Where and how does it happen?

Elemér E Rosinger
Department of Mathematics
and Applied Mathematics
University of Pretoria
Pretoria
0002 South Africa
eerosinger@hotmail.com

Abstract

It has for ages been a rather constant feature of thinking in science to take it for granted that the respective thinking happens in realms which are totally outside and independent of all the other phenomena that constitute the objects of such thinking. The imposition of this divide on two levels may conflict with basic assumptions of Newtonian and Einsteinian mechanics, as well as with those in Quantum Mechanics.

1. Conflict with Newtonian mechanics

Instant action at arbitrary distance, such as in the case of gravitation, is one of the basic assumptions of Newtonian mechanics. This certainly does not appear to conflict with the fact that we can think instantly and simultaneously about phenomena which are no matter how far apart from one another in space or in time. However, absolute space is also a basic assumption of Newtonian mechanics. And it is supposed to contain absolutely everything that may exist in Creation, be it in the past, present or future. Consequently, it is supposed to contain, among others, the physical body of the thinking scientist as well.

Yet it is not equally clear whether it also contains scientific thinking itself which, traditionally, is assumed to be totally outside and inde-
pendent of all phenomena under its consideration, therefore in particular, of the Newtonian absolute space, and also, of absolute time.

And then the question arises: where and how does such a scientific thinking take place or happen?

2. A difference with Mathematics

Mathematical thinking, especially in its modern and abstract variants, does not appear to need the assumption of any absolute space, or for that matter, absolute time. Such thinking may appear to unfold during appropriate local time intervals. However, when seen all in itself, and unrelated to the physical body of the respective mathematician, it is quite likely that such thinking has no location in any space, be it relative or absolute.

3. Conflict with Einsteinian mechanics

In Einsteinian mechanics a basic assumption is that there cannot be any propagation of action faster than light. Yet just like in the case we happen to think in terms of Newtonian mechanics, our thinking in terms of Einsteinian mechanics can again instantly and simultaneously be about phenomena no matter how far apart from one another in space or time.

Consequently, the question arises: given the mentioned relativistic limitation, how and where does such a thinking happen?

4. Conflict with Quantum Mechanics

Let us consider the classical EPR, or Einstein-Podolsky-Rosen entanglement phenomenon, and for simplicity, do so in the terms of quantum computation. For that purpose it suffices to consider double qubits, that is, elements of $\mathbb{C}^2 \otimes \mathbb{C}^2$, such as for instance the EPR pair
\[ | \omega_{00} > = | 0, 0 > + | 1, 1 > = \]

\[ = | 0 > \otimes | 0 > + | 1 > \otimes | 1 > \in \mathbb{C}^2 \otimes \mathbb{C}^2 \]

which is well known to be entangled, in other words, \( | \omega_{00} > \) is not of the form

\[
( \alpha | 0 > + \beta | 1 > ) \otimes ( \gamma | 0 > + \delta | 1 > ) \in \mathbb{C}^2 \otimes \mathbb{C}^2
\]

for any \( \alpha, \beta, \gamma, \delta \in \mathbb{C} \).

Here we can turn to the usual and rather picturesque description used in Quantum Computation, where two fictitious personages, Alice and Bob, are supposed to exchange information, be it of classical or quantum type. Alice and Bob can each take their respective qubit from the entangled, or EPR pair of qubits \( | \omega_{00} > \), and then go away with it no matter how far apart from one another. And the two qubits thus separated in space will remain entangled, unless of course one or both of them get involved in further classical or quantum interactions.

For clarity, however, we should note that the single qubits which Alice and Bob take away with them from the EPR pair \( | \omega_{00} > \) are neither one of the terms \( | 0, 0 > \) or \( | 1, 1 > \) in (4.1), since both these are themselves already pairs of qubits, thus they cannot be taken away as mere single qubits, either by Alice, or by Bob. Consequently, the single qubits which Alice and Bob take away with them cannot be described in any other form, except that which is implicit in (4.1).

Now, after that short detour into the language of Quantum Computation, we can note that, according to Quantum Mechanics, the entanglement in the EPR double qubit \( | \omega_{00} > \) implies that the states of the two qubits which compose it are correlated, no matter how far from one another Alice and Bob would be with them. Consequently, knowing the state of one of these two qubits can give information about the state of the other qubit.

On the other hand, in view of General, or even Special Relativity, such a knowledge, say by Alice, cannot be communicated to Bob faster than the velocity of light.
And yet, anybody who is familiar enough with Quantum Mechanics, can instantly know and understand all of that, no matter how far away from one another Alice and Bob may be with their respective single but entangled qubits.

So that, again, the question arises: how and where does such a thinking happen?

References

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