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The nature of the active ingredient in ultramolecular dilutions

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This paper discusses the nature of the active ingredient of homeopathic ultramolecular dilutions in terms of quantitative physics.
First, the problem of the nature of an active ingredient in ultramolecular dilutions is analysed leading to the recognition of the necessity of characterizing the active ingredient as a non-local quality.
Second, non-locality in quantum mechanics, which is used as a paradigm, is formally presented.
Third, a generalization of quantum mechanics is considered, focussing on the consequences of weakening of the axioms.
The formal treatment leads to the possible extension of the validity of quantum theory to macroscopic or even non-physical systems under certain circumstances with a while maintaining non-local behaviour. With respect to the survival of entanglement in such non-quantum systems a strong relationship between homeopathy and non-local behaviour can be envisaged. I describe how several authors apply this relationship. In conclusion, the paper reviews how quantum mechanics is closely related to information theory but why weak quantum theory and homeopathy have not hitherto been related in the same way. *Homeopathy* (2007) **96**, 220–226.

Keywords: potencies; non-locality; entanglement; weak quantum-theory; information

Introduction

When I started basic research on homeopathy more than 20 years ago I endeavoured to describe homeopathic potencies according to the laws of physics as far as possible. This soon led me to the hypothesis of a field being responsible for the homeopathic phenomenon. In investigating this hypothesis I learned from biophysics that such a field has to be closely related to electromagnetism, because of the ability of living organisms to react in a specific way on electromagnetic signals.[1] I concluded that the mechanism of homeopathic effects must be similar to resonances between electromagnetic waves and started to search for stored patterns of electromagnetic origin or, more generally, of physically measurable properties which differ between potencies and their solvent.

The results of the series of experiments that were carried out with a variety of standard physical-chemical methods[2] were disappointing. Almost none of the experiments could reproduce results reported in specialist literature, and for no experimental arrangement could the results be forecast. However, the totality of experiments with nuclear magnetic resonance (NMR) showed a clear tendency in favour of a difference between potencies and their solvent in the water- and OH-portions of the ethanol water-molecule.[3] I was quite pleased with this tendency, which is now being investigated by other researchers,[4] but I realized that looking for effects without having any clue of their significance is hazardous. Therefore, I started building models for the 'Therapeutically Active Ingredient' (TAI) and it soon became clear that models for the TAI have to have holistic character.[5]

While playing with models, I developed a construct which I called the 'Sequential Box Model' (SBM, see

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Appendix A). SBM is a thought experiment illustrating that the homeopathic phenomenon can be treated within physics with no consideration of the degree of dilution. Furthermore, the SBM explicitly underlines the long-standing presumption that for a TAI to emerge during the potentization procedure a quality beyond ordinary correlation between particles has to occur or be in existence already.

About this time the idea of the so-called 'quantum computing' was proposed in computer science.[6,7] This involves the idea of non-local correlations between states of entities. For my work, such non-local behaviour was the missing link between the SBM and a possible TAI, particularly as it was already known that non-local behaviour can occur in non-quantum systems under certain circumstances. The relationship between non-local behaviour of events in nature and the homeopathic phenomenon may give a clue to the 'nature of the active ingredient in ultramolecular dilutions' (NAIUD). It is the aim of this paper to analyse this relationship without going too far into technical details.

Necessity of a general principle

When we talk about the active ingredient of ultramolecular dilutions as used in homeopathy, we mean a non-material quality which—according to the principles of homeopathy—can be traced back to a substance. Moreover, this quality is understood to be able to make the symptoms of a patient disappear when administered via a vehicle. Many people call this quality 'information'. Let us first look at the set of events that are required for a therapeutic active ingredient to develop out of a substance. In this context, the existence of a TAI is temporarily assumed as being proven by successful treatment (Figure 1).

1. First of all, a proving (homeopathic pathogenetic trial) must have been conducted resulting in a drug picture with specific symptoms.
2. A mother tincture is prepared from the substance.
3. Apart from some specific procedures for the preparation of low potencies that depend on the nature of the substance itself, the mother tincture is potentized stepwise with no consideration of the degree of dilution. Dilutions far beyond Avogadro's number are used in daily practice.
4. When a homeopathic potency is prescribed, this is done according to the law of similars without consideration of the occurrence or not, of any molecule of the original substance in the medicine administered.
5. An artificial disease is triggered off resulting in healing.

These points demonstrate that the active ingredient of homeopathic potencies might have a variety of possible originators, especially when we only look at the squares and arrows in Figure 1 separately. There is no reason as to why two or more of these originators should complement one another. But if we look at Figure 1 as a whole, the necessity of a general principle becomes obvious. For such a principle, the symptoms of the homeopathic drug picture, the principle of releasing hidden energies of the substances by potentizing, the law of similars and the triggering of an artificial disease are specific projections. The problem is, how to specify this principle, especially with respect to the following questions:

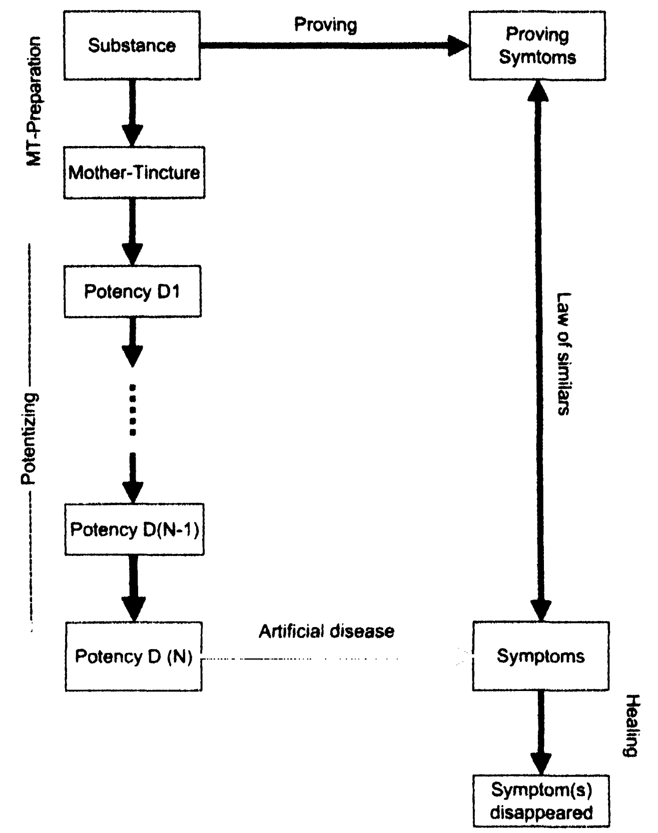

Figure 1 Schema of events which are required for a TAI to: (a) develop out of a substance, and (b) proved to be existent by successful treatment. Arrows represent procedures, they map states onto states.

1. Could such a general principle possibly be derived from the presence of a physical field?
2. For ultramolecular dilutions, interactions between molecules of the solute and those of the solvent do not make sense in terms of current scientific understanding. How can this be resolved?
3. Are there any reliable arguments for a concept of a global influence being responsible for an active ingredient in homeopathic potencies? Rupert Sheldrake's morphogenetic field[8] might serve as an example of such a concept.

In physics, fields are inevitably linked to interaction between material partners via interaction-particles. Photons, for instance, are the interaction-particles of the electromagnetic field.[9] Thus, potentization as well as treatment with potencies—procedures that implicitly do not depend on matter–matter-interaction—are not primarily based on physical fields.

Both procedures, however, suggest mind matter and matter–mind correlations.

1. Neither a specific chemical nor a specific physical property of the original substance is known to be transferred during the preparation of potencies although mother tinctures, which of course contain many molecules of the original substance, are mandatory for a starting point of this procedure. Potentization here appears to embody a procedure that relates matter to mind.
2. No common donor–acceptor-mechanism is known to be responsible for the effects of potencies. Treatment appears to embody a procedure that relates the 'mind of matter' to the 'mind of illness'. The latter of course itself is strongly related to biological matter and is often looked upon as a relationship belonging to psychosomatics.

Are these correlations better described by interaction mechanisms that are not linked to particles? A possible alternative is non-local correlations, known from specific effects in quantum physics. Roughly speaking these correlations have the following characteristic:

1. Non-local correlations between systems or entities represent a real simultaneous behaviour of the correlation partners because no interacting particles (which have a finite speed and therefore cause a time delay) are necessary for interaction.
2. Non-local correlations are not able to interchange matter but only non-material information.
3. Non-local correlations are, in principle, independent of spatial distances.

How non-locality arose

Although Einstein was one of the founders of quantum physics, he did not accept quantum mechanics as to be a complete description of the phenomena of the micro world. He explained the reason for this attitude in a paper which he published with Podolsky and Rosen in 1935. In this famous paper, the three physicists described a thought experiment in which two physical quantities have simultaneous reality.[10] For Einstein, this was a counter example for the completeness of quantum mechanics as a description of nature and for the rest of his life he did not change this attitude. He was not willing to accept counter-intuitive features in the description of nature. Schrödinger later on called this counter-intuitive property of quantum systems 'entanglement'. Only three decades later, John Bell[11] gave a theory-based criterion by which it was possible to decide whether a system is a quantum system or not. This criterion was applied in 1982 by Aspect and co-workers to an experimental arrangement in which they showed, for the first time, that entangled states can occur in quantum systems.[12] Since then many properties of systems in micro-physics have been demonstrated in experimental arrangements based on entanglement.[5,7] All have one thing in common: 'Entanglement in quantum systems'.

What is entanglement?

Entanglement is a highly counter-intuitive quality of quantum systems. The fact that entanglement is irrelevant to Newtonian physics does not justify the assumption that quantum physics is the only field where entanglement occurs. At least theoretically, entanglement can occur in any system that fulfils a certain set of axioms. Entanglement comes in various guises and it is not easy for non-specialists to see whether a phenomenon belongs to the category of entangled systems or not. For our purposes, it should suffice to get a clue what entanglement is, without too much technical fuss. Readers who are interested in a more precise explanation are referred to Appendix B.

As an example let us imagine a secluded island exclusively inhabited by females. Being asked what human beings are, the inhabitants of this island would most probably point their fingers at themselves. Similarly, the inhabitants of another island exclusively inhabited by males would identify human beings with males. For the rest of the world, human beings are females as well as males. This is a description of a factual connection, where a generic quality in a system has a different meaning in its subsystems. Furthermore, if we look at pairs of human beings there might be couples among them in the rest of the world, in total contradiction to the local meaning in the two islands.

A generalization of this example leads to the following. Let p_1 be a particle in a system A and let p_2 be another particle in a system B. System A and system B are assumed to be disjoined, ie have no common points/particles. System A rules the behaviour of particle p_1 and system B does the same for particle p_2 (see Figure 2).

It might be that states of the totality of the two systems occur which cannot be recognized in system A or in system B alone, but are exclusively linked to the recognition of $(A+B)$ as a third generic system. In the above example as well as in the following generalization constellations, in which global observations are not compatible with local ones, are possible. This is the idea behind entanglement.

Weakening the axioms of quantum mechanics

Quantum mechanics deals with states z_i and observables P, Q of quantum systems. Examples of observables are momentum, angular momentum, etc.

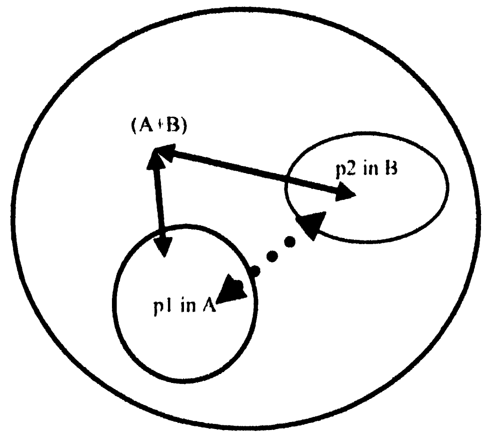

Figure 2 Schema of two entangled systems *A* and *B*. p_1 and p_2 are assumed to be correlated. Seen from (*A*+*B*) correlation can be observed. Seen from *A* or *B* only local observations are possible.

Observables are thought to act as maps on the set of states. So, an observable P maps a state z_1 into another state z_2. Onto z_2 a second observable Q may be applied resulting in a state z_3. Unlike in classical mechanics in quantum mechanics one does not always have $P(W(z)) = Q(P(z))$ or equivalently:

$$P \circ Q - Q \circ P \neq 0,$$

where '$\circ$' is to be interpreted as 'apply to', where '0' on the right-hand side of this inequality denotes the 'zero-operator' and where states 'z' have been omitted. Such a relation is known as a 'commutation-relation' of the two observables. Using states and observables as well as their relation to each other, quantum mechanics can be described as an algebraic system whose behaviour is ruled by a set of axioms that reflect the physical properties.

In 2002, Atmanspacher et al. published[13] the idea that weakening the axioms of quantum theory (weak quantum theory, WQT) could lead to theories that are no longer quantum systems or even physical systems at all, but which still have the property of possible entanglement. To be more precise, Atmanspacher et al. considered systems that comply with the following conditions (see also[14]):

1. Systems are any part of reality.
2. Systems are assumed to have the capacity to reside in different states. The set of states is not assumed to have the structure of the above-mentioned abstract space.
3. Observables are features of a system which can be investigated. They map states into states.
4. The composition $P \circ Q$ of two observables is also an observable. P and Q are called compatible if they commute (ie $P \circ Q - Q \circ P = 0$).
5. To every observable P there is a set of different (possible) outcomes.
6. There are special observables (propositions) whose possible outcomes are either 'yes' or 'no'. They follow the laws of ordinary proposition logic and have specific spectral properties (omitted here).

Within these conditions entanglement arises if global observables P pertaining to all of a system are not compatible to local observables Q pertaining to parts of the system (ie$P \circ Q - Q \circ P \neq 0$).

WQT and homeopathy

Since WQT systems are not necessarily quantum systems, WQT could be a tool to develop models for phenomena which are not quantum but have features which resemble entanglement, for instance, homeopathy. Several authors therefore have applied WQT to the homeopathic phenomenon. Walach, one of the co-authors of the original WQT paper,[15] presented a model in which the two semiotic processes 'substance and potency' as well as 'drug picture and symptoms of the patient' are assumed to be entangled by the law of similars. Milgrom has sketched a model for the homeopathic phenomenon in which the three pairs 'Patient and practitioner', 'patient and remedy' as well as 'practitioner and remedy' are assumed to be entangled in pairs.[16] In a metaphorical way he derives, in succeeding papers, from this entanglement triangle an astonishing variety of principles of homeopathy.

Both models presuppose the validity of WQT for the specific situation in homeopathy and Milgrom, at least, deduces implications which reflect the way homeopaths think. In terms of logic, the approach of these two models is called the sufficiency part of a proof. The necessity part would be the proof that the assumptions which underlie homeopathy such as the potentization, the law of similars, etc., fit the preconditions of WQT.

I have tackled the TAI problem in a previous paper.[17] This is where the SBM (see Appendix A) becomes relevant as a thought model, because it characterizes homeopathic potencies as a real physical system in which an unknown inner correlation is sought. In essence, paper[17] showed that sets $\{J_{i_1,\ldots,i_m} \cdot \sigma_{i_1,\ldots,i_m} \cdot \sigma_{i_1,\ldots,i_m}\}$ of spin-like states, where indices $i_1,\ldots,i_m$ vary over permutations, fit the axioms of WQT for an arbitrary big system B_N in the SBM. The sets $\{J_{i_1,\ldots,i_m} \cdot \sigma_{i_1,\ldots,i_m} \cdot \sigma_{i_1,\ldots,i_m}\}$ are a generalization of couplings $(J_{ik} \cdot \sigma_i \cdot \sigma_k)$ of two spins, in NMR-theory, for instance. The generalization strongly suggests to investigate the possibility of global couplings instead of pair-to-pair couplings.

In summary, a number of arguments exist for non-locality being the general principle underlying the NAIUD. Quantum mechanics, however, cannot be considered, without further investigations, the theoretical frame for the NAIUD. The paradigm is rather non-locality. Quantum physics is merely the scientific discipline where non-locality has proven to occur in reality. Figure 3 gives a schematic classification of phenomena which can be treated within quantum

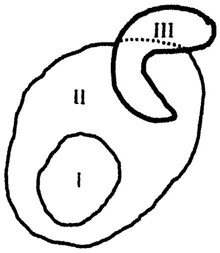

Figure 3 (I) The set of phenomena understood by quantum mechanics (essentially quantum physics); (II) the set of phenomena possibly understood by weak quantum theory (ie quantum physics and beyond); and (III) the set of phenomena belonging to homeopathy, possibly not a proper subset of II. Although quantum mechanics is an excellent paradigm for entanglement occurring in nature, quantum mechanics itself is not the frame in which NAIUD can be described.

mechanics, and those which have less structure in the set of their states and therefore need another theoretical environment, WQT. Questions concerning the NAIUD might even go beyond WQT.

Entanglement and information in quantum physics and beyond

It is the purpose of this section to explain the considerable difficulties one should be aware of when applying WQT instead of normal quantum mechanics to systems in nature.

This will be exemplified by the difficulties which arise when the attempt is made to translate 'informational content' (= entropy) in a quantum system to a system which is not quantum but which can be investigated by WQT. For formally correct representations of the factual connections given here, the reader is referred, for instance, to.[6]

The key concept of classical information theory is that of Shannon entropy. According to this concept, the entropy of a random variable A quantifies how much information we gain, on average, when we learn the value of A. Conversely, the entropy of A measures the amount of uncertainty about A before we learn its value. Thus, on the one hand, entropy measures the uncertainty associated with a classical probability distribution. On the other hand, in quantum ensembles density operators ρ, which represent the statistics of ensembles of different molecules in different states, formally replace probability distributions.

It was John von Neumann's brilliant insight that in quantum mechanics the entropy $S(\rho)$ of ρ can be expressed by the formula

$$S(\rho) = -\sum_{x} \lambda_x \log \lambda_x,$$

where λ_x are the eigenvalues of the density operator ρ. If entanglement between two subsystems of a quantum system occurs and if one considers the density operators of these subsystems separately it can be shown that the von Neumann entropy of one of these reduced density operators is a measure of the degree of entanglement. This measure has an upper bound $\log(s)$, where s (the Schmidt-number) is the dimensionality of an abstract space in which these states 'live'. Clearly, the bigger the s, the more the particles or states entangled. Applied to an arbitrary box B_N of the SBM this suggests that the bigger the box B_N is, the larger s has to be chosen and therefore the larger the measure of the amount of information.

These considerations, however, presuppose entanglement of those particles being directly concerned. If we turn to a situation where WQT has to be applied instead of quantum mechanics, many of the basic constituents are no longer present or at least no longer adequately defined. For instance, if the set of states is structured so poorly then the above formula for von Neumann entropy makes no sense.

Discussion

The principle of non-local behaviour of systems in nature, first investigated in the context of the counter-intuitive phenomena of quantum physics, is not necessarily restricted to physics at the micro scale. This is the essence of WQT. Roughly speaking WQT shows that in every system where local and global observables do not commute with each other non-local behaviour is possible. For some authors, WQT was the reason for using non-locality to characterize the nature of the active ingredient of ultramolecular dilutions. Some models have simply drawn consequences from such a possible generalized non-locality, another looks at the real potentization procedure, asking what non-locality might contribute to an active ingredient. But WQT is not known to be powerful enough to describe the NAIUD entirely.

So the question arises, why considered WQT in such detail in connection with homeopathy? The answer is simple. With WQT, for the first time, special emphasis is placed quantitatively on entanglement as an idea. Moreover, WQT has shown to be a powerful tool for the characterization of the physics of the class of mathematical problems which arise when the NAIUD is to be described.

It is a great temptation to use WQT as a special way of describing the laws of quantum physics. People who do so tend to ignore the restraints given of WQT and use it as a theory applicable to everything, including the NAIUD. This is certainly not the right way to describe the NAIUD. An attempt to characterize the informational content of a system to be investigated by WQT, shows that it is not easy to generalize the concept in quantum mechanics to WQT or beyond.

Of course, all these considerations do concern the NAIUD in modelling situations. The question is, why do such work instead of looking for the TAI in experiments? The answer is that model building is a method of finding a way of thinking which allows us to understand a set of phenomena in a wider context. In contrast, experimental work tends to reductionism. I hope that both tendencies will ultimately meet.

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Appendix A. The sequential box model (SBM)

Imagine a certain volume of mother tincture is present in a box B_0. Then imagine the contents of B_0 are poured into another box B_1, 10 times bigger than B_0 and already 9/10th full of solvent. Imagine then B_1 being vigorously shaken as in the preparation procedure of homeopathic potencies. Imagine then the whole content of B_1 being poured into another box B_2, 10 times bigger than B_1 and again 9/10th full of solvent.

This procedure can be continued to an arbitrary box B_N and it is clear that:

1. In every Box B_N the whole volume of mother tincture is present, ie the problem of high potencies can be, at least in a thought experiment, treated physically.
2. If one attempted to conduct this experiment in reality the procedure would come to an end very soon because of the unrealizable dimensions of the boxes.
3. The higher N grows the less probable is the occurrence of a molecule in a random sample taken out of B_N. This means that in B_N an additional property has to be present which carries the information of B_0. This property has to be non-local.

Appendix B. Entanglement

Mathematicians represent every point in the three-dimensional space of our experience as a sum of multiples of vectors of unit lengths in the x-, y- and z-axes. In the same way, they often represent objects in abstract spaces as sums of multiples of basic elements of these spaces. A direct application of this to quantum physics leads to the following.[6,7]

The states of quantum systems are mathematically represented by elements (points in) of an abstract Hilbert-space H. If points in this space are denoted by ψ and if the basic elements of H are denoted by φ_i ($i = 1, 2, \ldots$), representations of states look like

$$\psi = \sum_i a_i \varphi_i.$$

This is commonly known as the principle of superposition in quantum mechanics, ie a wave function ψ is the superposition of multiples a_i of basis 'waves' φ_i. In case of two particles forming two different systems we have the two representations:

$$\psi^{(1)} = \sum_i a_i \varphi_i^{(1)},$$

$$\psi^{(2)} = \sum_j b_j \varphi_j^{(2)},$$

where the numberings (1) and (2) are used to distinguish between the two. For the sake of clarity, we also index the Hilbert-spaces belonging to each of these representations (and get H_1 and H_2, respectively) although they are usually identical.

The crucial point now is the consideration of a system consisting of the two particles as a whole. In this case, it is necessary to construct another Hilbert-space $H = H_1 \otimes H_2$ out of H_1 and H_2 in such a way that this new system 'lives' in H_1 and in H_2 at the same time. In order to achieve this, a so-called tensor-product $H_1 \otimes H_2$ is formed. This is a new Hilbert-space whose points have the form

$$(\psi^{(1)}\psi^{(2)}) = \sum_{i,j} c_{i,j} \Phi_{i,j},$$

where $\Phi_{i,j}$ denote basis elements in $H = H_1 \otimes H_2$ and $c_{i,j}$ their multiples. Entangled states are those $(\psi^{(1)}\psi^{(2)})$ for which the multiples $c_{i,j}$ cannot be written as

$$c_{i,j} = a_i b_j,$$

with a_i and b_j being the multiples from above and independent from each other.

Remarks

1. The above relation between states can be interpreted as the possible arising of additional qualities when two single systems are looked upon as a whole.
2. The set of entangled states in most of quantum systems is not empty. For many systems, the subset of possibly entangled states is much bigger than the non-entangled.
3. The above characterization is not restricted to pairs of particles.
4. States $(\psi^{(1)}\psi^{(2)})$ in $H = H_1 \otimes H_2$ which cannot be split into products of pure states in H_1 and H_2, respectively, might be imagined as the pure states of the composite system.
5. The description of entanglement in quantum mechanics, which is a counter-intuitive, strongly depends on a mathematical apparatus with a rich structure.

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