

Time for a Change - FQXi Essay Notes

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[26, August, 2008]

- (1) The problem of time in quantum gravity
- (2) Solution to William James' version of the dichotomy
 - (3) Others on Zeno's paradoxes
 - (4) The non-existence of instants
 - (5) The non-existence of interval
 - (6) Are time and space quantized?

References

(1) When trying to merge quantum mechanics with general relativity, values – and time values in particular – often go to infinity and become non-renormalizable (are unable to be adjusted to be made finite). In other words, the mathematics breakdown, and this indicates that the two theories must be incompatible. On top of the mathematics for each theory being different, the reason for this clash of theoretical paradigms is thought to be mainly attributable to the geometry of space-time being a fixed backdrop in quantum theory – much like a background set in a stage play – while with general relativity, it is a dynamic and active member of the cast (this feature is sometimes called “background independence”). On the other hand, and from a different perspective, quantum theory describes physical processes that evolve over time *within* the framework of the universe, while general relativity essentially provides a timeless and independent view of it – a sort of God's eye view. Unsurprisingly, the two theories do not mix very well. Furthermore, either of them may be incomplete.

With quantum gravity and time by itself, things are just as mysterious. When trying to combine general relativity with quantum theory, time essentially vanishes! One way of looking at this is by noting that Einstein's view of time via general relativity, forces us to conclude that the total amount of energy of the universe is constrained to exactly zero. This surprising result has been known for a number of years, and it has a profound consequence for a quantum description of nature. In quantum theory, energy always goes hand in hand with time, so in a sense, the amount of energy determines the rate at which time passes. No energy thus means that time basically drops out of the description altogether! The same sort of phenomenon can be clearly seen in Canonical quantum gravity, and its cornerstone equation, the Wheeler-DeWitt equation. This equation makes no reference whatsoever to time and is completely time independent.

Time presents the greatest problem – J. A. Wheeler, 2005

Some people believe that time's great disappearing act in quantum gravity might be rectified by introducing time into the equations as another variable, in a similar way as Newton's absolute time works in classical mechanics. Others believe the theory is basically correct, but that time might be mysteriously hidden somewhere, and they

comb the formalism looking for something that might play its role. Others, on the other hand, myself included, do not think that time should play much of a basic part in quantum gravity at all. On the possible answer, as with quantum gravity theory in general, the jury is definitely out.

(2) With these realizations in mind, one then sees that the alternative proposed solution to the paradoxes of Achilles and the Tortoise, and the Dichotomy, of applying an exact velocity to the body in motion (so that, if the body travels at 10 meters per second, it reaches the 10 meter mark after one second), also falls over, because it presupposes that a moving body has a precisely determined or instantaneous position at a particular time, thus guaranteeing exact temporal and spatial values (representing instants in time and spatial points) before the fact in order to derive an exactly determined velocity.

Finally, William James' variation on the Dichotomy is also resolved by the same line of reasoning, and by recognizing that, in order to make each time dissection, the paradox assumes the existence of an instant in time to freeze and exactly determine an interval in order to provide an exact time value, when in fact, interval is constantly changing i.e. the hands of a clock continue to rotate – or even better, physical continuity always remains present.

The times are a-changin' – Bob Dylan

If the time value in William James' version of the Dichotomy paradox was perhaps said to represent an interval of time, rather than an instant (for example, the interval of 2 seconds, which represents the interval between 2 and 2.999..., seconds), in order to make the dissection, this assumes the existence of two instants (at 2 and 3 seconds) to bound and determine the interval, and the same applies. Interestingly, if the *Dichotomy* and Achilles and the Tortoise paradoxes were perhaps reformulated so that the focus was placed, not on the distance, but upon the time interval so that there was always some time remaining rather than a distance, this simply becomes a restatement of William James' version of the paradox.

(3) As with basically all ideas in science and philosophy, the thoughts underlying these conclusions are not all new. After the publication of my paper, I soon learned that over the centuries, going all the way back to the birth of Zeno's paradoxes 2500 years ago, a number of people were clearly thinking in the right direction. Probably the person that this most applied to was the first of them: Aristotle. When confronted with Zeno's Arrow paradox, Aristotle replied that it was moot because "time is not composed of indivisible nows." Aristotle was clearly right here, although he seems to have still believed that "nows" in time existed; it seems that he just could not quite decide how. Aristotle also applied this argument solely to the Arrow paradox, and saw the paradoxes of the Dichotomy and Achilles and the Tortoise as being different problems, and to be somehow tied up in the misunderstanding of the nature of distance, infinity and divisibility. If not by calculus, this is generally how the paradoxes have been treated by people ever since.

Very much later, however, the 18th century German philosopher, Immanuel Kant, took a groundbreaking look at the concepts of time and space. In his *Critique of Pure*

Reason (1781), he argued that space and time do not belong to things as they are in themselves, but rather to our way of looking at things. They are forms of our perception, and it is our minds that impose space and time upon objects, and not objects that impose space and time upon our minds. Kant correctly concluded that Zeno's paradoxes could be resolved by this realization.

In his 1891 Treatise, *Time and Free Will*, the French philosopher, Henri Bergson, also questioned the objective reality of space and time, and like Kant and Aristotle, seems to have been asking some of the correct questions about Zeno's paradoxes (if he also perhaps asked some of the wrong ones, including some that didn't make sense).

The mistake of the Eleatics arises from their identification of this [indivisible] series of acts, each of which is of a definite kind and indivisible, with the homogeneous space which underlies them. As this space can be divided and put together again according to any law whatever, they think they are justified in reconstructing Achilles' whole movement, not with Achilles' kind of step, but with the tortoise's kind: in place of Achilles pursuing the tortoise they really put two tortoises, regulated by each other, two tortoises which agree to make the same kind of steps or simultaneous acts, so as never to catch one another.

Henri Bergson

In respect to being on the right track with Zeno's paradoxes, in different ways, the same can be said for William James, Alfred North Whitehead, Leo Tolstoy, Abraham Fraenkel, Karl Popper, Gerald Whitrow, David Robjant, Frank Arntzenius, and several others.

(4) Although not really necessary until now, there are a number of points associated with instants of time, or the lack of them, that I would like to touch on. Earlier I explained that an instant in time could not exist, because if it did, as is its very nature, everything would by way of logical necessity also be frozen static at that instant. Although such a situation would enable a body to have a determined relative position, motion and change would be rendered impossible. Furthermore, everything would remain frozen at that instant, as by definition, an instant in time has no duration; there could be no progression. Incidentally, the same outcome would also result if an instant in time were hypothetically followed by a continuous sequence of further instants, as again, an instant has no duration, so neither could a further succession of them. In either case, rather than enabling motion, this would perpetuate a static instant in time, and change would be impossible.

However, there are some problems associated with such a conclusion. By definition, for something to be static, it must be *unchanging* for an extended interval of time. But how then could time be said to be frozen static at an instant when being so would require it to be static and unchanging for an extended interval? It seems a contradiction. In relation to a regular and sensible definition of static, this no doubt is a contradiction. When the definition is applied to time itself, however, a paradox appears. If there were such things as instants in time, everything, including clocks and watches, would also be frozen static, and interval in time would not be possible either. There could be no interval in time for something to remain unchanging. Thus, the normal definition of static breaks down when it is applied to time itself, and we are forced to search for a revised definition for this special temporal case. Thankfully, such a definition quickly becomes evident, and simply requires one to qualify the use of stasis by defining static and unchanging in the case of time as not being over

duration. At the same time, however, I think it should also be just enough to be aware of the problem of applying the notion of stasis to time itself and not worry too much about it, including in connection to the use of words like “remain” in this context.

(5) The question of interval’s existence is a very subtle topic, however, especially so because an assertion that is physical continuity which is basic and fundamental rather than interval, could equably be reversed, and interval in time and space be said to have physical existence (something which *could* be “measured”), this making physical continuity, and as such, motion and change possible. This is because both are completely indistinguishable, in so far as they both represent exactly the same thing (i.e. the capability for events to be continuous). Yet, they are also mutually exclusive, in that only one can be fundamental and come first. This poses a brilliant paradox, as, and although the same cannot be said for a specific interval of time or space due to, by definition, their requiring the existence of instants and spatial points to bound and determine their respective values as intervals, this indistinguishability also makes it impossible, in purely logical sense anyway, to say whether it is physical continuity, and as such, motion and change, which is basic and fundamental (with interval having no physical existence), or if it is the existence of interval which makes continuity possible.

However, I feel that once this paradox has been brought to light, it becomes evident that the indistinguishability between the two is the major cause of people mistakenly attributing physical reality to interval in the first place. They have not realized that there is a more basic explanation. I also think it doubtful that Nature would go to the trouble of giving interval in time and space existence, when just the presence of motion would fulfil the same purpose. It is surplus to needs and Nature is not silly. Finally, unlike us, without a need to “measure” intervals of time and space, She also has no reason to bother attributing reality to them! In respect to Nature having no need to attribute reality to interval (as well as to time and space in general), a similar thing could be said in connection to the universe not being conscious.

(6) A further implication of the work related to the question of whether or not time might be quantized and come in discrete atoms – particles of time. It becomes evident that there was no need in Nature for the existence of such particles to make possible physical continuity and progression, as the very reason events are continuous in the first place is due to there *not* being an atom or quantum of time.

We perceive space and time to be continuous, but if the amazing theory of loop quantum gravity is correct, they actually come in discrete pieces.

Lee Smolin

As such particles would represent a smallest possible interval in time – not just the smallest that we are able to represent with clocks, but which actually physically exist – such intervals would require starting and stopping points to bound and determine them. As was discussed earlier, however, if such stops – instants - existed, physical continuity, motion and change would be impossible. In addition to this, one could also argue that, because it is physical continuity which is fundamental, not time, it does not seem to make sense to talk of continuity being quantized.

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