# On the Problem of Cosmology and Time

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## *Introduction*

There has been voluminous writing on the subject of time, since the earliest ancient periods. One interesting dispute between the scientists and philosophers, on the one hand, and the theologians on the other has been this: Is there a *beginning* of time? It is the question that is the focus of this essay.

According to the Biblical Scriptures, *if we interpret them in a literal sense*, there was an initial time, when the material universe was created, *ab initio*. Many modern day cosmologists and physicists agree that there was such a singular moment in time. But they disagree with the religious fundamentalists on when this happened. To the fundamentalists it was around 6000 years ago. To the cosmologists it was around 15 billion years ago.

The religious fundamentalists base their opinion on their belief in the story of the creation (on their literal interpretation of the first book of the Old Testament – Genesis). The cosmologists base their conclusion on the *truth* of the Hubble law, that measures the rate of expansion of the universe as a whole, starting at some initial time when there was a 'big bang' to start it off. It should be emphasized that these two truths – *religious truth* and *scientific truth* – are different sorts of truth, one is irrefutable, since it is based on faith, while the other is refutable, since it is based on empirical testing and logical/mathematical consistency. That is to say, one cannot prove a scientific conclusion with a religious argument and one cannot prove a religious conclusion with a scientific argument – since religious truth and scientific truth are in different contexts.

There is also a cosmological model that asserts that before the presently observed expansion of the universe started at the last 'big bang', the matter of the universe was contracting, and after the present expansion it will again turn into a contraction, and eventually into an expansion again, and so on *ad infinitum*. In this view, the time of the latest big bang, 15 billion years ago, was only the beginning of the present cycle of an oscillating universe, from our particular reference frame, with no definite, absolute

beginning. *The question about the time of the beginning of the presently observed expansion is indeed a scientific question and requires a scientific answer*. But the question about the beginning of the universe, when all of the cycles started, *ab initio*, that is, the creation of the universe, is a theological question, not answerable in scientific terms, because
*it is based on religious truth.*

We will now discuss these ideas in a more detailed way, from the ancient periods to modern times.

*Ancient and Middle Ages Ideas of Time*

In ancient Greece, about 2300 years ago, Aristotle concluded that there is no beginning of time. His argument was as follows: 1. Time, by definition, is a measure of the motion of matter. 2. The reason that a given body moves is that it absorbed its motion (by an accident) from a *previous* motion (i.e. earlier in time). 3. The previous motion that affects the motion of the given body absorbed its motion from a still earlier motion, and so on *ad infinitum*. He then concluded that there is no absolute beginning of the earlier motions, and therefore no beginning of time.[1] He did concede, nevertheless, that there must have been an Ultimate Cause for these motions – a cause that we refer to as G-d. But in this context, there is no 'time' defined, pertaining to the creation of the universe, in Aristotle's view.

Ten centuries after Aristotle, in the Middle Ages, a Hebrew scholar Rambam (known in the Western world as Maimonides) did not agree with Aristotle.[2] He said, correctly, that a logical conclusion is only as true as its initial premises. He did not agree with Aristotle's premise that 'time', per se, is a measure of the motion of matter. Instead of Aristotle's definition, Rambam said that 'time' is a measure of the duration of matter. He said that when the matter of the universe was created, its duration was one of its qualities. Thus he agreed with the Scriptures that there was a beginning of time – the time of the creation of the universe.

However, according to Rambam's book, *Mishna Tora* (meaning the 'code of the Tora' – the biblical Old Testament) the truth of the Tora must be properly interpreted in a figurative sense, rather than the literal sense of the religious fundamentalists.

Eight centuries before Rambam's time, in the third century CE, the Christian theologian St. Augustine, discussed the concept of time in his *Confessions, Book XI*. He disagreed with Aristotle's conclusion that there was no beginning of time. As in Rambam,

he did not agree with Aristotle's definition that time is a measure of the motion of matter. He interpreted time as a measure of duration. But he did not interpret time as a quality of matter. Rather, he said that when God created the universe, He created matter and He created time, separately. The time was then available for the matter of the universe to endure in, as one might climb a ladder from an initial wrung at the bottom to succeeding wrungs. Thus, Augustine said that there was no 'before' to talk about, prior to the creation of the universe, since God had not yet created time. This view was then different from that of Rambam, who saw time as a quality of matter, and not separate from it. Rambam's view is more akin to that of Einstein, in his theory of general relativity, to be discovered in the 20th century, as a subjective element in the description of the laws of matter.

*Time in Einstein's Theory of Relativity*

The logical basis of the theory of relativity (in its special or general form) is 'the principle of relativity'. This is the assertion that the laws of nature must be fully objective – that their forms must be in *one-to-one correspondence* in all possible frames of reference, from the reference frame of any observer.[3] Einstein found that in order to maintain this objectivity of any law of nature, the language of space and time parameters to express this law must be relative to the reference frame. This is the origin of the word 'relativity' in the 'theory of relativity'.

At the initial stages of the theory of relativity, some physicists and others had the wrong impression about what this theory is about. They thought that it refers to the idea that 'everything is relative'. To correct this misunderstanding Einstein tried to change the name of the theory to: 'theory of invariants'. But the new name that came closer to the meaning of the theory, did not take hold.[4]

In the theory of relativity, the 'time' and the 'space' parameters and their connections form a language that is used to express the laws of nature. Einstein found that in order to use this language objectively, (i.e. to represent laws of nature that are independent of the reference frames in which they are expressed), the *measures* of time and space must be contracted in a reference frame that is in motion relative to the observer's frame. For example, when an observer talks about a time measure in a moving frame, he or she may have to put eight digits on the face of a moving clock, rather than the 12 digits on the face of his or her own clock. But this does not mean that anything physical has happened

to the spring behind the face of the moving clock, because of its motion relative to an observer, that does not happen to the clock of the observer's own reference frame.

Similarly this language translation of space and time measures does not signify that a human being moving away from another human being would age less than him, by virtue of his motion relative to the observer! The latter would be a physical effect that would have to be caused by intrinsic forces![5]

The transformations of the time and space parameters from one reference frame to another in the expression of a law of nature is analogous to translating a sentence between languages, say English and French, while maintaining the meaning of the sentence.

*The Problem of Cosmology and Time*

According to the theory of relativity, the temporal measure (and the spatial measure) must be relative to the frame of reference in which the law is expressed. There is no absolute frame of reference here, even that of the universe as a whole. Thus, there is no absolute time or space measure, as there is in classical physics. Thus, one may not postulate a cosmological model with an absolute beginning in time.

It then follows that the cosmological model, based on a singular 'big bang' at some initial time of the universe, is not compatible with the requirements of the theory of relativity. One may then ask the question: What was the state of matter of the universe before the big bang occurred, starting off the presently observed expansion? St. Augustine answered this question, as discussed earlier, by saying that there was no 'before' in existence. He said that when the universe was created at the initial cosmological time, an absolute time was then created along with it. But the theory of relativity rejects this answer because it rejects the concept of an absolute time.

In Newton's theory of universal gravitation, because of the mathematical separation of the space and time parameters, there is a prediction that all material bodies must circulate about other bodies, in stationary orbits, just as the planets of our solar system orbit the sun. On the other hand, in Einstein's theory of general relativity, the space and time parameters are not objectively separate from each other. There is a single spacetime wherein a purely time (or purely space) measure in the expression of a law of nature in

one reference frame transform to a mixture of space and time measures in other, relatively moving reference frames. Hubble's discovery in the 1920s, that each of the galaxies of the universe is moving away from any neighboring galaxy showed that the material elements of the universe are not in stationary orbits. Hubble's discovery ("Hubble's law") therefore confirmed the prediction of Einstein's relativity theory in the problem of cosmology. The Hubble law is: $v = Hr$, where v is the speed of one galaxy relative to another and r is their mutual separation. That is, as the separation between galaxies r increases, in the expanding universe, the relative speed v increases in linear proportion to r. The increasing value of v then signifies that the cosmic expansion is one of acceleration.

From a measurement of the Hubble constant H, one may then use Hubble's law to determine the time when the matter of the universe was maximally dense and when the 'big bang' occurred. This is the time of the 'beginning' of the presently observed expansion. It turns out to be the order of 15 billion years ago. But is this the moment of the *absolute beginning* of the universe?

The oscillating universe cosmology answers the question "How did the matter of the universe get into the state of maximum density when the 'big bang' happened?" by saying that before this occurrence, the matter of the universe was contracting from a less dense state. It then reached an inflection point where the repulsive component of the gravitational force in general relativity exceeded the attractive component and the contraction changed to an expansion once again. In this model, there is no absolute beginning of the universe; the cycles of expansion and contraction go on indefinitely.

Where do the attractive and repulsive forces come from in general relativity theory? They come from the terms that play the role of 'force' in Einstein's theory – that entail the 'affine connection'. These terms are not positive-definite fields. They can be positive, predicting repulsive forces under some physical conditions, and negative, predicting attractive forces under other physical conditions. Thus, when the matter of the universe is sufficiently dense and relative speeds are close to the speed of light, the mutual forces between matter constituents can be repulsive, predicting the expansion, and when the mutual forces are weak enough and the relative speeds are slow enough, the forces become attractive, predicting the contraction. This sequence of contraction and expansion of the universe continues indefinitely into the past and future according to the oscillating universe cosmology. It is compatible with the requirements of the theory of general relativity.

One might then ask: When was the actual beginning of all of the cycles of the oscillating universe? That is, when was the universe created, *ab initio*? This is not a scientific question; it is a theological or a metaphysical question, based on faith. It is akin to Aristotle's postulation of an 'Ultimate Mover'. There is no scientific answer here because 'scientific truth' is not the same sort of truth as religious truth. The former is a contingent truth that is in principle refutable while the latter is irrefutable since it is based on faith.

*The History of the Human Race According to Competing Cosmologies*

The single big bang model is the commonly accepted cosmology today. In this view, there was a singular event at an absolute point in time, when the universe started to expand, monotonically. Eventually, in this view, all of the stars and galaxies will use up their nuclear fuel and the entire universe will become a homogeneous cosmic dust, continuing on an everlasting expansion and ever-increasing rarefaction of its matter content.

Along the way, during a relatively infinitesimal time (compared with the infinite lifetime of the universe), planets are formed in the universe (including Earth) where the conditions are conducive to the development of life forms, including the human race. Then, after a relatively short time, the Sun, in our planetary system, will use up its fuel, and the human race will have frozen out of existence, disintegrated and mixed with the other global cosmic dust.

With this scenario, it appears that the existence of the human race was strictly an accidental occurrence during the monotonic expansion of the universe as a whole, never again to happen.

What is the scenario for the human race according to relativistic cosmology and the oscillating universe? Instead of freezing out of existence, as in the single big bang model, the human race would heat up during a contraction phase of the universe, as it approaches maximum density. The human race would then eventually vaporize, joining the rest of the material universe, to form a maximally unstable 'matter soup', from which the next big bang and the expansion would ensue.

As the expansion in the next cycle of the oscillating universe would evolve, the matter of the universe would cool down and eventually galaxies, stars and planets would form. Some of the planets would have prevailing conditions that are conducive to the formation

of life. A human race would then evolve once again, as it has happened in an indefinite number of previous cycles and will continue in future cycles.

We may then conclude with this cosmology that the human race is not an accident that occurred over an infinitesimal time of the evolving universe. Rather, the human race is just as old as the universe itself and it is a part of its intrinsic order.

Thus, in answer to the question at the start of this essay, we may conclude that an implication of Einstein's theory of general relativity is that there is no beginning of time. This agrees with Aristotle's conclusion – but coming now from the view of what we have learned in theoretical physics in the thousands of years since his time.

The cyclic behavior of the universe may be compared with local cyclic behaviors, such as the seasons of the Earth. With cyclic behavior as a local truth of nature, why should it not also be a truth of the universe as a whole? Einstein's theory of general relativity does give credence to this idea.

*References*

1. McKeon, R., *Basic Works of Aristotle* (University of Chicago Press, Chicago, 1941).
2. Maimonides, M., *The Guide of the Perplexed,* editor, S. Pines, (University of Chicago Press, Chicago, 1963).
3. Sachs, M., *Relativity in Our Time* (Taylor and Francis, London, 1993).
4. Holton, G. and Elkana, Y., editors, *Albert Einstein: Historical and Cultural Perspectives* (Princeton University Press, Princeton, 1982).
5. Sachs, M., *Physics Today* **24**, 23 (1971).