LETTER TO THE EDITOR: ON A NON-CONTRADICTORY BEGINNING OF THE UNIVERSE

CARTA AL EDITOR: SOBRE UN COMIENZO DEL UNIVERSO NO-CONTRADICTORIO

F. L. Falcón

Materials Science and Technology Institute, University of Havana. falcon@imre.oc.uh.cu

If you want to see the invisible, carefully observe the visible.

Talmud

A review of the different models about the origin of the universe under discussion nowadays shows that they don't resolve the contradiction between the universe with a beginning versus the universe having existed forever in the past.

However, there is a possible solution to this contradiction which was surmised in the fifth century BC by Zeno of Elea. One of his famous paradoxes states that if we want to cover any distance previously established with steps that are always a fraction of the remaining distance to cover, we never reach the end. In other words, it would be necessary to make countless steps to cover the total distance.

Let's take a look at the main structural states of matter arisen during the evolution of the universe and the estimated times when these changes have occurred [1]:

Table I

Time of events	Time lapses relations
10^{-43} s: non-differentiated forces	10^{-24}
10^{-34} s: elementary particles soup	10^{-9}
10^{-10} s: formation of protons and neutrons	5.55×10^{-13}
3 min: atomic nucleus	1.93×10^{-11}
300 000 years: atoms	3×10^{-4}
10^9 years: stars (with the subsequent formation of atoms more complex that hydrogen)	

The time lapses relations in the table shown above point out the quotient between the time elapsed from $t = 0$ to the occurrence of event denoted in the corresponding line, and the time elapsed from $t = 0$ to the occurrence of the next event. As we can see, these relations exceedingly fulfill Zeno's paradox. The overall tendency to retardation of changes in the state of the universe could be explained by taking into account the combination, on the one hand, of its ever existing expansion and, on the other, the limited value of the velocity of interactions between its different constituents, i.e., the velocity of light in the vacuum, c.

This result suggests a model of the universe with a beginning in time but with infinite states of matter in its past. Such model reconciles the contradiction mentioned at the beginning of this paper, by fulfilling both requirements: firstly, the law of conservation of matter and, secondly, the experimental data suggesting the existence of a beginning in time for the known universe.

In Table I we see that elementary particles arose at approximately 10^{-34} seconds later than $t = 0$ and, taking into account that our reasoning was reached by paying attention to the data on the evolution of baryonic matter, it raises the question whether Zeno's paradox would also be fulfilled for $t < 10^{-34}$ s.

In this direction, there isn't any physical argument against the assumption that the expansion of the universe holds for all kinds of matter (mass or energy) and therefore, this process must have taken place for $0 < t < 10^{-34}$ s as well. In this pre-baryonic universe with pure undulatory behavior, the oscillation frequency of its states necessarily depends on the universe volume, in a similar way that the pitch of a string musical instrument depends on string size, according to the relation $f \propto 1/l$, where f is the oscillation frequency and l the length of the string.

For times nearer to $t = 0$, that is, for smaller volumes of the universe, higher oscillation frequencies of the energy states will be expected and consequently, smaller duration of each of such states, fulfilling Zeno's paradox. As expressed in [2] "the universe looks like a very peculiar book. As we flick through it to get back to the beginning, its pages get thinner and thinner. An infinity of pages need to be flicked through to get to the start of the beginning, and we can never read the author's preface."

The early universe was a quantum-relativistic system and, for this reason, time and spatial dimensions were not exactly determined, but the relation of frequency of states, time and spatial dimensions corresponding to an expansion process must have taken place in order to fulfill the causality principle. Following what have been exposed before in this letter, there exists the possibility, inferred from logical and physical facts, that the universe had a beginning in time and, at the same time, a sequence of infinite states toward the past, obeying Zeno's paradox with the consequent elimination of one of the fundamental contradictions in cosmology.

[1] E. Chaisson, *Cosmic Evolution: The rise of Complexity in Nature*, (Harvard University Press, 2001).
[2] J. P. Petit and G. d'Agostini, paper presented at the *International Meeting on Variational Techniques* (CITV), Le Mont Dore, 2007.