to offer an escape from the claustrophobia of a mind confined –in some sense- within the material cortex. In proportion as this line of thought may be maintained, something of the 'naïve realism' which commonsense so strongly insists is the way we access the outside world (or for that matter, our own bodies) might be allowed back in.

Almost all mind/brain 'modelling' currently under study takes it for granted that the Mind-Brain ensemble delivers its performance through the agency of the cortex acting as some kind of computer. Shifting the mind up into the wave function would seem to offer some hope of a substantial bonus here by raising the computational stakes in the game. In particular, the possibility is being pursued that the immediate quantum substrate may be involved with fine grain computations at the molecular level, and at 'clock speeds' a great deal faster than that of the laggard cortical network. May it not be, then, that such a 'computer-within-a-computer' thus envisaged would boost processing rates to the point where the astonishing performance of the mind/brain ensemble might come within its reach?

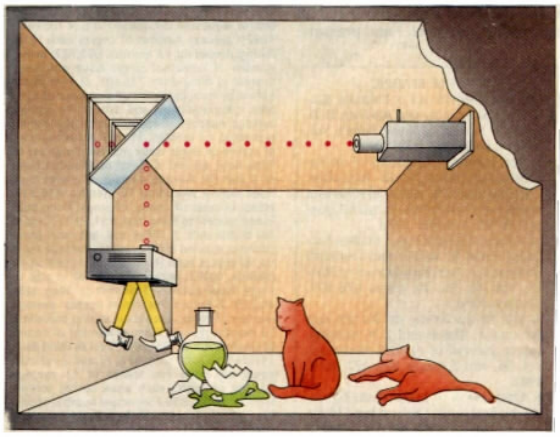
In summary, the wave function seems to offer itself as a more hospitable receptacle for mind than the lifeless particles of concrete reality –to the extent that such a world be allowed a continuing existence. as Globus puts it:

> ".....Quantum physical properties are so strange that it is no longer obvious that explaining consciousness in quantum Neuro physical terms is to indulge in a category error. Given two kinds of scientific framework, classical and quantum, consciousness might be categorically incompatible with the former. Quantum concepts bring revolutionary properties that might somehow undermine the charge of category mistake. "

What is somewhat surprising about this avenue of approach is how widespread has been its appeal to professionals of strikingly divergent philosophical persuasion and professional occupancy. Among its champions are to be found mathematicians, physicists, professional philosophers, biochemists, an anaesthesiologist, a supreme court justice and a Nobel laureate neurophysiologist. Although of particular appeal to secularists and physicalists, Eccles, for one, has sought to enlist its resources in the service of neoCartesian dualism, while Penrose's scheme seeks to draw a nourishing coherence of a unique kind from the Transcendental Realm via a 'Platonic pipeline'.

The history of the relationship between quantum physics and mind has been one of a fascinating pas de deux between physicists seeking to resolve stubborn paradoxes within their own discipline, and psychologists and neuroscientists in search of a hospitable substratum for mind and consciousness. Curiously enough, the journey started at the physics pole of the dichotomy, and this very soon after quantum physics had been proved to be stunningly successful in bringing coherence to many fields of the discipline and in making 'risky' predictions which were born out at the laboratory bench, it stood completely mute over the matter of 'collapse'. Far from failing to provide any mechanism for this event; it gave no hint as to why it should happen at all. Yet such collapses were occurring all the time, and none of these were closer at hand, to the physicist, than those precipitated by him in the operation of equipment measuring quantum phenomena. This was to lead to the 'observership' theory of wave function collapses. It was postulated that the act of observation itself caused the collapses, and in its absence, wave functions would grow and diffuse into each other without end. This mechanism –in which the wave forms of the observer's questing mind, and that of the measuring device –perhaps the pointer on an ammeter- was originally conceived by Niels Bohr at Copenhagen. Schrödinger was sceptical of the whole idea, dramatizing his displeasure in his famous live/dead 'cat' Gedanken experiment.

This really takes the logical form of a reductio ad absurdum. In the absence of collapse events, the individual wave functions of all of the particles of which the cat's body were composed would diffuse into each other, eventually forming a cat-wide condensed system. Suppose, now, that the cat were placed within a hermetically sealed box harbouring a mechanism of execution -see figure 5.1



Schrödinger's Cat
Figure 5.1

If during the period of isolation covered by the experiment, a spontaneous decay were to occur within the radioactive source, then a deadly gas would be released, killing the cat. If not, then the cat would be found to be alive when the box was opened. (It must be presumed that the probability of a single such decay fell within the time interval during which the cat was in isolation). If we were to take 'observership' seriously, then we would be required to conclude that the cat was neither alive nor dead, until the moment of encounter at the box opening; during this interval, he wouldn't be in some intermediate state of sickness because he would be a quantal wave, and not a real object. One might wish to go even further and assert it would not be a matter of either-or at all, but rather of both-and; this would seem to follow from the brute-force Hilbert space model in which complex vectors of all possible collapse outcomes are all 'up there' contending, as it were, for a passage into the denser ontology of concrete existence. A *superposition* is not at all the same thing as a *disjunction*.

This embarrassment was to lead to modifications in the theory, starting with von Neumann, and passing up through Wigner to the present day, when Henry Stapp has become its leading proponent. The notion of 'observership' has undergone generalization, to the point where the thermal intrusions of atoms and molecules are deemed to act as observer surrogates. So, even if there were no humans at all, or other organisms with equivalent perceptual capabilities, there would be no Schrödinger cats around. More important, within the context of the present discussion, is the way in which the evolving theory had elaborated into a coherent mind/brain theory –to challenge others being offered for consideration; quantum physics had entered into the mind-brain dialogue as a robust contender. This trend of events was to be given a substantial boost by Bell's theorem (1964), and more particularly by its startling experimental disproof which was to follow in 1969 and 1986. Bell reinstated the possibility of the existence of 'hidden variables' (mistakenly demonstrated by von Neumann to be a logical impossibility) which might get around the embarrassing prediction that if true as it stood, wave mechanics implied that action-at-a-distance between arbitrarily widely separated waveforms would occur if the particles had been involved in a previous mutual encounter. Bell pointed out that the matter was open to experimental verification, and

predicted that when the necessary experiments had been conceived and carried out, no action-at-a-distance would be discovered. Much was his surprise, therefore, when Clauser and associates, in 1969, and Aspect and Granger, in 1986, disproved his theorem by detecting such 'magical' interconnections. This clear instatement of non-locality as a *fact* –indeed, as such, it was independent of *any* theoretical presuppositions whatsoever- a great boost to quantum mind/brain theories, given the overriding holism so characteristic of the conscious moment –particularly those of 'distributed' percepts as those offered by vision. Beyond this, it was to encourage broader speculations leading to a resurgence of panpsychism

The forms which quantum theories of mind have taken are, unavoidably, very much a function of the wider philosophical presuppositions of their authors, as will become evident in the description which follow. They may be classified under the following four:

- O Extensions and elaborations of orthodox Quantum Mechanics
    1.'Collapse' theories –reaching their apotheosis in Henry Stapp
    2.'State' theories calling upon Bose-Einstein condensates

- O In a class by itself; the Penrose/Hameroff Collaboration.
- O The NeoCartesian Dualism of Beck & Eccles
- O Bohm's Neorealist Reformulation of Quantum Mechanics.

'Collapse' versions of Copenhagenism limit consciousness to the collapse instant itself; the 'flavour' of the underlying formalism is 'top-down' rather than 'bottom-up', as is the case with 'state' theories –which call upon Bose-Einstein condensations to provide the needed enduring platform.

Absolutely in a class by itself are the speculations entertained by Eccles and Hameroff. While their theory of consciousness and subjectivity is 'collapse' cantered, it also makes an essential call upon Bose-Einstein condensates to provide the needed substratum. To account for the collapse event –about which the Schrödinger equation is so silent- Penrose has evolved an extension to theoretical physics expressly in support of mind. His 'exact quantum gravity', though conceived in the service of mind, also contributes to theoretical physics in a more fundamental way in pointing towards a unification of relativity and quantum physics. Finally, Penrose's theory stands aloof, alike from theoretical physics and Mainstream mind/brain speculations, in its break-out from secularism. Penrose's concern, here, is that of providing for mind what is *in principle* beyond the reach of any computer –that of meeting the 'Gödelian challenge' of accounting for all mental phenomena calling upon true innovation of every kind.

Beck and Eccles bring quantum physics into their own neoCartesian dualism. Their calls upon wave functions are uniquely limited; they are required to do no more than establish a connection between the two domains of mind and brain –forever a sticking point of this paradigm from the days of its origin. They are not required to provide a substratum for mind –which, true to the Cartesian canon, is an entity unto itself. As an ironic aside, Eccles the theist and Penrose the atheist are alike in demanding a breakout from both secularism and positivism.

Bohm's initiative, unlike all of the others, entails a complete reformulation of quantum mechanics –something which can hardly be said of Penrose's 'collapse' accommodation. Though primarily conceived as a means of coping with the ailments besetting quantum orthodoxy, Bohm's vision is generous in the hospitality which it offers mind, ending up by . Bohm is unusual among physicists in his attempt to meet mind on something like its own terms, extending the mental modality into his own version of panpsychism. For reasons which are more emotional than logical, few among either neuroscientists or theoretical physicists have chosen to follow the Bohm initiative.

I found the notion sufficiently appealing to attempt to take a hand in the game, despite my limited grasp of the technicalities involved. My intention was simply that of exploring whether the idea might be portable into the very different metaphysical and ontological frameworks of my own system of philosophy. I finally abandoned the quest, partly because of the discouraging technical difficulties with which all those pursuing this line of enquiry have found themselves confronted. A much stronger reason has had to do with my conviction that wave functions, far

from embodying the true essence of cosmic existence, constitute a unique ontological stratum serving to bridge the gap between transcendence and a fully-manifest quotidian existence.

Copenhagen 'Observership'

I will start with its 'strong form' –that which it took at its initiation by Bohr in the late 1920s and early 1930s. Bohr needed mind to explain why wave functions should collapse at all; he wasn't primarily addressing the mind-brain problem. In Bohr's epistemology, the collapse event occurs by an observing mind reaching out to engage the measuring instrument –perhaps, for example to take a pointer reading. Bohr envisaged the bulk of the recording apparatus in quotidian, 19th century terms, while the information delivered to the meter awaiting observation was taken to have the form of a superposition of all meter readings made possible by the circumstances of the experimental set-up. The encounter with the observer's mind caused a collapse in which one of the superpositions became real; which one was dictated by a probability density envelope hidden within the waveform. Bohr clearly saw consciousness as being 'out there' at the meter's pointer; the brain did not appear to enter the conversation, or was simply left in the background.

Von Neumann was to take issue, both with Bohr's complementariansm (the effective co-presence of classical and quantal configurations within the experimental equipment) and also with cavalier disregard of mind qua mind. Von Neumann insisted upon quantum physics 'all the way' –from the brain of the observer, and across the gap to the measuring apparatus, perhaps like a tumbling line of dominos. In so doing, von Neumann seemed to have reinstated a latter-day 'naïve realism (already implicit in Bohr). Von Neumann insisted, to the contrary, that there was one world 'out there', not two; and the world was about waveforms. Bohr, it would seem, had executed something of a sleight of hand

> "….Heisenberg's transition from 'the possible' to 'the actual' at the dumb measuring device was shown to be a superfluous and needless complication by von Neumann's analysis……[he] introduced the measuring instruments and the body/brains of the community of human observers into the quantum state, which is quantum theory's only representation of 'physical reality'. He then showed that if an observer experiences the fact, for example, 'the pointer on a measuring device has swung to the right', then this increment in the observer's knowledge can be associated exclusively with a reduction (i.e., sudden change) of the state of the brain of the observer to the part of that brain state that is compatible with this new knowledge." p 149

By the time we get to Stapp –today's major advocate of the von Neumann/Wigner paradigm, mind has come to take stage centre both within the brain, and in shallower forms within the living realm –and beyond.

> "…..I follow, therefore, the von Neumann/Wigner formulation, in which the entire physical world is represented by a quantum mechanical state, and each thinking human being is recognised as an aspect of the total reality; each thinking human being is a body/brain/mind system, consisting of a sequence of cosmic events, called knowings, bound together by the physical structure that is his body/brain."

This makes it clear that Stapp stands firmly behind the von Neumann doctrine of 1932, though he appears to have erased the blemish of naïve realism epistemology in the von Neumann viewpoint. Given that Copenhagenism offers us a world view which is essentially of waveform constitution, *information* rather than substance is what cosmic existence is all about, both mentally and physically. This being the case, is becomes abundantly clear that waveforms are much better impedance-matched to mental processes than is a material substratum:

> "……My purpose, in what follows, is to reconcile the insight of the founders of quantum theory, namely that the mathematical formalism of quantum theory is about our knowledge, with the demand of Einstein that basic physical theory be about nature herself. I shall achieve this reconciliation by incorporating human beings, including both their body/brains and their conscious experiences, into the quantum mechanical description of nature

> The underlying commitment here is to the basic quantum principle that information is the currency of reality, not matter: the universe is an informational structure, not a substantive one. His fact is becoming ever more clear in the empirical studies of the validity of the concepts of quantum theory in the context of complex experiments with simple combinations of correlated quantum systems, and in the related development of quantum information processing. Information-based language works beautifully, but substance-based language works not at all." p149

On the surface, matter, particularly in its more classical forms, is so inhospitable to the entrance in mind, that it is hardly surprising that physicists of a former generation saw the problem of accommodating mind, to be more that of explaining it *away,* of "how to discredit our misleading intuition by identifying it as a product of human confusion, rather than recognizing the physical effects of consciousness as a physical problem that needs to be answered in dynamic terms" [p144]. It is a bit hard to see how thought on the subject could have evolved in any other way, given the overshadowing of the classical physical world-view by the concept of locality; there was a place for everything, and everything should be in its place:

> "……This *local* character of laws is crucial. It means that each tiny localized part responds only to the states of its immediate neightbors. Each local part 'feels' or 'knows about' outside its immediate microscopic neighborhood. Thus the evolution of the physical universe, and of every system within the physical universe, is governed by a vast collection of local processes, each of which is 'myopic' in the sense that it 'sees' only its immediate neighbours." [p144]p:

It must be conceded that little could be more incompatible with the directly intuited and perceived nature of consciousness than pan-localization. Such is the lingering repugnance of mind's presence that in the post-classical, quantum age, the preferred approach has remained one of dismissal, or of minimization:

> "……Most efforts to improve upon the original Copenhagen quantum theory are based upon the von Neumann formulation. This includes the present work. However, almost every other effort to modify the Copenhagen formulation aims to improve it by *removing* the consciousness of the observer from quantum theory: they seek to bring quantum theory in line with the basic philosophy of the superseded classical theory , in which consciousness is imagined to be a disconnected passive witness…….I see no rationale for this retrograde move." p152

Stapp's approach if nothing else, is a resoundingly *top down* one. The following quotation, in emphasizing this, does double duty in contrasting 'collapse' with 'state' theories of waveform mind –those grounded upon Bose-Einstein condensations.

> "……The situation, therefore, is this: elementary considerations show that the Heisenberg uncertainty principle *forces* the wave packet that represents body-brain to evolve, in the absence of any reduction, into a shower of possibilities that includes *all* of the of the different macroscopic behaviours that are at all likely to occur in the physical situation at hand. The dispersing of the wave packet in this way is in no way disrupted by thermal noise: it occurs quite independently of the thermal noise and of all other classical uncertainties. Nor is it dependent upon any long-range quantum coherence in the brain. In any individual situation it is therefore the reduction of a wave packet that controls which of the macroscopic behaviours will manifest……I consider, in principle, the wave function of the entire body-brain and its relevant environment (really the whole universe) and never appeal to 1999 p62

Clearly, an early requirement is that of deciding just how the three strata of the quantum world sort themselves out, as the odyssey of consciousness proceeds. This, of course, is not given, a priori, and is at present unknown:

> "……the central issue, in the present context is precisely the character of the brain states that are associated with conscious experiences. It is not known, a priori, whether or how a self-observing

quantum system separates into these various parts. It is not clear, a priori, that a self-observing brain can be separated into components analogous to observer, observee, and environment." P150

Stapp makes it clear that he has emancipated himself from the 'naïve realism' epistemology underlying early Copenhagenism. Both the person and the field of observation have a direct association with the underlying activity of the 'enchanted loom' below. Each instant of experience will actualise a brain state from a constrained envelope of possibilities. The neural pattern which picks up afterwards will closely resemble that which existed previously. Consequently, Stapp envisions a two-way connection to corresponding bodies of scientific knowledge which have been accumulated:

"……In this theory, each conscious event has as its physical image not a reduction of a state of some small physical system that is external to the body-brain of the person to whom the experience belongs, as specified by the Copenhagen approach. Rather, the reduction is in that part of the state of the universe that constitutes the state of the body-brain of the person to whom the experience belongs: the reduction actualises the pattern of activity that is sometimes called the 'neural correlate' of the conscious experience. The theory thus ties in a practical way into the vast field of mind-brain research: i.e., into studies of the correlations between, on the one hand, brain activities of the subject, as measured by instrumental probes and described in physical terms, and, on the other hand, the subjective experiences, as reported by the subject, and described in the language of 'folk psychology' (i.e., in terms of feelings, beliefs, desires, perceptions, and the other psychological features.) p153

So here, in outline, is how the odyssey of experience in terms of incrementations of knowledge proceeds:

"……The basic idea, the basic rules of Copenhagen quantum theory are strictly maintained; the quantum state continues to represent knowledge, and each experiential increment , or knowing, is accompanied by a reduction of the quantum state to a form compatible with that increase in knowledge. P 152 ,

This is consistent with the flow of experience, as naively given, in which the subliminal apprehension of dispositional mind –roughly 'memory'- acquires an incremental augmentation at each passing moment.

When it comes to interpreting the stream of conscious experience in wave function terms, Stapp urges that we be on our guard against acceptance of a commonly held, destructive presupposition:

"……A superficial understanding of quantum theory might easily lead one to conclude that the entire dynamics is controlled by just the combination of the local, deterministic Schrödinger equation and elements of quantum randomness. If that were true then our conscious experiences would again become epiphenominal side-shows." P153

To the contrary, Stapp emphasises that this omits a vital added component. When this is added in, the three process, listed under eponymous headings, are:

- A local, microscopic *Schrödinger* deterministic process –that of the diffusing of the wave function in the 'resting' period between successive reduction.

- An open, *Heisenberg* elective choice, to be regarded as the mundane equivalent of the scientist's decision concerning which aspect of the situation at hand shall be interrogated.

- A brain-wide *Dirac* Stochastic collapse event, governed by the probability density function holding at the time. which renders as nature's answer (within the mind-brain vicarious representation of the world) to the question posed.

This Heisenberg choice "……is not fixed by the Schrödinger equation, or by the Dirac choice, so it is most naturally fixed by the experiential part of the system, which seems to pertain to macroscopic aspects of brain activity taken as units". Again, "….the observer, in quantum theory, does more than just read the recordings; he also chooses which question shall be put to nature."

The odyssey of the flow of mental events –the stream of consciousness- may be viewed in terms of a cyclic succession:

> "……Each experience is asserted to have an intentional aspect, which is its experiential goal or aim, and an attentional aspect which is an experiential focussing on an updating of the current status of the person's idea of his body, mind and environment.
>
> When an action is initiated by some thought, part of the instruction is to monitor, by attention, the ensuing action, in order to check it against the intended action.
>
> In order for the appropriate experiential check to occur, *the appropriate question must be asked*. The intended action is formulated in experiential terms, and the appropriate monitoring question is whether this intended experience matches the subsequently occurring experience. *This connection has the form of the transference of an experience defined by the intentional aspect of an earlier experience into the experiential question attended to –i.e., posed- by a later experience*." P 157

Stapp reports that he had here drawn some inspiration from the great American psychologist William James, who nearly a century ago, made this same point:

> "……a discrete composition is what actually obtains in our perceptual experience. We either perceive nothing, or something that is there in sensible amount. This fact is what is in psychology is known as the law of the 'threshold'. Either your experience is of no content, of no change, or it is of a perceptual amount of content or change. Your acquaintance with reality grows literally by buds or drops of perception. Intellectually, and on reflection you can divide these into components, but as immediately given they come totally or not at all." P 155

He makes it clear that within the limits of the situation, a genuine, free choice is exercised, although not so clear is whether this is seen as taking the stronger form of a voluntaristic 'free will'. He appeals to the 'Zeno effect' as a way in which a true efficacy of mind may be maintained. Regardless, to be efficacious in a way which can be given a quantum physical interpretation. Here he looks to the theoretical prediction and empirical demonstration of a 'Zeno' effect.

> "……The question then arises as to whether just the choices about which questions are asked, with no control over which answers are returned, can influence the dynamical evolution of the system.
>
> The answer is 'Yes': the evolution of a quantum state can be greatly influenced by the choices and timings of the questions put to nature.
>
> The most striking example of this is the Quantum Zeno Effect….In quantum theory, if one poses repeatedly, in very rapid succession, the same Yes-or-No question, and the answer to the first of these posings is Yes, then, in the limit of very rapid-fire posings, the evolution will be confined to the subspace in which the answer is Yes: the effective Hamiltonian will change from H to PHP, where P is the projection operator onto the Yes states. This means that evolution of the system is effectively 'boxed in' in the subspace where the answer continues to be Yes, if the question is posed sufficiently rapidly, even if it would otherwise run away from that region." P 159

He envisages a mind-brain model in which cortical events are modulated by the passage (or blockage) of calcium ions leaving the presynaptic membrane and the quantum fuzziness of their encounter with the post-synaptic vesicles (controlling the response of the downstream neurone). Calcium ions of roughly 0.2 nanometre diameter have a positional uncertainty of the same magnitude as they work through a channel of 1 nanometre diameter; those which emerge must make the 50 nanometre trip across the synaptic gap to reach the targets on the far side. Clearly, if we think in terms of simple yes-no alternatives at each channel or calcium ion then a huge combinatorial number of possible distinct stages of the cortex may be run up.

> "……The magnitude of the effect of the spreading of the wave function of the post-synaptic calcium ions is enormous; it will cause the wave function of the person's body, in its environment, to disperse, if no reduction of the wave function occurs, into a profusion of branches that represent all of the actions that the person is at all likely to take in the circumstances at hand." JCS 6 #1, 1999 p 63

The scale of the relevant pre- and post-synaptic structural configurations, and the width of the intra-synaptic cleft are such as to create a large element of uncertainty at each of the target sites, controlling whether or not a neural actually occurs. We are dealing here, therefore, with a huge population of the form 2^N of combination of synaptic firings, each of which might, or might not occur.

Globus [1998] Presents his own update of the Copenhagen viewpoint, combines hard physics with an attractive poetic wonderment about what is going on.

> "......In a post-modern alternative to brain information processing, the brain supports a spontaneous eruption.....the emphasis....is on spontaneity, original plenitude, ungroundedness, openness, and dynamical interaction -anything but like the serial, logical, externally programmed necessity of computing machinery which has an internal emptiness only overcome when information is put-in. Recursively organised, autopoietic autorhoetic, optimising, dynamical systems continually spring forth and input constrains their evolution" Self, Cognition, Qualia and World in Quantum Brain Dynamics.

This paragraph is resonant with 'Gödelian' overtones, and as such is strongly reminiscent of Penrose's 'Platonic pipeline' –to be examined further below. It is not clear -from his account – within the compass of the referenced article- whether his larger ontology is constrained to secularism or points to a Transcendence –a Source- lying beyond. At any rate, no explicit acknowledgement is made.

He contemplates a rather ingenious dodge whereby actual instantiations may be provoked from the world-view seeming ensconced within the protein substrate of the wave functions:

> " The imaginary numbers must be made to go away and get replaced by real variables which are associated with obsevables. Of course there is a way to get real numbers from the multiplication of complex numbers: multiply a complex number...by its conjugate...and all the imaginary terms drop out, leaving a real term. Thus, in the famous Born postulate, the complex-valued Schrödinger wave function is arbitrarily multiplied by its complex conjugate and the real number is interpreted as a probability."

He then goes on to propose a non-arbitrary collapse mechanism:

> "....Suppose physical reality is a complex reality and mental reality (cognition and memory) is conjugate to it. The ontology of both physical and mental realities has an imaginary dimension and so neither is observable. But when cognition and memory support a conjugate match in the interaction with physical reality, observables appear. Perception is where quantum cognition, quantum memory and quantum reality meet and make a conjugate match"

Globus is one of the very few people around who has truly transcended the 'naive realism' fallacy. However, as he points out at some length, the relocation of mind within the wave function carries the internal reconstruction of the 'outside world' -which we take, in naive realism, to be that world itself- to a higher level of remoteness.

> ".....The result is queer -is a little horrific, really!- because it makes of each person a non-locally controlled monad living in the illusion of a world-in-common, Maya. Though we always find ourselves already thrown in the seemingly common world, we actually have an isolated monadic existence. The quotidian world-in-common must be given up....This 'monad' is functionally windowless- there is nothing outside to see.....
>
> If not a picture window, there is an abstract opening that keeps the monad from hermetic isolation.....The monad is a lighted place or clearing (lichtung) in the midst of quantum no-thingness; Monads clear worlds in parallel in the conjugate match of interacting quantum fields...The idea that the quotidian world-in-common is an illusion, and replacing it by the idea of parallel worlds kept more or less coherent by social consensus on cognition is so implausible that we best pause and consider standard theories of the quotidian world which might save its homey, shared, common qualities"

How well does reconstituted 'Copenhagenism' –as outlined in the above accounts- stand up, in practice? There are, I believe, substantial formal difficulties –as Mutnick suggests [2000] suggests. In particular, there seems to be a most delicate 'gestalt' matter of just how figure-ground differentiations are to be made. Within the overall wave-function hierarchy, how are the necessary distinctions drawn between observer, observee and the peripheral world beyond? Where Stapp's account is concerned, I sometimes get the impression that I am being drawn into a game of '3 card Monte' in which he himself is caught up in the delusion. However, this aside may be completely unjust; taken as a whole, his overview does seem to 'hang together'.

As Stapp and Globus both concede, the Copenhagen view hovers on the brink of a Berkelean Absolute idealism; there is something disconcerting in the thoroughness with which the 'quotidian' aspect of physical reality seems to have vanished. In his review of Globus's "The Post-modern Brain", Jeremy Hayward feels that he has somehow missed his way regarding the existence of the shadowy world which must be the reference to which our internal reconstruction is pointing. Granted that it must be both ontologically sparse and metaphysically threadbare in comparison with our representation of it, yet it must have some minimal existence if communication between individual humans is to be possible; to believe otherwise would be to signal a retreat into solipsism. Accepting his vision that "*...An actual thrown-in-the-world existence is continually unfolded out of quantum field interactions*", this very process is duplicated in numerous other beings who seem to be aware of the presence of others, and to be able to communicate with them.

Stapp's concept of the flow of consciousness, as illustrated by his quotation of James's strikes me as simply too restrictive. Although long stretches of the mundane flow of consciousness may partake of this form, it somehow falls short of the mind's amazing ability to change direction at the drop of a hat –a situation in which the internal cohesion of dispositional mind seems to be deep and rich to the point of implying that *everything is connected to everything*.

One way and another, one has the feeling that in common with other theories, things are being s-t-r-e-t-c-h-e-d.

'State' Theories: Bose-Einstein Condensates

We are concerned here only with 'state' theories of quantum mind which are grounded upon mainstream interpretations of quantum theory, hence stemming ultimately from the Copenhagen canon. Bohm's theory of quantum mind is also seemingly in the 'state' category, but it is one grounded upon a completely novel reformulation of quantum physics. This will be explored separately further below. In passing, one might also mention that the neoCartesian theory of Beck and Eccles –also to be examined later - is very much a 'state' theory of mind, but in

their case, the only calls made upon quantum physics are those needed to provide a two-way interface between the two regimes.

What distinguishes those following this 'state' initiative is a stressing of a distinction between inorganic and organic configurations especially those taking the form of brains. As such, mind and life are granted entrance upon something like their own terms. Stapp –as the leading 'collapse' adversary also takes mind very seriously, as we have already seen, but the emphasis is quite different.

> "……Jibu and Yasue…draw a sharp distinction between the quantum physics of non-living and living matter. In the case of non-living matter, complex systems of atomic ingredients manifest completely disordered (also called uncorrelated, incoherent or thermalised) dynamics which is well described by long-established quantum statistical mechanics. The atomic ingredients of living matter, in contrast, can show strong mutual and long-range correlation (coherence, collective macroscopic order). Here quantum statistical mechanics is no longer approximate and quantum field theory must be utilized. Globus [ ]

Others have called for the need of such an organic/inorganic distinction, though not necessarily one appealing to wave functions to provide a direct substratum for subjectivity. Douglas Bilodeau [ ] for example, contrasts the distinction between a machine assembled from components, to serve the needs of its designer, with "a complex organ like the brain, whose structure has not been imposed but seems to arise as an expression of the potentialities of the organic molecules themselves. A machine is constrained by design to behave in accordance with rules imposed from without. The brain follows its own nature". Bilodeau makes it clear that he is after far bigger game; he speaks of our present understanding of nature as but the 'tip of the iceberg'.

All 'state' theories of Copenhagen origin known to me look to (hopefully brain-wide) Bose-Einstein condensates to provide the sought-after substratum.. Such fields, of course, have long since been observed within the inorganic realm, eg. the coherent light of lasers, the phenomena of superconductivity and the superfluidity of liquid helium. The trouble is that the first of these calls for high energy while the others emerge only at very low temperatures (the superfluidity of liquid helium is only to be found within a degree or two of absolute zero). Finding credible mechanisms which might function under biologically viable conditions has not been easy. Fröhlich has proposed one such which has been widely adopted:

> ".....The British physicist Herbert Fröhlich proposed that living systems might be capable of hosting a type of Bose-Einstein condensate based on ferro-electricity, a kind of persist electric polarisation analogous to the sort of permanent magnetism found in iron. Ferro-electric behaviour has never been directly observed in any biological system, but Fröhlich's hypothesis is indirectly supported by experiments in which weak electric fields cause a disproportionately large effect on living systems, such as actively dividing yeast cells.
>
> Marshall proposes that a Fröhlich-style ferroelectric system exists in the brain and, when electrically excited, gives rise to conscious experience. The most important consequence of such a mechanism is an explanation of our perceived unity of conscious experience. The Fröhlich mechanism, marshal claims, gives inner coherence both to our inner experience and to the otheries uncoordinated activities of the human nervous system, for the same reason that a laser produces light whose waves are coherent over a distance of many meters –both systems consist of particles that occupy the same quantum state.
>
> Marshall proposes that his hypothesis be tested by searching for the presence of ferroelectric behaviour in areas of the brain associated with consciousness. He also suggests that the consciousness-eliminating action of general anaesthetics may proceed by quenching the ferroelectric state through an alteration of elastic constants of neural membranes. The wide variety of substances, some of them –such as xenon- actually chemically inert, that act as anaesthetics does indeed suggest some physical rather than chemical mechanism of anaesthetic operation." p265-266 Herbert's Elemental Mind [ ].

I think that the following quotation of Nunn's captures the intuitive appeal of state theories of quantum mind:

> "……A Bose condensate is a thing, a unified object that exists for a definite duration. Each 'tapestry', therefore, will not only be a an information-containing experience but also a physical entity which will appear, exist for a while and then disappear. Time is needed for 'tapestries' to be generated and decay, and the rate at which they succeed one another will determine the rate of conscious information processing". Nunn [ ]

Various candidate substrates have been proposed, including synaptic vesicular grids, microtubules, neural membrane proteins, etc varying in the demands that they put upon the extent of condensation and delocalisation. and hence indirectly upon the degree of isolation needed to preserve the coherence in question.

The default favourite among those seeking to lodge mind within wave functions has been the microtubule model of Stuart Hameroff. It is ironic that Penrose, in his collaboration with Hameroff is advocating a 'collapse' rather than a state theory of quantum mind –that based upon his 'exact quantum gravity. I shall return to this later..

Worthy of special mention among the Bose-Einstein votaries are the speculations of Chris Nunn [ ]. He is hopeful that knot topology, including perhaps a configuration of Seifert surfaces will provide the kind of textured complexity which mind seems to call for. If I understand his position correctly, it is the neural entanglements within the cortex which are taken to provide the complex topological substratum which is drawn upon to form what he terms a 'quantum tapestry'.

> ".....Bose condensates would possess the attribute of reflectivity in a more profound sense than is possible in patterns of classical brain activity. It would reflect not only the classical brain activity supplying its energy, but also the features of the environment which that classical activity was modelling; it would be entangled with ordinary brain activity *and relevant parts of the environment*.....It's not unreasonable to suppose that this extra ingredient (of profound reflective entanglement at two levels of brain *and environment* might be sufficient to give substance to Hofstadter's and Edelman's basic notion about what generates sentience". [My emphasis]

Nunn envisages these nominally cortex-wide fields as possibly reaching beyond, to the immediate environment. In so doing –Nunn seems to be saying- something like an ESP coupling made be established between acts of perception and the objects which are grasped in the process. That is to say, a rationale is provided for a reinstalment of naïve realism as a legitimate epistemology of perception.

He takes consciousness to be efficacious as well as sentient:

> ".....The neural activity in brain maps will have some particular geometric structure , so any Bose condensates based on a proportion of that activity will share the structure, thus providing a possible basis for a language of consciousness. In this picture the direction of information flow is from classical neural activity to conscious experience, but reverse flow should also occur giving a means by which consciousness (as it is envisaged here) might be able to influence the information content of classical neuronal systems. This possibility arises because Bose condensates are unique lowest energy states of whatever system they involve. When they appear, therefore, a redistribution of energy occurs within the system".

> ".....a Bose-Einstein condensate is a thing, a unified object that exists for a definite duration. Each 'tapestry', therefore, will not only be an information-containing experience but also a physical entity which will appear, exist for a while and then disappear. Time is needed for 'tapestries' to be generated and to decay, and the rate at which they succeed one another will determine the rate of conscious information processing".

Since the above was written, an interesting account has truned up (–see Scientific American Nov 2002: "Rules of a Complex Quantum World" by Michael A. Nielsen) in which they speculate about the possibilities of a new mode of information processing based upon entangled quantum configurations. The Equivalent to the 'bit' of conventional logic (either a 0 or a 1) is the qubit where the possibility of superposition can make a qubit simultaneously both zero and one. There is also the possibilities of partial super-positions

The author is not seemingly 'into' quantum configurations as a substratum for mind, but he makes this interesting claim:

> "……The goal of quantum infotmation science is to understand the general high-level principles that govern complex quantum systems such as quantum computers. These principles relate to the laws of quantum mechanics in the way that heuristics for skilful play at chess relate to the game's basic rules.

What is interesting about the above is that this is stated as a fact, to a speculation. The seeminging implication is that heuristics as merely classical processes operation below the articuale surface of consciousness.

The doctrine of 'functionalism' widely held today, may be regarded as a surrealist surfacing of synechological pantheism. in which purposeful performance is taken to be inseparable from a conscious correlate - quite independently of the substrate.

> ".....It's hard to believe that the sentience which Chalmers and Seager must logically grant to a room thermostat both exists and is in principle a simple version of our own awareness" C.M.H.Nunn On the Geometry of Consciousness JCS 3 no 5-6 1996

He goes on to point out that thermostats can hardly enter into the kind of unity required to function as conscious entities because the noisy thermal environment within which they dwell would collapse any growing condensations long before they can make the 'measurement' needed to exercise their function.

Unfortunately, all such state theories have run into serious trouble. The condensate fields must somehow be maintained in the face of decohering forces –particularly those of thermal origin; the brain, after all, is both warm and very active, metabolically. To survive, the condensates must both be maintained by appropriate mechanisms – such as the Fröhlich process- and their substrata enjoy some form of protection of appropriate molecular constitution. Max Tegmark [Feb 2000 physical review] has subjected Hameroff's microtubule model to close scrutiny and found it to be lacking. His conclusion –that to work, the microtubules would need to be sustained at a temperature near to absolute zero. Hameroff has responded that that Tegmark was operating under a number of misconceptions about the tubule model. It is hard for the non-specialist to weigh the evidence here; one can but say that any Bose-Einstein theory calls for a great deal of stretching of assumptions if it is to deliver the goods, and Tegmark's analysis does suggest that things have been stretched to the breaking point. As critics have also pointed out; what is special about condensates within brains which makes them candidates for conscious emergence. Why not also –as Penrose has asked- superconducting systems?

Hameroff & Penrose

These authors have made what is perhaps the most celebrated entry into the quantum mind-brain sweepstakes. Their schema is dominated by these three suppositions and speculations:

A novel wave function collapse mechanism, conceived by Penrose and dubbed 'Correct Quantum Gravity'

- O A coupling of the wave function's interior to the eternal Platonic realm. This ethereal pipeline is viewed as an essential and continually active conveyor of trans-algorithmic coherence without which the mind would become no more than a shadow of its real self.

- That the ordered molecular sequences of tubulin molecules within the ubiquitous microtubules provide the backbone of the substratum for the evolving wave function condensates. This configuration also renders service as a 'tight loop', closely-coupled computer –a machine-within-the-machine.

> ".....Penrose's main contribution to the quantum mind/body question is his conjecture that gravity holds the key to the quantum measurement [i.e. 'collapse'] problem.....According to Penrose's conjecture, for systems larger than a certain critical mass, space-time curvature effects cause the system's wave function (the superposition of the system's possibilities).....to 'collapse under its own weight' into one real actuality". Nick Herbert Elemental mind.

This is strong medicine indeed; in the process of coming to terms with the Mind/brain relationship, Penrose aims to resolve two of the stubborn and persistent problems of modern physics, thus killing two (or more!) birds with a single stone. First, the mystery of the collapse wave function about which quantum mechanics itself is strangely silent. And second, the bridging of the disjunction between gravity & relativity and quantum physics, thus moving us one step forwards towards the long awaited but elusive 'theory of everything'.

> ".....There are strong arguments to suggest that the appropriate union of general relativity (Einstein's theory of gravity) with quantum mechanics -a union often referred to as quantum gravity- will lead to a significant change in *both* quantum theory and general relativity.....whereas..OR [Orchestrated Objective Reduction -Penrose's proposed collapse mechanism) is not a generally recognised part of the normal quantum mechanical procedures, there is no plausible or clear-cut alternative that standard quantum theory has to offer. The OR procedure avoids the need for multiple universes". Hameroff & Penrose

Both Hameroff and Penrose look to microtubules within the neurone to provide both the needed substratum for the emergence of wave function condensations and also a closely-coupled computing mechanism.

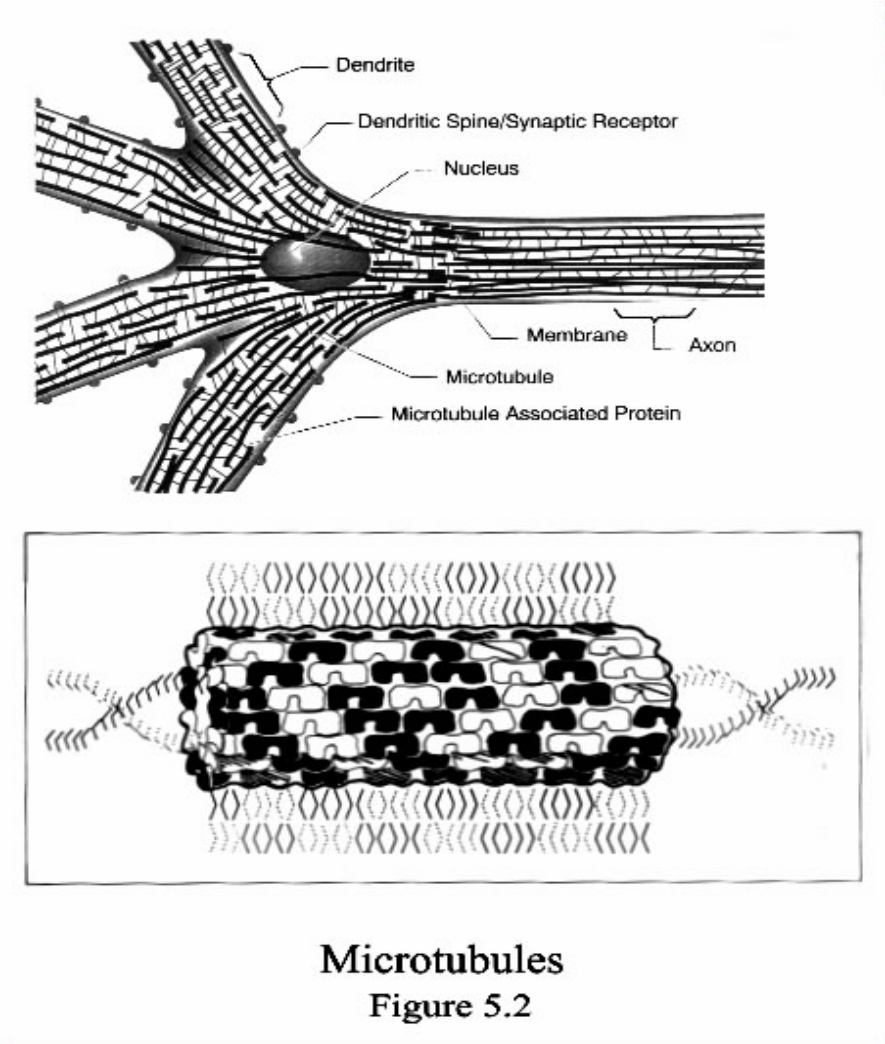
> ".....It is proposed, therefore, that microtubules' ubiquitous presence and crucial involvement in regulatory and cognitive functions in neurones and other eukaryotic cells can mediate quantum effects in a wide range of significant biological functions. In particular, quantum coherence (Fröhlich pumped phonons, Bose-Einstein condensations, ordering of water) in cytoskeletal microtubules and related structures can lead to quantum computing and emergence of macroscopic states suitable for a unitary sense of consciousness. Consciousness is described as an emergent macroscopic quantum state driven or selected by neurobiological mechanisms (neural networks, attentional circuits, coherent firing of distributed neurons) with origins in quantum coherence in cytoskeletal microtubules within the brain's neurons. Microtubule quantum coherence is thought to derive from two possibly inter-related mechanisms:
>
> - Bose-Einstein condensates stemming from a 'Fröhlich pumped phonon' mechanism of dipoles in hydrophobic pockets of microtubule subunits.
>
> - A quantum-dynamical system of water molecules and a quantised electromagnetic field confined inside the hollow microtubule core. The latter induces a specific collective dynamics called 'super-radiance' by which coherent photons are created and penetrate without dissipation in the microtubule core in a quantum effect called self-induced transparency." [p105-106 1994 JCS Vol1 #1 ?]

The authors conceive of the brain-as-computer on the following hierarchical terms. The kernel is provided by the microtubules themselves comprising some 10^7 tubulin dimers –see figure 5.2

The tubules, acting as waveguides are cross-connected by MAPs ((Microtubule Associated Proteins) which "act as 'nodes' which tune and orchestrate quantum oscillations..." -see figure 5.3

Figure 5.4 illustrates the microtubules in action as a 'cellular automaton'. Each cell has 8 neighbours, and at a given time, each can exist in one of n states (typically two) Each directly communicates only with its neighbours, and finally the entire device is driven in synchrony by a universal clock.

Neuronal synapses are taken to be the basic building blocks of a larger computer -Sherrington's 'enchanted loom'. In taking this latter step, the authors are but 'joining the crowd' -but with this signal difference; the cortical



Microtubules
Figure 5.2

network is to enjoy a continuous enrichment of Platonic supervenience filtering down from the cellular automaton which the microtubules jointly constitute:

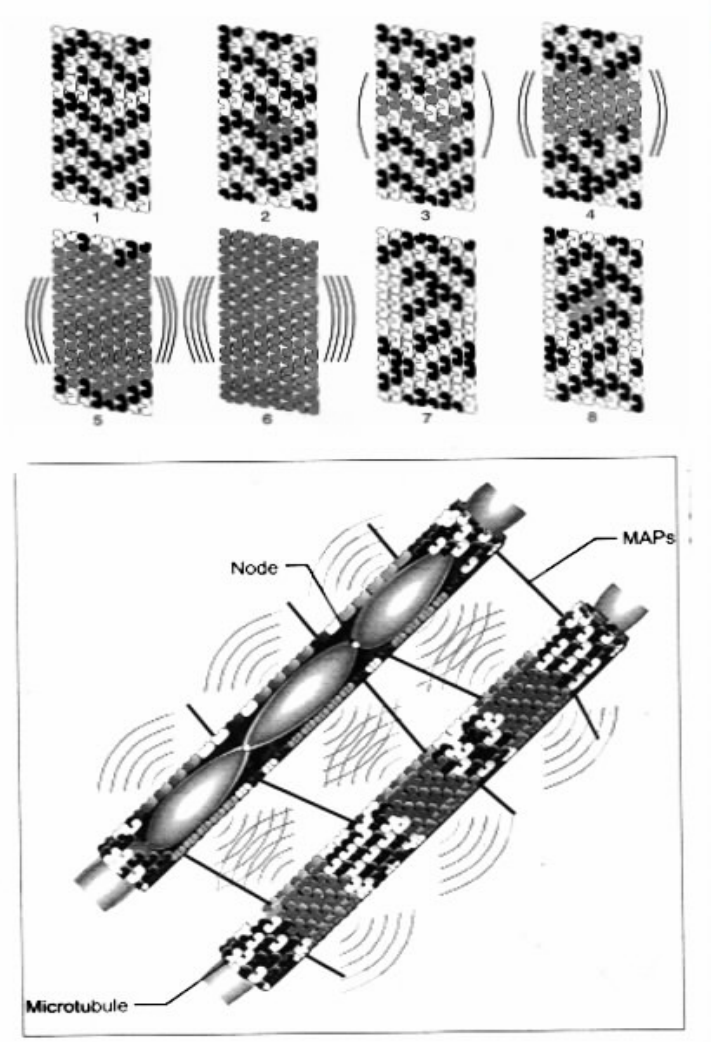
> ".....Thus we are accepting (provisionally, at least) that with fixed synaptic connections, the brain is indeed acting as some kind of computer -albeit a computer with built-in random ingredients. As we have seen.....it is exceedingly improbable that such a scheme could ever provide a model for human conscious understanding. On the other hand, if the specific synaptic connections that define the particular neural computer under consideration are subject to continual change, where the control of those changes is governed by some non-computational action, then it remains possible that such an extended model could indeed simulate the behaviour of a conscious brain." p372 SM

Finally, the properties of delocalisation and phase-entanglement of waveforms are taken to underwrite a brain-wide instantaneous unification of microtubule activities -thus complementing the leisurely conversation that the

neurones conduct with one another through their axonal currents. The 'critical mass' causing the wave function condensates to collapse is thought to involve something between a thousand and a million neurones, consequently the whole machine is a parallel one comprising perhaps a million neurone group.

Evidently, all in all, we are being presented by exotic processing machinery of intimidating and hard-to-circumscribe power; truly, the authors believe, the promise of a new day:

".....If conscious experience is intimately connected with the very physics underlying space-time



Microtubule Computer
Figure 5.3

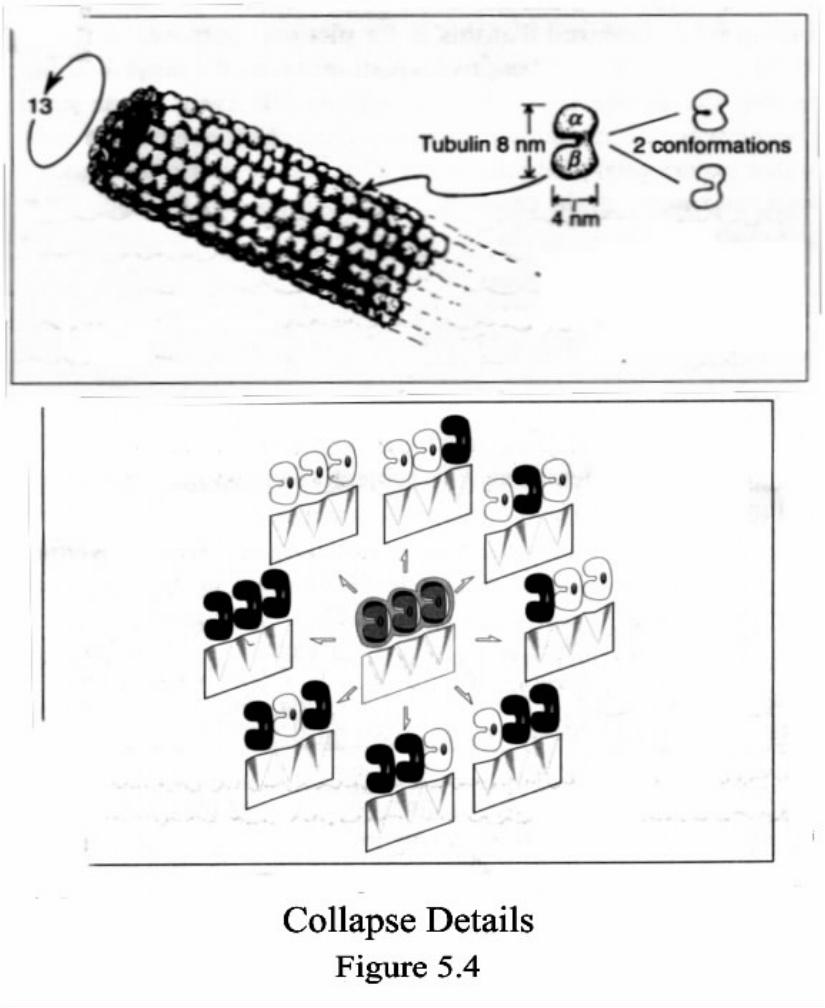
structure, then OR [Orchestrated Objective Reduction] in microtubules indeed provides us with a completely new and uniquely promising perspective on the hard problem of consciousness" Penrose & Hameroff .

Yet, as I hope to show later, there are strong reasons for doubting that it can account for even the simplest of our everyday performances.

What of the relationship between consciousness and the wave function phenomena?. Of this Penrose does not have a great deal to say:

".....We shall be having enough trouble with coming to terms with 'consciousness' as it stands, so I hope the reader will forgive me if I leave the further problems of 'mind' and 'soul' alone." Penrose (1989, p.407)

In other words, notions about the intrinsic nature and significance of this 'principle player' appear as no more than a shadow upon the blueprints of the mind-brain edifice which has been put together. Perhaps the reason for this lies within the nature of the postulated quantum gravity itself. He takes consciousness to enter only instantaneously at the moment of collapse, having nothing to do with the articulate condensation process which precedes it -see figure 5.5



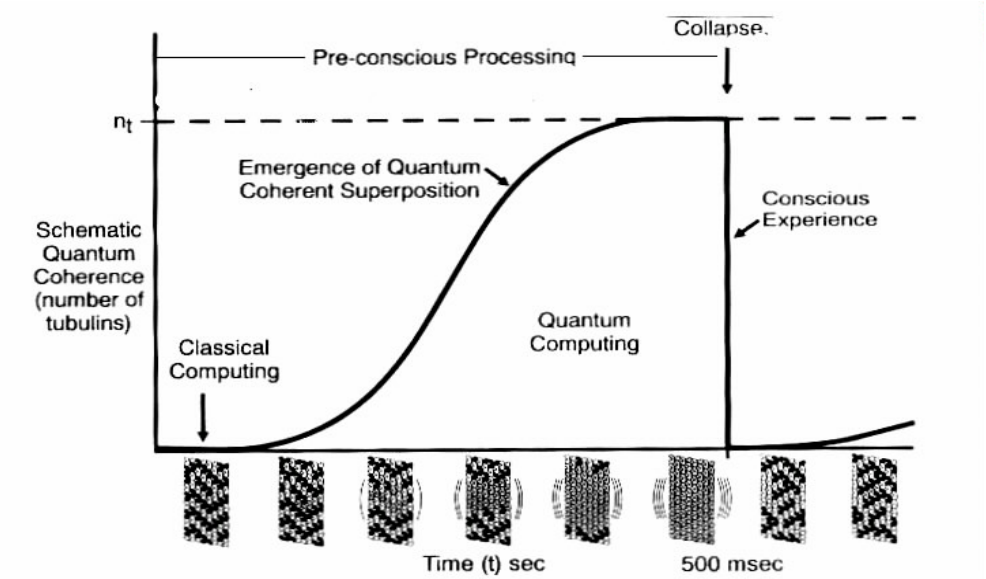
Collapse Details

Figure 5.4

Penrose discounts the possibility of an enduring consciousness partly because of the seeming implication that inorganic manifestations of Bose-Einstein condensates ought to be conscious. Thus it would appear that consciousness itself is epiphenomenal and hence non-efficacious -a 'helpless spectator'? If this be correct, then the mind-brain ensemble moves deterministically. I do not recall that Penrose has said so, in so many words; it is the opinion of justice Hodgson, however, for one, that this is what he has in mind. To me, this denouement comes through as surrealistic in its conflation of determinism with trans-algorithmic 'computation'. In this grand scheme, the eternal Platonic realm has been made captive to a higher determinism. Penrose seems to have taken back with his left hand what he had offered with his right. He quenches the Promethean fire stolen from heaven in the cold water of a larger fatalism.

Figure 5.6 rounds out this account by displaying the geometry and dynamics of the collapse mechanism. Note he space-time superpositions which progressively evolve until a critical mass is reached –whereupon one of the possibilities becomes an actuality.

Among mind-brain proposals in general, Penrose's position is almost unique, not only for the collapse mechanism (correct quantum gravity) which he proposes but also on account of his break-out from the constraints of secularism. In particular, the interior of the wave function is taken to be coupled to the realm of transcendence by a Platonic pipeline. In common with just about all productive mathematicians (including even the arch-formalist David Hilbert?), he is a Platonist. However, in his view the Platonic realm contains more than the truths of mathematics; he appears to be advocating something more like a return to Plato's theory of universals. He maintains (in my view, and that of some others, correctly) that even the most commonplace everyday understanding cannot proceed in the absence of a kind on ongoing Platonic refreshment which is essentially *non-algorithmic*, that is, to be



The Collapse Event

Figure 5.5

regarded as something *supervenient* to whatever computational processes may be proceeding in the background. In making this appeal, Penrose unburdens *whatever* computing facilities the brain may be offering of the need to supply something that is set *absolutely* beyond their means. This is indeed a huge step forward over what 'establishment' opinion has to offer. Of the contending mind/brain paradigms, the otherwise antithetical Cartesian models are the only ones able to appeal to the resources of Transcendence in making good the Gödelian ellipsis.

A number of objections can –and have- been brought in criticism of Penrose's thesis –some of which are peculiar to his particular vision while others are those shared by contending versions of the quantum mind concept.

First, let's take a look at Hameroff's microtubule computer. As has been made clear in an earlier chapter, the neuronal network of the cortex leaves much to be desired as an adequate substratum productive of mind's performance. Hameroff seeks to make good this deficiency through the agency of a computer-within-a-computer. What Hameroff ends up offering us is a cellular automaton consisting of some 10^4 cells (the number of microtubule subunits per neurone) whose states correspond to different conformational configurations of the protein molecules; the system is taken to be advanced by a universal clock running at some 10^9cps. If only two alternative conformational states per subunit be granted, Hameroff notes that this 'network within a network' speeds up neural 'processing' by some seven orders of magnitude. This may sound impressive yet hardly bears up under examination. First, for reasons already examined in an earlier chapter, the computing shortfall of the 'enchanted loom' as computer s so huge that there's little reason to believe that these extra orders of magnitude will do more than scratch the surface of the problem. But the difficulties run much deeper. What we are being offered is a cellular automaton

-which is just about as refractory a computing device as can be conceived. It took the genius of John Conway to demonstrate that such contraptions could operate as Turing machines *at all* let alone how huge they would need to be to so qualify. Why this should be so is clear enough when one considers the layout of the device in relation to what it is required to deliver. What is demanded is that memory be carried along concurrently with the computing flow; it has no world of its own. To put it differently, the *covariant* string must deliver the goods in the absence of an *invariant* source; this is simply more load than it is able to bear. It is perhaps precisely here that an appeal to the justly respected name of Whitehead has been misleading. This philosopher does indeed ground actual reality within 'epochalism' that is to say, in a sequence of occasions. To state this is simply to affirm an existentialist manifesto. Dispositional mind from which these quickened instantiations spring, is devoid of actual value. Its significance is entirely that of *potentiality* where this takes the form of an invariant source of great power and versatility, embodied within a reticulum of concepts whose organization and modus operandi are yet to be understood in strictly formalistic terms. Actually, as has been explored in a previous chapter, the neural network regarded as some species of highly parallel von Neumann computer must labour under exactly the same limitation. It too must labour under the cellular automaton handicap. Yet it does seem to have this advantage over its microtubule counterpart. It is an anastomotic re entrant network inter-connected within a high-dimensional lattice space; to put it differently, though everything doesn't directly connect to everything, it directly connects to an awful lot. In fact, the output of every neurone can reach every other by passing through only some half dozen intermediaries.

As if to silence his critics through overkill, Hamaroff goes on to point out:

> "……Considering the *simplest* case of microtube automata (two conformational states per microtubule subunit switching 10^{-9} sec intervals, 10^{4} microtubule subunits neuron) yields about 10^{23} brain bits per second."
>
> Hameroff [1966]

Analogous arguments have been urged by those seeking prove the sufficiency of the neural network in delivering the goods. As they stand, such arguments are essentially empty. All Hameroff has done is to sweep out a huge combinatorial space without any evidence that it can self-organize into a formal engine of *any* kind, let alone one which can meet the exacting standards that everyday human performance demands.

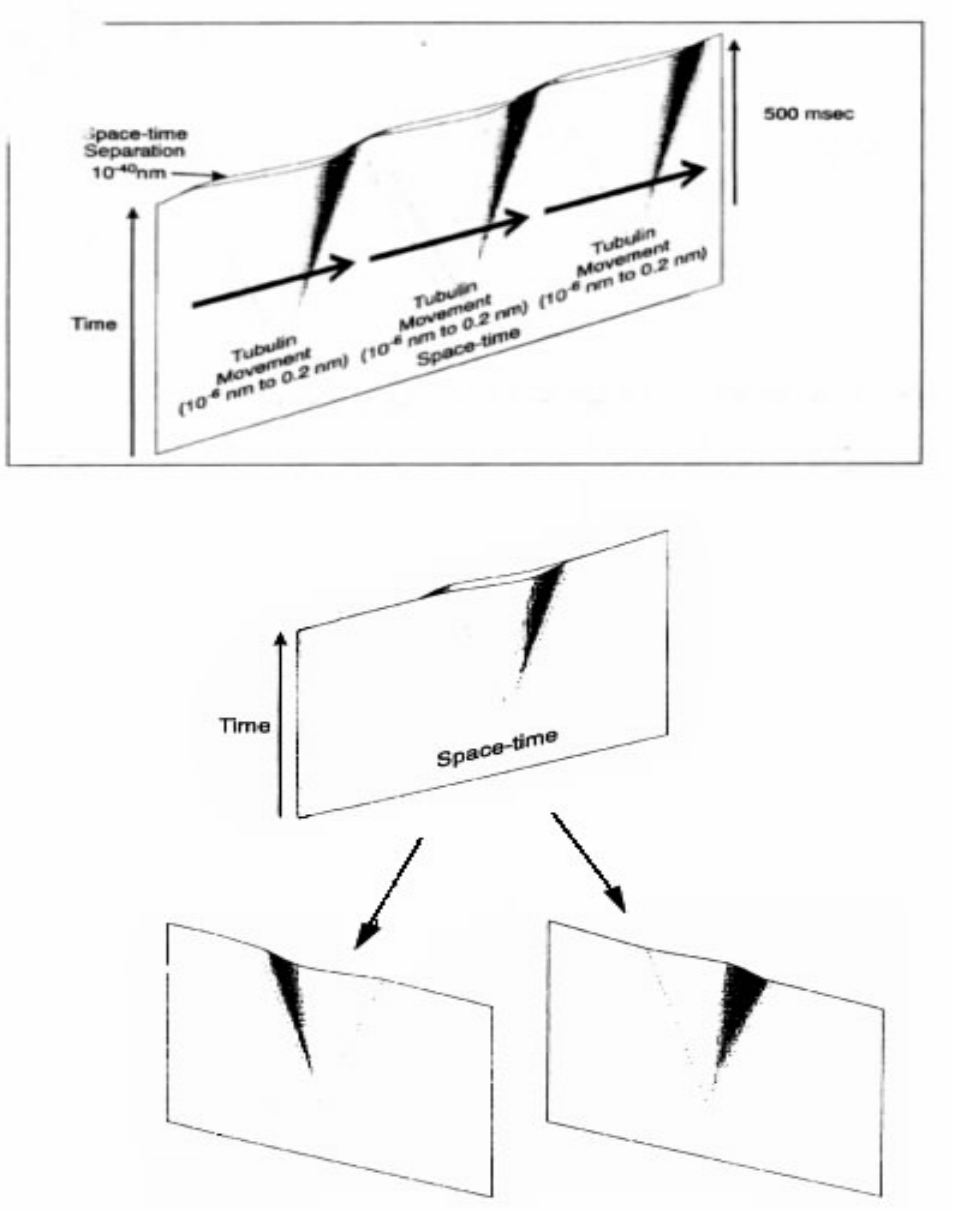
Penrose's quantum gravity collapse concept brings its own special problems:

> ".....not only must his hoped-for 'correct quantum gravity' produce non-linear quantum effects, but these effects must be precisely tailored to reduce all quantum possibilities to zero except one, Furthermore, this rather special many-into-one nonlinearity must operate robustly and reliably in an immense variety of physical situations -essentially everything that can happen in the world- in order to ensure that no Schrödinger cat phenomena accidentally emerge from the quantum underworld to intrude upon our commonsense perceptions.....Combining the fundamental Gravitational constant G with the fundamental quantum constant h, one can form a quantity called the *Planck mass* -which is an order of magnitude estimate of the size of a system at which quantum gravity effects might be expected to manifest. The magnitude of the Planck mass is about 10^{-5} grams (equivalent to 10^{18} Daltons), about the mass of a flea.....If quantum collapse acted only when things got heavy, then the activities of synapses, nerve cells, and most micro organisms would always be carried out in the world of pure possibility. Every living thing smaller than a flea would enjoy a Schrödinger cat-like existence, living no actual life but only lots of imaginary possible ones. Faced with the possible non-existence of most cellular life (large amoebas might actually exist), Penrose sheepishly admits that the Planck mass is embarrassingly large, and he is currently working on ways to calculate quantum gravity effects which lead to smaller crucial collapse masses". Nick Herbert Elemental Mind

Finally, as we shall see later, it is very dubious that the Bose-Einstein condensates essential to the functioning of the microtubule engine –and also in support of the demanded persistence of the diffusing wave function prior to the conscious collapse episode- can in fact be maintained

It is ironic while Penroses's 'Platonic pipeline' delivers –in principle at least- a transformal contribution absolutely beyond reach of *any* computer, he has been unable to stretch conservative computational resources to the point where they show any promise of providing what is required. Neither of these needs can alias for the other. It is necessary to have both if we are to end up with a viable mind/brain ensemble.

It is appropriate at this point to say a little more about Gordon G. Globus. He makes common cause with



Geometry of Exact Quantum Gravity

Figure 5.6

Penrose –up to a point. His major departure is over the mechanism of collapse. For Globus as with Stapp- consciousness is the cause of the collapse, rather than emerging as an epiphenomenal concomitant of a strictly causal event.

Globus offers us a warm 'world within' which is resonant with spontaneity, richness, creativity, and all of the things which are absent from the models of cognitive psychologists and AI people; he dispatches naive realism, but seeks to lodge the mind as some kind of dialogue between spontaneous wave-function evolutions with various kinds of resonant states with entrained proteins in the brain below. He disavows that the cortex is acting as any kind of computer.

> " '.....While the computational metaphor often seems to have the status of an established fact, it should be regarded as a hypothetical and historical conjecture about the brain [Daugman 1990]'.....The shibboleth of the cognitive and brain sciences that the brain 'computes' is but an expression of modernity....whose lineage is traceable to the Socratic philosophers in ancient Greece...The present twentieth century phase of this evolving paradigm, which post-modernism calls 'metaphysics' is none other than our ubiquitous technology "

Globus views things very differently. For him, the dialogue is between two quantum levels –an interior, 'upper' one encompassing mind and consciousness, and a 'lower' one involving the brain and world. This has led Hayward [ ] and others to the conclusion that Globus has overstepped the mark by doing away with objectivity altogether, hence instating some form of absolute idealism.

Neocartesian Dualism

At the present time, few Cartesian dualists are to be found. Eccles, of course, is a prominent exception, having been the leading proponent of this paradigm for half a century or more, though it is only recently that he has made an articulate quantum theory commitment [Eccles & Beck 1992].

The quantum waveform involvement proposal of Eccles and Beck is unique for the modesty of the demands set upon the presence of 'condensations' which involve no more than a few hydrogen atoms (sited within the vesicular grid of the presynaptic membrane). These waveforms may tunnel to the left or to the right, thereby determining whether or not exocytosis is to occur. Should the former be the case, then an electrotonically propagating disturbance would be generated, to converge with those originating in other boutons, towards the neuron cell body. Should a threshold value be exceeded, then a depolarising discharge would be initiated, propagating along the axon to reach the dendritic nets of other neurons to which it is targeted. These authors also propose that the organization of the presynaptic grid is such as to support a grid-wide resonance, and that this in turn might account for the remarkable observation that never more than one vesicle is ever discharged in response to any entering impulse.

This huge plurality of local quantum events are required to provide no more than a two-way coupling interface between the mind (on the far side of the 'Cartesian cut') and the brain. Eccles takes consciousness to be an integral entity embodied within a two stage hierarchy. The lower, which he terms the 'psychon' is assumed to be in anatomical association with those neuroanatomical structures known as 'dendrons', each such being a grouping of some 100 neurons. These psychons in turn, are absorbed into the larger unity of the psyche, the two strata constituting something of a subject/object hierarchy. In total, there would appear to be some 40 million dendron/psychon couples altogether. Only about 1/3 of the population of cortical neurones would be encompassed, because not all neurones enter into the dendron complexes.

It seems to me that such a schema of this type may provided a successful rationale in solving the mind/brain problem, provided only that one is prepared to move much of the needed machinery 'upstairs'. The mystery of just what it is that resides within the upper story of the mind-brain mansion remains unresolved.

As remarked earlier, Eccles's invocation of quantum mechanics really has little to do with mind per se or how it does what it does; at least, by shifting it 'upstairs' he is able to dodge the humiliating and hopeless task of accounting for human performance in solely (if at all) in terms of neural networks. he has put quantum physics to work simply as a bridge of communication between the two tiers, a role it might credibly fulfil. Given also its affirmation of a Realm of Transcendence, closely associated with the mental modality, the door would appear to be open for the entrance of essential 'Gödelian' modulations.

To my mind, the Beck-Eccles proposal is refreshing for the way in which it avoids the near-infinite stretching of the material resources which physics is able to provide; in fact, in this respect it is near unique. Whether or not one wishes to 'buy in' will, in consequence, be determined by one's ontological predilections rather than upon a weighting of evidence.

I have noted above that Cartesian dualists are but rarely to be encountered these days. Justice Hodgson is supportive of the concept of quantum consciousness, and appears to align himself with neoCartesian dualists for his insistence that the wave function collapse is caused by consciousness in the process of exercising free will:

> "……in order to explain the emergence o consciousness and choice, there would have to be much more as is necessary to constitute the *potential* for this emergence. This is the best argument I know for the existence of some pervasive consciousness and capacity for choice as a fundamental feature of the universe; that is, for the existence of something like what human beings have called God." [Personal communication]

This sounds to me like the kind of affirmation of theism typically associated with the dualist paradigm, but perhaps Hodgson is doing no more than making his own plea for a panpsychism.

Neorealism; Bohm & Bell

The golden decade of quantum theory's formulation and those which immediately followed were ones captive to a diaphanous ontology of a wave-dominated cosmos in which substance was conspicuous by its absence, save for odd 'singular' events in which evaporation followed immediately upon the heels of materialization. This was the 'default' Copenhagen position.

There have always the odd realist around, however, struggling to express a contrary point of view; in one way or another their aim has been that of attempting to accord waves and particles at least equal billing, thus planting one of physics' two feet back upon terra firma. What they had in common was the notion that particles were continually present, though subject to a guidance imposed, in one way or another, by quantum waveforms. Starting from the earliest days, a golden thread of neorealist sanity can be traced, passing all the way up to the present day. This thread links together the thoughts of a number of the leading luminaries who came to grace the stage of quantum physics.

1922 (?) Einstein's 'Führungsfeld' (coupled to electromagnetism)
1927 De Broglie's 'guiding wave' extension to the Bohr atom
1935 Schrödinger's scepticism; the infamous 'cat' Gedanken experiment
1935 Einstein again (this time with colleagues); the 'EPR' conjecture
1951 Bohm launches his neorealist reformulation of quantum theory
1964 Bell's Theorem
1969; 1984 Clausen and Aspect (and colleagues) disproof of Bell's theorem

In 1935, very critical of the equation bearing his name, Schrödinger, in conceiving his 'cat' Gedanken experiment was clear in stating its neorealistic implications:

> ".....Physics takes its start from everyday experience which it continues by more subtle means. It remains akin to it, does not transcend it generically; it cannot enter into another realm. Discoveries in physics cannot, in themselves, so I believe, have the authority of forcing us to put an end to the habit of picturing the world of reality." Schrödinger, quoted by Herbert (ibid) p157

> ".....The reigning doctrine rescues itself, or us, by a recourse to epistemology. We are told that no distinction is to be made between the state of a natural object and what I can know about it.....actually -so they say- there is intrinsically only awareness, observation and measurement."
> Schrödinger, quoted by Goldstein. (who describes Schrödinger as one of quantum theory's 'most acerbic critics.')

Here is Bohm's neorealism in a nutshell. The theory is defined by two equations: Schrödinger's equation for $\psi(t)$ and a first order evolution equation:

$$\frac{d\mathbf{Q}_k}{dt} = v_k(\psi;\mathbf{Q}_1, \ldots, \mathbf{Q}_N) \equiv \frac{\hbar}{m_k} \mathrm{Im} \frac{\psi^* \nabla_{\mathbf{q}_k} \psi}{\psi^* \psi}(\mathbf{Q}_1, \ldots, \mathbf{Q}_N)$$

-where Q_1.....Q_n are the positions of the particles. [Goldstein]

> "…..A third element in Bohm's system is 'a statistical rule analogous to one used in classical statistical mechanics. It stipulates precisely how one goes about 'averaging over' one's inevitable ignorance of the exact states of physical systems. It runs roughly as follows. Assume one is given the wave function of a certain system but no information about the positions of its particles. To calculate the motions of those particles in the future, what one ought to suppose is that the probability that those particles are currently located at some position (X_1……X_{3N}) is equal to $|\psi(X_1……X_{3N})|^2$ If information about the positions of the particles becomes available (as during measurement) the rule indicates that that information ought to be used to 'update' the probabilities through a mathematical procedure called straightforward conditionalization" [Bohm & Hiley]

In more everyday terms, particles are to be viewed as enduring entities which *never were* waves. Associated with each is a private wave existing within a field which Bohm called the quantum potential. These pilot wave forms are real, not probability density functions. The field permeates the whole of cosmic space, but does not have the kind of inverse-square fall-off characterizing gravitational and electromagnetic fields. Further, it exerts no *force* on the particles. Connections within the field are immediate and non-local.

Bohm's vision of cosmic reality contemplates two intercoupled layers or strata –which he respectively dubbed the 'explicate' and 'implicate' orders. The first is concerned with localized goings-on between the fundamental particles of physics and their atomic and molecular conglomerates behaving quasi-classically. The implicate order, by contrast, is global and holistic; it is here, one way or another, that consciousness is to be found. Consequently, mind's presence within the mind/brain ensemble would seem to take origin from a wider 'panpsychism'.

This concept is open to many interpretations and has been a perennial mystery-maker. A brief look at the alternative ways in which it may be taken is therefore in order. Charles Hartshorne's very clear overview [ ] recognises two major branches, -'monadological' and 'synechological'. The first links consciousness with individual existents of which organisms such as you and I offer the quintessential example. But its umbrella extends beyond the organic domain; 'monads' –to use a broader and more inclusive term, extend all the way downwards to the particularities of inorganic physics. As Whitehead was to put it, atoms are to be regarded as primitive organisms harbouring sentience; in today's parlance, it's 'consciousness all the way down'. 'Synechological' panpsychism is less structured and more homogeneous. In this view everything *regardless of organization* has a psychic concomitant, hence sticks and stones are to be viewed as embodying a *corporate* -if marginal- sentience. Over a century ago, the 'father of psychophysics, Theodore Fechner, wished to grant a soul to planet Earth; as if to placate sceptics who complained that our satellite home didn't seem to be behaving like a living being, Josiah Royce countered that maybe this was because it (or 'he', perhaps?) moved in geological rather than human time frames. Obviously, the undoubted occurrence of some version of Bohm's 'implicate order' riding, so to speak as a second stratum above the localised 'explicate order' of the classical canon lends encouragement to this line of thought. Here's how physicist Nick Herbert puts it:

> ".....I confess that I do think that consciousness will turn out to be something grand -grander than our most extravagant dreams. I propose here a kind of 'quantum animism' in which mind permeates the world at every level. I propose that consciousness is a fundamental force that enters into necessary cooperation with matter to bring about the fine details of our everyday world." [Nick Herbert Elemental Mind]

To Herbert, as to some others, this has seemed to offer support for their belief in ESP (extra-sensory perception). I am myself sceptical of such notions; although at one time was 'neutral in favour' of the idea. The continuing flimsiness of the evidence, its complete 'bolt from the blue' unpredictability of phenomena, and the repeated exposure of charlatans has hardened me against any acceptance. Regardless, it is certainly the case that panpsychism has always appealed to the holistically-minded. Schrödinger, writing in one of his 'slim volumes' written many years are his seminal contributions to quantum theory, was to speak of one mind and of one 'now'.

> "……The overall number of minds is just one. I venture to call it indestructible since it has a peculiar time-table, namely mind is always *now*. There is really no before or after for mind. There is only a now that includes memories and expectations. But I grant that our language is not adequate to express this, and I also grant, should anyone wish to state it, that I am now talking religion, not science –a religion, however, not opposed to science, but supported by what disinterested scientific research has brought to the fore."
> Schrödinger, quoted by Foster –The Philosophical Scientists Dorset Press 1985

To summarise; Bohm's 'explicate order' restores sanity by making 'be-ables' rather than 'observables' the essence of physical reality, while his complementary 'implicate order' gives mind and consciousness plenty of room within which to manoeuvre.

A Comparative Evaluation of 'Quantum Mind' Proposals

The two major considerations to be weighed in the balance are first: how well the psychological needs are met; and second, the extent to which the corresponding demands upon quantum physics can reasonably be maintained. Stated thus, it would appear that the process of converging towards the winner reduces to a cost-benefit analysis. But it's not that simple. More is involved because of the differing metaphysical and ontological presuppositions which the various proposals bring with them.

Looking first at the cost-benefit analysis itself: if this were the only criterion, the neoCartesian dualism of Eccles would have the edge over Bohm's neorealism and to be hands-down over the rest. Mind's occupancy of a private domain, configured within a different substratum and operating under its own 'top-down' logic, put it in a privileged position. Of all of the schema which have been proposed, dualism is most free of the tyranny of an absolute dependence upon the loom of the cerebral cortex –enchanted or otherwise- to account for the gamut of mind's extraordinary performance. At the same time, its demands upon physics by way of accommodation are minimal and the most easily met. This follows directly from the very limited role which the wave function is asked to play. Far from having to provide residency for mind, all that is demanded of it is that of providing an *interface* between the two categories of mind and brain. There is no unseemly stretching of the Schrödinger resources which mar most of the other quantum mind candidates.

A close runner-up is Bohm's 'undivided universe'. While providing excellent digs for the occupancy of mind, its reformulation of quantum physics eliminates most of the problems dominating orthodoxy. There are substantial doubts as to its consistency and completeness –for a start, it lacks Lorenz invariance. However, there is none of the desperate-stretching of resources to make ends meet –where the requirements of mind and consciousness are concerned. It is true that Bohm, like Eccles, has little to say about just how the mind delivers the goods, but then so are all the rest. Few are to be found who have really faced up to the huge *quantitative* gap between 'toy' examples of performance which familiar algorithms can handle, and problems of real-world magnitude. What continues to mislead here is the *transparency* with which everyday problems are handled at the twinkling of an eye, but which defeat the best efforts of our largest computers.

All of the remaining entrants (with the partial exception of Penrose) are grounded upon orthodox wave mechanics, and as we have seen, fall into two categories. take two forms. The 'observership' people –the followers of the von Neumann-Wigner initiative- paint upon a broader canvas –with respect to both the exteriority of physics and the interiority of mind. The Bose-Einstein advocates stay closer to home, being largely brain-limited, and perhaps offer a more compliant substratum for mind's grounding. But they absolutely require that these condensates

be maintained against premature collapse in the face of ambient metabolic and thermal noise. As we have seen, there is little or no hope that anything of the sort is possible.

A special word needs to be added about Penrose's augmentation of Hameroff's microtubule schema. His 'Exact Quantum Gravity' is no reformulation of quantum mechanics, as is the case with Bohm's neorealism, but rather an attempt to throw a bridge across the chasm separating relativity from quantum theory, and there are doubts that his proposal can really carry the day. More significant is his attachment of the interior of the wave function to the nether world of Platonic Transcendence. This opens the door upon Gödelian supervenience –something which is essential if the mind/brain ensemble is to deliver the goods. Perhaps something of the same is implicit with Cartesian dualisms. But there is nothing special about Penrose's proposed collapse mechanism making it a pre-eminent candidate for pipelining. Exactly the same could be claimed by any of the quantum mind models; indeed, that of Globus is pregnant with such implications.

So much for the cost-benefit analysis. If the default posture to be adopted were to be determined by this alone, then the Received Doctrine would be the lesson according to Eccles or Bohm. Actually it is neither. No matter whether the approach be from theoretical physics or neuroscience, mainstream political rectitude demands exclusion of three avenues of approach be put beyond the pale. First to be axed is Eccles's neoCartesian dualism; his flirtation with quantum physics does nothing to mitigate the major offence of all Cartesian theories –their theistic contamination. A close runner-up is Penrose's 'exact quantum gravity' –not on account of theoretical difficulties but because of its appeal to an eternal structured Transcendent realm; for all of his (apparent) atheism, this is a step in the wrong direction, a dangerous move away from the sanctuary of secularism towards the abyss of theism.

> "".....Platonism, surely, is a kind of convenient myth, rather like the way in which frictionless planes and ideal gases are convenient myths."
>
> Grush and Churchland [1995]

To be viewed with almost equal repugnance are 'neorealist' solutions of Bohm/Bell type. Physicists reject it because the distributed delocalisation of the 'implicate order' and its likes run directly counter to their stubborn, deeply buried 19th century instincts. Classically, there should be a place for everything, and everything should be in its place. All activity is to be mediated by contact forces; what might seem to be 'action-at-a-distance' field effects –as seemingly exhibited by gravity and electromagnetism- are henceforth to be mediated by 'real' gauge bosons and their virtual counterparts –hence the frantic search for the so-far elusive 'gravitons'. One might have thought that this was an odd posture to adopt, given that delocalisation, and *instantaneous* action over arbitrarily large distances is a firmly grounded empirical fact, and hence has broken free of its theoretical dependence upon Schrödinger's equation. One might also have thought that those concerned with the mind/brain problem would be largely free of this constraint, especially considering the directly given introspective experience of the 'binding' attribute which so characterise acts of perception. However, the psychological sciences have fallen captive to a physicalism which denies them any life of their own. When the physicist speaks, all heads nod in synchronous capitulation.

This narrows down the choice to the two forms of Copenhagen orthodoxy. Both Stapp and Nunn claim that their form of orthodoxy is the default paradigm, but a counting of heads, if nothing else, must give the day to the Bose-Einstein people.

However, to say that we have established a front runner is not to say that *any* quantum theory of mind has received general acceptance. To the contrary, most of those ruminating upon the mind/brain enigma seek to conjoin mind to 19th century materiality –as though quantum theory had never come into existence. Perhaps they also been influenced by considerations of the kind voiced by Scott:

> "".....In the insightful formulation of the Austrian physicist Erwin Schrödinger...components of a quantum wave function are calculated as solutions of a linear wave equation, appropriately called Schrödinger's wave equation. These components are simply added together in a linear fashion to obtain a global wave function (or *wave packet*), which is interpreted as a probability density for finding the system in one or another of its characteristic states (eigenstates). Thus quantum theory is linear in Schrödinger's representation.....*Stable and globally coherent states that arise*

naturally in classical non-linear systems are aped with difficulty by the wave packets of quantum mechanics." [JCS article]

Stapp has protested that Scott's critique ignores interactions with *fields* -which are subject to no such constraints. Scott does seem to me to have made a valid point when he goes on to remind us that anastomotic networks –of which the cerebral cortex is the ultimate example- can behave non-linearly in spectacular ways. In other words, is Stapp's 'Observership' paradigm non-linear *enough*? However, in dismissing Stapp, Scott has done nothing to redeem the extravagant promises made by himself and others on behalf of chaos theory and complexology in general.

In summary, despite its intuitive appeal, those struggling to make sense of the quantum mind-concept within the ambiance of orthodox quantum theory have neither proved their point, nor given any indication that they are on the right road, and that victory lies ahead. They have stretched the resources under their command to the braking-point –and to no purpose.

The neorealism of Bohm's reformulation of quantum theory offers a more promising substratum for the siting of mind –both within brains and throughout the organic realm in general. At the very least, he offers a great deal more room within which to productively manoeuvre. This having been said, Bohm and his followers have so far failed to fill this ample space with configurations showing promise of delivering mind's astonishing performance:

"……[Bohm and Hiley] postulate the existence of some form of connection between mind and matter whose common ingredient is said to be a mutual participation of both in some kind of implicate order. To be honest, the arguments advanced by the authors in support of this position are sometimes a little poetic ". Chris Isham [ ]

Of much greater interest to the present writer are the persuasions of a very small minority who doubt the adequacy at natural law as -currently understood and accepted- to underwrite the phenomena of life and mind. They hold the lex naturalis to be essentially incomplete and in need of augmentation the point, and that a great broadening of horizons is in order. Hut & Shephard [1966], for example, deplore the shabby accommodations granted to mind by most of their colleagues. If the demands of intra and inter-subjectivity are to be met, then something quite revolutionary must be done. They urge a drastic change of perspective which turns our present viewpoint 'sideways' and 'upside down'. Douglas Bilodeau [ ] refers to the sum total of current scientific wisdom as constituting no more than the tip of the iceberg. My own feelings reflect a similar viewpoint.

Quantum Mind & The New Monadology

If, then, I had accepted the default metaphysics and ontology of the mainstream intellectual, I would have found myself confronted by the same hardened choice –that between two all-inclusive alternatives. Either join the crowd and accept the material brain as the substratum of mind, or step upstairs into the Schrödinger wave function. My instincts inclined me towards the latter –for all of the reasons entertained by most adopting this avenue of approach. However, in approaching this delicate matter I had already long since reached the conclusion that the demonstrated performance of the mind/brain ensemble demanded extensions to the canon of Natural Law, expressly in its service (and that of the organic realm in general). My opening assumption was that both materiality and wave functions would be carried up into this exotic domain, and that mind would step into wave forms which were better able to serve its needs. However, this flirtation with quantum mind was to be cut short by developments occurring elsewhere in my philosophical speculations. The interested reader is referred to a companion volume to the present one: The New Monadology: a Glimpse of the Fourth Culture". Put very briefly, I was to end up assigning quantum mechanics to a special modality -that of 'Nascence' As such, it is to be regarded as providing a kind of continuing ontological bridge between the Source-Realm of Transcendence and fully manifest Existence. True to the principle of monism, it must carry something of both consciousness and materiality; what there is of consciousness, within this schema, does indeed reside on the 'inside' of the wave function, where it manifests only at the moment of its collapse. But that's as far as quantum mind goes. That of true monads –such as you and I- has nothing to do with Schrödinger, but resides within an exotic extension of material physics. The nature of this substratum –which must carry the memory preserving personhood, as well as the full extent of the 'know that' and 'know how'.

Nonetheless, in retrospect, it does seem to me that those seeking to lodge consciousness within the wave function had their hearts in the right place. Where they missed there footing was in their attempts to extrapolate from the spark which is all the collapsing wave function is able to provide into the organic realm of thinking and experiencing creatures. The wave function has no upwards mobility into exotic physics; its raison d'etre is limited to its contribution of the nascent influx. We might think of the wave-particle entity as a *monad manqué.* Very much supportive of this designation are the stochastic envelopes governing the 'selection' of particular instances from an invariance of possibilities. Stochastic selection is the inorganic shadow, or degenerate equivalent of freely willed acts.

I may say in passing that so far as my understanding of quantum physics is concerned, I was immediately won over by Bohm's neorealism –it was love at first sight. I only depart from him in his lodging of minds in general within the wave function. The cosmic-wide mental overtones of his 'implicate order' are suggestive of a synechological rather than monadogical brand of panpsychism of the type that I have proposed.

Hence, in summary, I might say that the wave function concept of subjectivity has been brought full circle. Within the inorganic as opposed to the living realm it is indeed the one place where mind is to be found. The instincts of those physicists selecting waveforms rather than matter as an appropriate substratum for mind must therefore be seen as sound. Where the enterprise miscarries is in the belief that Schrödinger waveforms can carry the burden of fully-manifest mind characteristic of authentic monadship. Quantum consciousness is not something that true mind can be *extrapolated from;* more properly rather, it is to be regarded as its doppelgänger.

Bibliography

Beck, Friedrich, Quantum Mechanics and Consciousness. J.Consc.St. vol 1, 1994, p.253-5.

Bilodeau, Douglas J.,Physics, Machines, and the hard Problem. J.Consc.St. Vol 3, 1996,#5-6, p.386-401.

Daughman, J.G "Brain Metaphor and Brain Theory" in Computational Neuroscience . Ed E.L.Schwartz Cambridge MA MIT Press 1990

Eccles, John C., How the Self Controls the Brain, Springer Verlag Berlin-Heidelberg 1994.
Esfeld, Michael Quantum Holism and the Philosophy of Mind JCS Vol 6 No1

Gardener, Martin, Computers near the Threshold? J.Consc.St. Vol 3, 1996, # 1, p.89-94.

Globus, Gordon G., Self Cognition, Qualia and World in Quantum Brain Dynamics. J.Consc.St.Vol 5, 1998, # 1, p.34-52.

Hameroff, Stuart Quantum Coherence in Microtubules: A Neural Basis for Emergent Consciousness? JCS (1), No 1 1994 p91-118

Hameroff, Stuart, Penrose, Roger Conscious Events as Orchestrated Space-Time Selections. J.Consc.St. vol 3, 1996,# 1, p.36-53.

Hayward, Jeremy: review of Globus 'post modern brain. JCS 4 #1 1997

Hut, Piet & Shephard, Roger n> Turning 'The Hard Problem' Upsidedown and Sideways.
JCS 3 #4 1966

Mutnick, Peter "The boundary, local operators, and measurement theory" JCS posting 03/14/2000

Nunn, C.M.H., On the Geometry of Consciousness. J.Consc.St. Vol 3, 1996, # 5-6, p.477-83.

Scott, Alwyn, On Quantum Theories of the Mind. J.Consc.St. Vol 3, 1996, # 5-6, p.484-91.

Stapp, Henry. On Quantum Theories of Mind JCS vol6 No1