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## Quantum Logic

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The bivalent logic, which started with the ancient Greek philosophers, is based on well defined and isolated concepts forming a long chain of closed systems and sets. One starts with a well defined hypothesis A and through a series of steps, B, C, D,... reaches a final conclusion. The problem arises when A leads to B, but B **points back** to A; when there is a recursive interaction between A and B. Then we are stuck and the circular, self referential reasoning leads to a paradox. Philosophers such as **Epimenides** (about 600 BC) and **Zeno** (about 400 BC) saw the shortcomings of this logic and designed ingenious paradoxes.

### **Achilles and the Tortoise Paradox**

A race is organized between the fast runner Achilles and the slow tortoise. Achilles, sure of his speed, gave some starting advance to the tortoise. Zeno argued that the fast runner Achilles can never overtake the tortoise, since Achilles must first reach the point whence the tortoise started, so that at every new distance -or step- the slower tortoise must always hold a lead and Achilles can never catch up with the tortoise.

This way of reasoning is correct if only distance is taken into account. Speed, on the other hand, is a function of both distance as well as time. The definition of speed is the ratio of distance over time ( $v = x/t$ ). If for a fixed amount of time the fast runner covers a larger distance, then the speed of the fast runner will exceed the speed of the slow runner and there will be no paradox at all.

But the paradox has deeper implications when carefully analyzed. Achilles has to complete any step in a finite duration of time. Before he completes a step in time  $t$ , he must cover the distance of half a step in time  $t/2$  and this time interval can also be divided in two halves,...ad infinitum. The limit of halving the time intervals leads to an interval of zero duration. This means that time, is in fact, a mental concept with no real basis of reality. The real moment is an instantaneous snapshot that one is unable to grasp. So, Zeno's paradox is still valid at the limit of an infinitesimally small time interval. Such an instantaneous time interval is the **now** and reality exists only in the **here**.

### **Quantum indeterminism**

Observation is always valid for "here" and "now". Quantum theory does not make any assumption regarding the past or the future of a system. The past and

the future are –to a large extent- constructs of the brain. We cannot go back in time and traveling to the future is still impossible. They are linear extrapolations stemming from our capacity for rationalizing events. We have come to the concept of time because we believe in continuity. But Quantum theory says that all events are discontinuous and causality is an approximation. Causality is valid in the macro level of our daily experience. We believe that all effects must stem have prior causes. Such a world view leads to determinism, which came to be accepted as the method of explaining events.

If we get rid of our assumption that the world is deterministic, then we will be able to change our logic and start to think differently. I already mentioned the And-And logic in article **17, A New Way of Thinking** (1). Quantum theory tells us that the world and all events are non-deterministic and causality should not be accepted at face value. This is because causality is decoupled from locality.

There are non-local interactions which have been experimentally proven. Einstein could not accept that non-local interactions –which happen faster than the speed of light- do exist in nature. Himself with Podolsky and Rosen proposed a thought experiment, known as the EPR experiment. He claimed that no message can be sent faster than light. But this assumption has been disproven experimentally.

In order to understand this complicated experiment, please watch these two videos who simplify the EPR experiment. (2, 3). Entangled interactions have been experimentally proven. There exists a unity and a holistic connectivity in all that is in the universe. So, all that is ‘out there’ is both discrete as a particle **and** interconnected as a wave. The external world is both distinct from ourselves **and** is part of ourselves. There is a never ending instantaneous interaction between ourselves **and** the background we live in. The ‘and’s are bold, because all that is, is interconnected and inseparable.

The bivalent way of thinking leads to paradoxes, because one assumes that there exist rigorous and precise distinctions among concepts which do not overlap or interact. But in fact the micro as well as the macro systems interact and do not exist as isolated, independent and closed units or sets of similar entities. Any macroscopic object is both a wave and a particle. Here is a video of the French physicist **Alain Aspect** (4), who was able to demonstrate that information can travel faster than light and also that the only way to understand Quantum theory is by accepting to change our bivalent logic to a new logic, which I have called the AND-AND logic. If we change our way of thinking and accept that the AND-AND logic is correct, we will no more encounter paradoxes and start to understand the world as it is.

## References

- (1) <http://www.halukberkmen.net/pdf/143.pdf>
- (2) <https://www.youtube.com/watch?v=5HJK5tQIT4A>
- (3) <https://www.youtube.com/watch?v=z-s3q9wLLag>
- (4) <https://www.youtube.com/watch?v=Cg7jMXQHxvM>