Understanding reasoning and behaviour in terms of a modular mental structure

Concise report about the '2014 Update of the Parallel-Systems Mind Model of 2010', read at the University of Pretoria, 18 November 2014, under the title "Re-philosofying physical science and other heresies"

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Preface

The author has, over the past decade, presented a number of seminar lectures on the general theme of Cognitive Physical Science, all for the purpose of critically reviewing physical science in the light of findings of the cognitive sciences; psychology and neuroscience in particular. The justification for focussing on the cognitive sciences was the author's conviction that "physicists know all about their self-designed tools for measuring the parameters of the universe, but they know next to nothing about the inherited tool for planning measurements and for interpreting the results of measurements, viz. the brain".

During my researches for cognitive physical science, I, a physicist, have not only lost my original illusion of simply having to turn to psychology and neuroscience to find ready answers to a physicist's questions re. cognition, but also the illusion that philosophers would be willing and /or able to assist. As it turned out, a majority of philosophers adhere to Scientific Realism (i.e. the view that "the world is as science describes it, rather than a construction of how we think of it") with disregard for the findings of the cognitive sciences. This led me to the conclusion that physical science would have to be re-philosofied from

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within, i.e. by physicists themselves. This gave rise to the most recent lecture in this series, titled "Re-philosofying physical science and other heresies", presented on 18 November 2014 (as usual at the Dept. of Physics of the University of Pretoria, South Africa).

As was pointed out in the lecture, the philosofying physicist must, on the one hand, use the full contents of the much-underused philosopher's toolbox, and, on the other hand, devise means of applying the philosopher's tools to problems of physical science. What is a full set of philosopher's tools? It simply is the totality of methods and findings which have emerged over time from the daughter disciplines of the mother discipline of philosophy. And these daughter disciplines embrace all sciences (from the exact to the humanistic sciences). In other words, the philosopher's toolbox is, ideally, filled with methods and findings of all these sciences.

For the problem in hand, i.e. investigating the effects on physical science arising from the limitations of the human brain, one has to select those tools which have a bearing on human cognition. These are found in those humanistic disciplines which have a bearing on human cognition, such as neuroscience, psychology, sociology, evolutionary biology, anthropology, ethnology, linguistics, psychiatry, psychopathology, and various others (i.e. the cognitive sciences for short).

The identification of the tools to be applied is only a minor part of the task ahead. Really problematic are aspects such as (1) that no standardised definitions exist for many of the most important concepts in the cognitive sciences, (2) that the absence of strict methodical regimens in these sciences opens the door to interpretations of findings that are considerably more speculative than in physical science, (3) that the findings of different sciences are argued on different science-specific levels of logic, and (4) that, hitherto, no coherent information-flow-and-processing model of the brain has been proposed into which these findings can be integrated in a way which meets the standards of physical science. All of these aspects were given attention to (though rather concise) in the lecture.

As an outsider to the cognitive sciences, I have the advantage of not being primed to think in any specific direction in any of the cognitive sciences. I share this advantage with the philosopher. As a physicist, I have the additional advantage of being able to bring the methodology of physics to bear on these problematic aspects of the cognitive sciences. I have done so in 2010, when I proposed a definition of mind (missing in psychology), called the parallel-systems mind model. Since then, I found ever more reasons for making this model a starting point for my personal version of re-philosofying physical science. One can, therefore, also say that the lecture of 18 November 2014 was essentially a concise version of a 2014-update of the parallel-systems mind model of 2010. This concise version is presented here as Essay 2 Short Version, in the series 'Essays on Cognitive Physical Science'. A long version is in preparation.

The Essay 2 Short Version is a timely status report of the ongoing research in Cognitive Physical Science. It is timely because it reports findings which should be made public for early critical scientific discourse.

One of these findings is that the parallel-systems mind model of 2010 continuous to be very helpful in the understanding of human reasoning and behaviour (not only for myself, but, apparently, also to some of my colleagues).

This model proposes that the mind has a modular structure arising from an equivalent physical modular structure of the cognitive regions of the brain. That such a physical modular structure exist is consentient knowledge in neuroscience (e.g. Rita Carter, The Brain Book, Dorling Kindersley, 2014). The message in the 2014 update of the model is that one should move away from viewing the two equivalent modular structures as distinctly different entities (as one does in computer technology when distinguishing between hardware and software), because the structures imply one another. In the cognitive regions of the brain the physical structure is generated by the incoming sensory signals, on-the-go so to speak. And, since the physical structure represents the information conveyed by the sensory signals, the physical structure represents also its mental structure. The physical structure is strengthened or modified by new sensory signals. In other words, both structures are so intimately linked that a physical change implies also a mental change. This must be kept in mind whenever arguments are formulated in terms of the parallel-systems model.

A second finding of immediate interest is about the importance of levels of logic in scientific arguments. The proposition is that one can establish a hierarchy of levels of logic, based on the idea of an analogous hierarchy of levels of complexity of natural systems. Key to both hierarchies is that the levels in either hierarchy are separated from one another by the emergence of new properties on a new (higher) level which are not found on the previous (lower) level of complexity or level of logic. Of particular interest are the rules that can be derived from such a hierarchy of levels of logic, which (rules) are helpful in revealing problems associated with attempts of linking findings in one area of study (such as psychology) to those in other areas of study (such as neuroscience).

According to these rules, a direct linking of findings of psychology to findings of neuroscience is not admissible, because the two can be related to one another only via an intermediary level of logic (or level of complexity). This intermediary level of logic was proposed to be that of the modular mental structure of the brain, i.e. essentially the structure proposed in the parallel-systems mind model.

The finding about the modular mental structure as an indispensable intermediary between the findings of psychology and those of neuroscience, is a very helpful one for anyone who previously thought that understanding the functioning of the brain could be accessed only via neuroscience. In fact, the levels-of-logic rules make it clear that also neuroscientists will have to feed their findings into a modular physical-cum-mental model of the cognitive regions of the brain such that the reasoning and behaviour of man can be understood, in particular if these findings are to be harmonised with those of psychology. But, most important for the purposes of cognitive physical science is that physicists get access to the enigmas of human reasoning and behaviour via an easy-to-understand modular mental-structure model, which (model) they can contribute to by means of their vast experience with modelling of systems.

A typical physicist's contribution to the lecture of 18 November was that of treating the problem of re-philosofying physical science by the Ansatz approach, where (based on the principle that "all science is speculative", Karl Popper) an Ansatz is defined as "establishment of starting assumptions and/or propositions into an educated guess about a problem and its solution that is verified later by its results". As explained in the lecture (and above), the Ansatz used was that of a modular physical-cum-mental structure of the brain, in which every module is proposed to consist of a neuronal network dedicated to a particular task, and where the specificity of a module's task is proposed to derive from a combination of the triplet: (1) configuration of the network, (2) types of neuron involved, and (3) types of synapse regulating the signal transmission between neurons.

This rather simple Ansatz was shown to lead to a first-order information-flow-and-processing model of the cognitive regions of the brain capable of opening the way to an understanding of human reasoning and behaviour to a degree hitherto not thought possible (at least not by philosofying physicists). I am calling this a first-order model because the available knowledge base is insufficient for anything more than a rather general description of the model. In other words, the description of this first-order information-flow-and-processing model of the brain cannot, at present, be taken to a diagram stage.

This first-order model is the result of an intellectual exercise rather than a representation of established facts. Why? Simply because psychology and neuroscience can contribute far fewer securely established facts than are required for a model which would be satisfactory to a physicist, i.e. a model which is self-consistent and plausible throughout. In consequence, where contributions from psychology and neuroscience appeared questionable, these were substituted by better-fitting propositions. Such substitute propositions were required, for instance, for existing views about the intake of sensory data and memory, but also for existing views about the function of consciousness, about conscious self-determination, and about the self.

The substitute propositions about the function of consciousness, about conscious self-determination, and about the self are of particular significance because they cannot be called anything but heretical. The heretical substitute propositions are (1) that consciousness has a far less important function than that of managing human reasoning and behaviour, and that, hence, (2) the widely held view of a *conscious* self-determination of man is a myth, and (3) that the self is not an inherent property of man, but that the self is learned information just as any other learned information about any object.

These heretical propositions are certain to have severe consequences for those aspects of physical science in which one or all of the concepts of consciousness, conscious self-determination, and the self play a role, such as in certain views of entanglement in quantum theory. But also in all scientific action in which attributes of reasoning such as rational, logical, objective, unbiased, etc. play a role.

Moreover, these heretical propositions have significant implications also for a number of humanistic disciplines in which the concept of motivation plays a key role, such as in law, psychology, sociology, economy, politics, and history. This pertains in particular to applications of game theory, in which human actors are assumed to act "rationally".

The following is a script of the lecture of 18 November 2014, consisting of a speaker's introductory summary, followed by a set of key messages in form of statements, tables, and brief texts. These key messages constitute a rather concise description of the 2014 Update of the Parallel-Systems Mind Model. A full description is in preparation.

As can be expected of an update, the 2014 Update supersedes a number of positions taken in Essay 1 of 2010. Among them was the meanwhile superseded view that private conceptual subsystems of mind develop into relatively large entities, with one of them becoming dominant at the adult state (Preface of Essay 1). In the 2014 Update, the Ansatz is that these subsystems of mind increase more in number than size, viz. into "many millions of - mutually interconnected (indirectly or directly) - modules of neuronal networks".

Re-philosofying physical science and other heresies

Werner H. Gries

(Seminar lecture presented at the Dept. of Physics of the University of Pretoria, South Africa, on 18 November 2014)

Speaker's introductory summary

In my seminar lecture in April 2014, "How much philosophy do physicists need?", the focus was on what physicists can learn from their mother discipline of philosophy. For instance, about the multitude of possible philosophical stands that one can choose from for a private philosophical profile, and about the stage-wise progression of physical science (as proposed by science philosopher Thomas S. Kuhn). Today's seminar lecture is not about importing more philosophical findings into physical science, but about how to re-philosofy physical science from within.

What does it mean to re-philosofy physical science, and why is it necessary? For the simple reason that pretty little progress has been made in almost a century towards understanding quantum physics and the universe with the halting efforts of both philosofying physicists and philosophers. The philosophers because it is easier to choose ethics, human conflict, sociology, and linguistics as the objects of critical study, and the physicists because they ignore the toolbox of philosophy. What is the contents of this toolbox? It simply is the totality of tools which have been developed over time by the daughter disciplines of the aging mother discipline of philosophy. Physical science is one of many daughter disciplines.

Because of the large number of daughter disciplines, and because tools used in these disciplines differ in significant ways, it has become virtually impossible for philosophers to remain the universalists of old. When it comes to physical science, their main contribution is to "knock holes" into poor arguments, rather than to initiate a new paradigm. Therefore, there is a good reason for physical science to be re-philosofied from within, viz. by making use of the much-neglected tools of philosophy.

The tools of philosophy which I propose to be particularly useful for this task are the findings of evolutionary biology, psychology, sociology, neuroscience, and other cognitive sciences, as well as certain findings of physical science. I propose all of these to be combined into an Ansatz aimed at identifying the boundary conditions which the human mind is subjected to when attempting to understand nature. This lecture is a progress report of this intellectual exercise.

A major problem on the way has been that some of the findings of the cognitive sciences are not in a form suitable for direct incorporation into a physical model of the human mind, be it that they lack the called-for definitiveness or that their levels of logic do not match. Here, it is explained how these problems can be ironed out. This exercise has led to some heretical results re. human consciousness, the self, and the widespread axiomatic belief in conscious self-determination. These incidental results, if confirmed, have far-reaching implications beyond physical science, but also for some ideas of physical science, such as the explanations offered for the so-called measurement problem of quantum theory.

Messages of the lecture

The work presented in this seminar lecture consists of two parts, viz. a first part about how to re-philosofy physical science, focussed on understanding human reasoning and behaviour in terms of a proposed modular mental structure of the brain, and a second part which consists of heretical propositions about the function of consciousness, about the belief in conscious self-determination, and about the self.

Because of the status-report nature of the presentation, I want both parts to be regarded as intellectual exercises, without any claim for finality. The presentation is intended primarily as a stimulus for thinking in an entirely unconventional direction, a direction which may eventually lead to a new paradigm of science in the Kuhnian sense.

Part 1

Objective:
Opening up a new perspective on physical science by way of investigating the boundary conditions inherent in the evolutionary design of the human mind.

Method:
Formulating a physical-science-compatible Ansatz in which use is made of a combination of tools from a number of relevant daughter disciplines of philosophy. These tools provide the "starting assumptions and/or propositions" for the "educated guess" meant to constitute the Ansatz for solving the problem of human reasoning and behaviour at the modular-mental-structure level of the brain. The modular-mental-structure level has been chosen on the basis of considerations re. the hierarchy of levels of logic.

Table 1: Corresponding hierarchies of levels of logic and levels of complexity

Levels-of-complexity hierarchy	Levels-of-logic hierarchy
Man is an assembly of organs (supervised by one of them, the brain)	Level of observable phenomena *is also* Level of logic of **psychology ***
Brain is an assembly of modules	Upper level of logic of the parallel-systems mind model (module assemblies)
Module is an assembly of neurons	Lower level of logic of the parallel-systems mind model (single modules) *somehow equivalent to* Upper level of logic of **neuroscience**
Neuron is an assembly of molecules	Lower level of logic of **neuroscience** *also known as* Level of logic of **wetware ****
***** E.g., definition of Motivation: Driving force, such as thirst, hunger, or sex, that elicits, perpetuates, and maintains goal-directed behaviour. ****** E.g., definition of Neuron: Cell with long processes specialised to receive, conduct, and transmit signals in the nervous system.	

The levels-of-logic hierarchy in the foregoing table (column on the right) is of key significance in the formulation of an appropriate Ansatz for a solution of the problem in hand. It is based on an analogous hierarchy of levels of complexity of assembly of systems, as shown in the foregoing table (column on the left). The levels of complexity are distinguishable from one another by the emergence of new properties in every new (more complex) assembly. E.g. the assembly of molecules in a neuron give rise to emergent properties of a neuron, not possessed by any of the molecules in isolation.

When I presented this level-of-complexity scheme in a seminar lecture in 2011, someone in my audience introduced the term level of logic into the discussion, and I caught on to this idea, proposing that there exists also a hierarchy of levels of logic which is analogous to the hierarchy of levels of complexity. Now what is the significance of the correspondence between the two hierarchies?

Levels-of-logic rules:

Of key significance is that the emergence of new properties at every next-higher level of complexity limits attempts at explaining such emergent properties to the properties of constituents before their assembly into a more complex entity. E.g. the emergent properties of a neuron can be explained in terms of the interaction of its constituent molecules, but not in terms of the interaction of atoms in one of these molecules. In other words, only two adjacent levels of logic should, preferably, be involved in an explanation. For example, the level of logic of wetware cannot be used to argue an explanation for a psychological finding on the level of observable phenomena. But the level of logic of the parallel-systems mind model can be used to argue an explanation for a psychological finding on the adjacent level of observable phenomena. Likewise, the level of logic of wetware can be used to argue an explanation for the behaviour of (single) brain modules.

The foregoing contemplations make it clear why the two (intermediate) levels of logic of the parallel-systems mind model shown in the table are indispensable for, firstly, linking the findings of psychology to those of neuroscience, and for, secondly, advancing the understanding of human reasoning and behaviour by use of a relatively simple Ansatz and model.

Tools:

Tools for providing the "starting assumptions and/or propositions" for an Ansatz for a functional modular mental model of the brain can, in principle, be taken from any of the daughter disciplines of philosophy, as well as from philosophy itself. A subset of the tools behind the starting assumptions and/or propositions used so far are listed in the third column of the following table; they derive from the eight disciplines listed in the second column. The tools are listed in statement style.

The individual contributions of these tools to the Ansatz is not further elaborated because such elaboration cannot be accommodated within a single seminar lecture. They are going to be published in 2015 in sufficient detail for a meaningful discussion to ensue.

Although the parallel-systems mind model is not specifically referred to in the table, this model is basic for the intended Ansatz.

Table 2: Tools used for an Ansatz for a modular mental model of the cognitive regions of the brain

	Source disciplines	Tools (key statement listing)
ANSATZ	← Evolutionary biology	The evolutionary process reigns. Evolution favours modular addition. Brains that can learn, will learn. The least-effort principle reigns.
	← Neuroscience	Learning causes information-specific neuronal network modules to form. Configurations can be permanent or flexible. Synaptic linkages are subject to the use-it-or-loose-it principle. The brain is never dormant (cf. "default mode brain activity"). Most brain processes are subconscious.
	← Neuro-technology	Computers can communicate with modules of the brain.
	← Artif. Intelligence study	Neural (computer-simulated) networks can be trained to recognise patterns.
	← Neuro-psychology	Brains construct imaginations, illusions, hallucinations.
	← Psychology & Sociology	Concepts/findings of key interest: Theory of Mind Groupthink Needs hierarchy Cognitive dissonance Memory classification Memory feats of savants Timeline of brain development
	← Philosophy	Paradigm-governed science (Kuhn). Collective intentionality in the construction of social reality (Searle). Linguistic deconstruction (Derrida).
	← Physical science	Ansatz methodology in physical science modelling. Hierarchy-of-complexity model. Hierarchy of levels-of-logic model. Open dynamic systems far from equilibrium (complex systems).

Procedure:
With the identification of the tools to be applied, we are coming to the more difficult part of the exercise. This is the task of extracting information from the tools such that this information can be combined into a set of self-consistent "starting assumptions and/or propositions" for an Ansatz suitable for a modular

mental-structure model of the brain which allows human reasoning and behaviour to be plausibly explained.

The difficulty is that the diversity of sources and tools make it necessary for every tool to be individually analysed, viz. for its relevance and significance for the intended Ansatz, for its status in the source discipline, for possible counter arguments, and for the convertibility of the tool's information into a form suitable for arguing on one of the two levels of logic of the parallel-systems mind model.

For instance, the findings of neuroscience and psychology re. learning and memory are certain to be of top significance in both source disciplines, as well as for the intended Ansatz. The problem here is that the psychologist's classification of memory into different types (episodic, semantic, procedural), though formally correct, can be misunderstood as suggesting that every such type is assembled in a specific locality different from another type. This would not be compliant with the ideas inherent in the parallel-systems mind model. For instance, semantic and procedural components of an episodic memory remain closely associated therewith, without being physically laid down in three separate mental memory-type modules.

At this stage, it is necessary to explain what the results should be like from the aforementioned Ansatz. This is easy if an Ansatz leads to a mathematical formula. Then the result is a numerical value which emerges from application of the formula to a set of numerical input values. Not so here! The Ansatz here, intended to give rise to an update of the parallel-systems mind model, leads to a characterising description of the mental modules which constitute this mind model, and that in terms of the properties which these modules must give rise to if the findings behind the tools listed in Table 2 are to come about, and that, in turn, on provision that all of these properties are backed up by the principles of physical science.

This description of properties must be such as to explain the mental output of an individual module, but also the joint mental output of any number of modules jointly engaged in processing an input. For instance, if the input should be the proposition that human reasoning and behaviour is consciously managed, then application of the description of the modular mental model (i.e. the 2014 Update of the Parallel-Systems Mind Model) to this proposition will lead to a justification rating for this proposition; this is the result. In this particular case used as an example, the result turns out to be that there is no justification for assuming that human reasoning and behaviour is consciously managed.

The description of the modular mental model depends, obviously, on the analyses of the tools used in the generation of the description. This cannot be gone into in sufficient detail in this seminar lecture. Therefore, the following is a very abbreviated listing to give my audience an idea of what this description is like:

- The evolutionary development of brains has been modular from the earliest beginnings.

- Modules for learning are retraceable to earliest forms of life. Modules for *flexible* learning developed more recently.

- The specific learning-acquired contents of a module is laid down in form of a specific configuration of synaptic linkages between neurons, known as a neuronal network (also referred to as a neuronal circuit). (Not to be confused with a *neural* network, which is a much simplified computer model of a modular neuronal network.)

- Neuronal configurations result from the growth of synaptic linkages between neurons that is induced by signal inputs through the sensory organs, but also by self-generated signals of the brain.

- Flexible learning means that configurations are alterable (ideally throughout life, e.g. by the growth of new linkages and the withering of disused linkages, known as the use-it-or-loose-it principle). Some configurations, once established, are unalterable (being essential for permanent memory).

- Configurations of the neuronal network constitute - in computer terminology - both hardware and software of a non-digital biophysical computer.

- The overall neuronal network of the brain consists of almost a hundred billion neurons. A large fraction thereof is available for specific cognitive tasks, performed by many millions of - mutually interconnected (indirectly or directly) - modules of neuronal networks.

- Evolution has favoured the development of different types of neurons, optimal for different tasks and subtasks.

- The grand ensemble of neuronal modules has neither a command centre nor a coordination centre; it is self-organised.

- But there exists an importance ranking among the modules, such that certain modules are more influential in the joint processing of information than others.

- Part of the self-organisation is that modules connected to a sensory organ work jointly towards the common goal of analysing the incoming information for initiating actions aimed at survival and at satisfying the needs of the organism.

- In general, a given input to the neuronal network is processed by only a subset of modules, namely those which are of immediate relevance.

- This subset constitutes a complex system (i.e. an open dynamic system far from equilibrium, which may behave in a seemingly chaotic way although it is driven deterministically at all times), thus capable of giving rise (in complex-system manner) to large variations of behaviour for relatively small variations of the stimulating sensory input.

- The output of this complex system is strongly influenced by the importance ranking among modules in the subset (where importance ranking in this context means the relative strength of the feedback from a given module to other modules in the subset).

- etc., etc.

An important afterthought (given due prominence in the Preface) is that the traditional distinction made between brain physiology and mind may be artificial. The mind-vs.-body disjunction may not exist as claimed, due to the mutual interdependence of the two, viz. in that the physical structure of a learning module represents also its mental structure. In other words, hardware and software cannot be separated as in a man-designed digital computer.

Part 2

The focus here is on the heretical propositions referred to earlier. These propositions are about the function of consciousness, about the belief in conscious self-determination, and about the self (*inter alia* defined by psychologists as "an inner agent or force with controlling and directing functions over motives, fears, needs, etc."). These propositions, listed in the following, are consequences of the modular mental model sketched above:

- *All* signal processing in the brain is subconscious.

- Consciousness has *no* managing function whatsoever in human reasoning and behaviour.

- The *only* function of consciousness is the identification of the self in any situation that the individual is in.

- The information necessary for the identification of the self is largely learned and is deposited in one or more suitably dedicated neuronal network modules.

The implication of these propositions is that man is unable of conscious self-determination (and, hence, also of conscious motivation and conscious decision taking), despite sensations to the contrary.

Please note that with these propositions, I am overruling my own standpoint of 2010, when, in a discussion of the Benjamin Libet findings of the early 1980's, I reserved a 'veto power' for consciousness so as to give consciousness the final say in a subconsciously initiated motor action. I no longer hold this view!

These propositions have wide implications, viz. for everything in which the concept of motivation plays a major role, as, for instance, in psychology, in sociology, in politics, and in law. They open up a new vista into a future society in which the action of man is no longer seen as *consciously* self-determined, but as *subconsciously* determined. A wide field, indeed, for future philosophical contemplation.

So much on the wider implications. Here, we are concerned in particular with the implications for physical science. In the remaining time, I shall focus on the implication of the new heretical view of consciousness on certain interpretations of quantum phenomena.

Misuse of the existing notion of consciousness in quantum theory:

Let's consider the so-called measurement problem of quantum theory. This problem, also known as the Copenhagen Interpretation of quantum theory, is almost nine decades old and is still an enigmatic key issue of the philosophy of science. The problem is how to explain the fact that electrons passing through a slit are registered as particles, whereas they show wave-like interference effects when passed through a double slit.

In order to reconcile the alleged particle and wave natures of a quantum object, like the electron, Bohr, assisted by Heisenberg, came up with a so-called

Complementarity hypothesis and with the Copenhagen Interpretation in which the observer plays an essential role. It is here where, even today, the consciousness of the experimentalist is regularly brought into the discussion of the problem: Unjustified, as shall be shown.

What is the "logic" behind the argument *for* a linkage between consciousness and quantum phenomena? As I see it, key to the argument is the alleged action-at-a-distance between quantum objects, known as entanglement, which is believed to be evidenced by a joint change of quantum states of two distant quantum objects said to be entangled. If the experimentalist or his/her consciousness is proposed to influence the measurement of an electron, then one has to allocate a quantum state to the experimentalist or his/her consciousness.

Some theoreticians do this by regarding the experimentalist as a quantum system, when one finds statements alleging that an entanglement exists between the quantum state of a quantum particle (such as the electron) and the quantum states of all objects in the environment, i.e. inclusive of the quantum state of an observer (as discussed by science philosopher Michael Esfeld in *Philosophie der Physik*, Suhrkamp, 2013). This type of entanglement with the observer as a whole is said to have the consequence that "such an observer would neither be at a definitive location nor have definitive properties of *consciousness*" (thus Esfeld).

Other theoreticians do this by identifying a specific tiny constituent of the experimentalist as a quantum object able to entangle with the electron subjected to measurement. This is the strategy followed by renown mathematician Roger Penrose and his collaborator anaesthesiologist Stuart Hameroff. These authors believe this tiny constituent to be so-called microtubules within neurons, which microtubules they propose to be the generators of a *conscious mind*.

This is when the argument becomes unscientific, even if these microtubules were able to entangle with an electron: Because, there is no evidence that would link microtubules to a conscious mind, nor can there be any such evidence, because consciousness is an ill-defined phenomenon on the psychological level of logic, whereas a microtubule is an entity on the lower level of logic of neuroscience. In other words, the levels of logic differ by an unacceptable three-level interval (as discussed earlier).

If we now reduce the position of significance that Penrose and Hameroff allocate to human consciousness (in their argument for an entanglement with an electron in the measurement problem of quantum theory) to one of insignificance compared to subconsciousness (as is done in the aforementioned heretical propositions), then the Penrose/Hameroff argument falls by the wayside, anyway.

Also, the argument in which the experimentalist as a whole is regarded as a quantum system can be taken apart in a similar way.

And finally, theoretical chemist Jan C. A. Boeyens is taking the Copenhagen Interpretation apart on entirely different grounds, viz. by regarding fundamental particles as hyper-spherical solitons in four-dimensional spacetime. The implication is that there exists no particle-wave duality because particles are wave-like by nature. Hence, in this picture the measurement problem of quantum theory disappears completely.

Epilogue

The foregoing intellectual exercise has opened up a vista into a possible future science scenario in which a new (Kuhnian) paradigm has taken over. This paradigm is envisaged to be a post-humanist one, i.e. it rejects the humanist claim of humans being of unique standing in nature. But not only that; the paradigm is envisaged to be one under which man is regarded as a biological machine, controlled by an ever-developing, ever-varying, because ever-environment-interacting, non-digital biophysical computer, the brain. This computer, though very unlike the man-designed digital computer, is one which can be studied and explained by scientific methods of the types used in physical science.

Under such a paradigm, man will have to adapt his/her visions of how physical science has come about, how it has developed, and how it is likely to develop in future. As part thereof man will have to adapt his/her views of how human reasoning and behaviour come about, and what drives human acting and interacting. The adapted views will not only be of relevance to physical science, but they will substantially affect the teaching and practicing of all human sciences in which the current, then outdated, concept of conscious self-management plays a role. This new paradigm is likely to give rise to an entirely different human society; easily a project for centuries to come.