Paper Title: Implications of a Finite Universe
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Abstract:
The cosmic data of NASA´s satellite WMAP (Microwave Anisotropy Probe), as reported by the New York Times in February 11 of 2003, basically confirmed the Big Bang theory and gave an estimate of the "age" of the Universe to be $(13.7 \pm 0.2) \times 10^9$ years, previously anticipated by work based upon Einstein´s standard cosmological equations. This is a finite number as are $Ro \approx 1.38x10^{28}$cm approximately (present radius) and $M_u \approx 4.09x10^{54}$g (total mass) of the observable universe.

Einstein's equations with zero cosmological constant lead to the conclusion that the term involving $c^2|k|$ (space curvature in an open universe) remains negligible for ever if M_u is <u>infinite</u>, but becomes dominant at $R>R+\approx 2GM_u/C^2|k|$ when M_u is <u>finite</u>, no matter how large.

In agreement with the previous estimate, the total mass of the observable universe is given by $(M_u) \approx <Ng><Ns>M_s \approx 2x10^{54}$g, where $<Ng>\sim 10^{10}$ (estimated number of galaxies), $<Ns>\sim 10^{11}$ (estimated number of stars per typical galaxy) and $M_s \approx 2x10^{33}$g (mass of an average star, like the Sun).

What are the implications? Focusing on the metaphysical implications, it is clear that a <u>finite</u> physical universe is <u>contingent</u> (non necessary), and, therefore, <u>created</u>. The above considerations will be contrasted with speculations based upon inflationary cosmology.

Biography:
Julio A. Gonzalo is Professor of Physics at the UAM and is the author of several books on Condensed Matter and on Cosmology, the latest "Inflationary Cosmology Revisited" www.worldscibooks.com/physics/5748.html In 2003 he was awarded the Medal of "Alfonso X El Sabio" by the Government of Spain.

Paper Text:

1. The Paradox of Olbers

In 1869, Professor Stanley L. Jaki, later to be the 1987 Templeton Prize on Science and Religion, published his scholarly book on "The Paradox of Olbers´ Paradox"(1).
As it is, (or rather as it should be), well known, Olbers´ Paradox consists in the puzzle posed by the darkness of the night sky, which should be ablaze at every point if the universe were infinite and filled everywhere with stars and galaxies. We know that the number of stars is about 10^{10} in a typical galaxy (like our Milky Way), a finite number, and also that the total estimated number of galaxies in the observable universe (the only

Universe about which were are entitled to talk) is about 10^{11}, both numbers, very large, are therefore, finite. This is consistent with the observed darkness of the night sky. Otherwise we would see a continous bright sky either with the average brilliance of an average star (if each galaxy contained infinite stars), or with the average brilliance of an average galaxy (if the universe contained infinite galaxies).

As Professor Jaki points out in the Introduction, there is an experimental approach to science which shows a long series of steps which precedes an incoming achievement. The survey of the past often contains vital lessons. Since contemporary human culture is influenced by science in an increasing proportion, it is very informative to take a long look at the potentialities and limitations of the road of science, paying due attention to the attitudes, qualities and shortcomings of its practitioners.

The story unfolded in "The Paradox of Olbers´ Paradox" has a paradoxical character in the sense that the publications which constitute the major milestones in the story, were not consulted by most of those who discussed the question since the middle of the nineteenth century or so. The original texts of Halley , Cheseaux and Olbers are given in the book in order to put into proper historical perspective the meaning and significance of the paradox.

Ever since Wilhem Olbers reformulated the paradox in 1823, he and many others after him, tried to "save" the pretended infinity of the Universe. At least some of them did so for undue reasons: an infinite Universe could be taken as the ultimate entity, and could therefore serve as a substitute for God. But in so doing they had recourse to artificial and/or false arguments.

Professor R.H. Dicke, from Princeton University, commented on the first edition of "The Paradox of Olbers´ Paradox": "Professor Jaki has considered with great care the origins, history, and significance of this question and his scholarly, but interesting and readable work will be <u>the</u> definitive historical statement for years to come".

Professor Michael Hoskin, from Cambridge University, said: "Professor Jaki´s book will be of as much interest to the educated people eager to have an insight into de often strange workings of the scientific mind as it will be to professional astronomers and historians of science".

Let as summarise the contents of chapter eleven, "Paradoxical Solutions", an entirely new chapter in the June 2000 "Real View Books" enlarged and entirely reset edition of Jaki´s book. He notes that in the previous three or so decades a "scientific" solution of the paradox was not worked out. "By that solution, specific quantitative results are meant and not merely the fact…that acceptance of the finiteness of the Universe provides the logical framework if such a solution is to be arrived at. The solution must contain a derivation of the actual degree of darkness of the night sky from other physical factors, all specified in quantitative terms. Those factors have grown in number as more and more has been learned about previously unsuspected celestial bodies, and instruments of observation also have become available that were not even imagined thirty years ago".

Paradoxical features are to be expected, even if one assumes that in order to give that solution, one may practically abstract from making a choice between finite or and infinite universe as one derives the degree of darkness at night from a set of finite quantitative values. Ultimately, the choice between finite and infinite universe is not scientific…"

"The reality of strict totality of a fully coherent things, which is the universe writ large, can be demonstrated only on strict philosophical grounds (2). In a far deeper sense than Kant ever suspected, the universe is one of the three mayor topics of metaphysics. Kant listed the soul and God as the two others: contrary to Kant, non of those three are the bastard products of the metaphysical cravings of the intellect. He was, of course, right in claiming, that once one of those three is proven to be such a product, the two others also turn out to be such if one is consistent with one´s argumentation. He was also right in his strategy that the best way of discrediting the notions of soul and God is to begin with applying the pseudo metaphysical crowbar and monkey wrench of "critical" reason first to the notion of the universe".

It is sufficient to recall that the best description of cosmic affairs is given by the Big Bang concept, pioneered by George Lemaitre, later developed by Gamow and co-workers and now almost universally accept, to recognise that: "The expanding Universe is the business of a finite amount of matter and therefore of a finite amount of light-emitting bodies within a finite space-time". This gives a reasonable enough justification of Olbers´ Paradox.

A number of cosmologist, as shown by Jaki in the last chapter added to his book, did not succeed in attempts during the last thirty years, to keep alive the paradoxical character of Olbers´ Paradox. Olbers, like J. Gribbin (3) managed to conclude from the consideration of the dark night sky, that the universe is finite: "The most fundamental observation in all of science is that night follows day. This simple fact is enough to show that the Universe has not always existed, everywhere, in the form that we see it today. There must be an `edge´ to the Universe…"

At the end of the chapter, it is shown that in recent times serious contributions to the understanding of Olbers´ Paradox have been given by R.Kippenhahn (4) (Max Planck Institute, Munich) and B.M. Tinsley (5) (Yale University Observatory).

2. The results of WMAP and their implications

On February 11th, 2003, the spectacular cosmic data acquired by the NASA satellite WMAP (Wilkinson Microwave Anisotropy Probe) made front page news in the "New York Times" and the following day in the main dailies around the world. The report gave an spectacularly precise "age" for the Universe (time elapsed between the moment of the Big Bang and the present): 13.7 billion years.

While the age of the Universe given by the WMAP does not fit exactly with the ages gived in Alan Guth´s “Inflationary Theory” (which became exactly twenty five years old this year), the “New York Times” report presented the NASA´s satellite data as confirming that theory, which postulated a tremendous expansion of the universe radius “R(t)” at a very short time, 10^{-39} sec after the Big Bang. The energy density of the cosmos would have remained constant during the very short inflationary period, under strict physical conditions, far removed from anything accesible now at the largest accelerators in the world.

As it is well known, Astrophysical Cosmology, as a scientific discipline, gives the first tentative steps in the first decades of the 20^{th} century, with the first consistent theorical formulation given by Albert Einstein within the framework of his General Theory of Relativity, and with the first systematic observations of the general recession of the galaxies from each other as first observed by Melvin V. Slipher and later painstakingly studied by Hubble and Humason at the large telescopes of Mount Wilson and Mount Palomar in California.

From the cosmological equation of Einstein, the Russian mathematician Alexander Friedmann first, and them the Belgian priest George Lemaitre, former artillery man during the first World War (later to become president of the Pontificia Academia Scientiarum under Pius XI and Pius XII), obtained explicit solutions for R(t), the radius of the Universe, as a function of time, which implied very large velocities of expansion, resulting in large recession velocities for the galaxies, of the order of c , velocity of light. In fact, Lemaitre, with his hypothesis oh the exploding cosmic primeval atom, became the true pioneer of the Big Bang concept.

By the middle of the last century, two cosmological theories were in dispute for the primacy: the “Steady State Theory” proposed by Gold, Bondi and Hoyle, and the “Big Bang Theory”, based upon a seminal idea of Lemaitre and later developed by Gamow, Alpher, Herman and others. The Steady State Theory postuleted a continuos growth of the universe’s radius “R(t)” at <u>constant density</u>, something very similar to what Alan Guth, in his “Inflationary Theory”, would postulate later, albeit not as drastic. In both cases, however, the principal of mass-energy conservation was violated in the process of expansion.

In this respect, it is worthwhile to bring forth the words of a great British astronomer and theoretical physicist, Sir Arthur S. Eddington, in his “Fundamental Theory” (Cambridge, 1949):

> *“We are of course allowed to rearrange the matter of the Universe… But in such rearrangement the experimenter <u>cannot</u> and the theorist <u>must not</u>, violate the conservation of energy”.*

The report of the cosmic background radiation in 1965 by Penzias and Wilson was instrumental in discrediting the “Steady State Theory”. Thirty, fourty years later, the results of COBE (1990) and WMAP (2003)and very specially the “age” of the Universe given by the later (13.7×10^9 years) could be correctly interpreted (6) without recourse to the “Inflationary Theory” and their implicit assumptions (large amounts of dark matter, dark energy…) which necessarily imply

$\Omega = \rho/\rho_c = 1$ (ρ_c= time dependent critical density)

Already from classical antiquity (7) different schools maintained different views on the finite or infinite character of the Universe. The Stoics conceived the Universe as an infinite extracosmic vaccuum surrounding a finite Cosmos, composed by a finite number of stars. The Epicureans on the other hand, represented by the Roman philosopher Lucretius ("De Rerum Natura") saw the Universe as composed of innumerable worlds filling infinite space, each in turn composed of atoms ruled by "natural laws".

In the 17th Century, Rene Descartes ("Principes de Philosophie") defended that matter extended itself infinitely in all directions. Newton, on the other hand, attributed a finite extension to the starry realm, surrounded by an infinite and eternal space. Olbers´ Paradox, as noted above, was pointed out later in the game. It suggested very clearly a finite Cosmos.

What are the implications of the most recent observational data about the finitude, or lack of it, of the observable Universe?

First, we must say that lately, and with ever increasing boldness, it has become a respectable fashion among cosmologists to talk about "multiverses", each characterised by a different set of characteristic universal constants (G = gravitational constant, c = velocity of light, h = Planck´s action constant, etc) with different characteristic numerical values in each one of them. Unrestricted combinations of numerical values, different from the corresponding values in our observable Universe, would produce infinite imaginary aditional universes.

To answer the question above we will consider only the observed Universe, with a set of well known universal constants. Einstein´s (8,9) cosmological equations for a homogeneous universe with spherical symmetry (and zero cosmological constant, $\Lambda = 0$) reduce to

$$\frac{1}{2}\left(\frac{dR}{dt}\right)^2 = \left(\frac{GM_u}{R}\right) - kc^2, \qquad [1]$$

where k<0, i.e k=-|k|, being the spatial curvature negative if the Universe is open (expanding in our local neighbourhood at velocities larger than the escape velocity), G is Newton gravitational constant, M_u the total mass and c the velocity of light.

WMAP´s data, based upon a Hubble constant (H = (dR/dt)/R) value and the local known cosmic mass and energy density values, allow one (6) to get from Eq [1] the following set of cosmic values

$$t_0 = (13.7 \pm 0.2)10^9 \text{ years}, \quad R_0 = 1.38\text{x}10^{28} \text{ cm}, \quad M_u = 4{,}09\text{x}10^{54}\text{g}. \qquad [2]$$

It may be noted that in Eq [1], for M_u infinite, (physically not conceivable, and mathematically conceivable only as a limit). The second term in the right hand side, involving |k| c^2, becomes always negligible, and ceases to play any meaningful role in the description on the time dependence of the cosmic radius R(t). This is tantamount to say that the curvature becomes negligible, $\Omega = \rho/\rho_c=1$ always, as the "Inflationary Theory" postulates. Then, large amounts of dark mass and dark energy become mandatory.

On the other hand, the value of $\Omega = \rho/\rho_c \sim 1$ at cosmic conditions back in the space-time sphere corresponding to the background cosmic radiation, is perfectly compatible with $\Omega_0 = \rho_0/\rho_{c0}=0.04$, being now

$$\rho_{co} = \left[\left(\frac{dR}{dt} \right)_0^2 \Big/ R_0^2 \right] \left(\frac{1}{8\pi G/3} \right),$$

the critical density at present space-time.

The total mass of the Universe can be obtained directly, on the other hand, using

$\langle Ng \rangle \sim 10^{10}$ galaxies, $\langle Ns \rangle \sim 10^{11}$ stars / galaxy, $Ms \sim 2x10^{33}$g

for the total number of observable galaxies, average total number of stars per galaxy, and typical solar mass for a star, respectively. This gives

$(M_u)_{obs} \sim \langle Ng \rangle \langle Ns \rangle Ms \sim 2x10^{54}$g (large but finite)

What are the metaphysical implications?

The implications are clear: Our physical Universe is finite, and therefore, contingent (non - necessary) and therefore, created. Sophisticated theories which elude recognising the finiteness of observable Universe, like the "Multiverse Theory", or the "Inflationary Theory", are artificial and shallow.

As it is well known, Saint Tomas Aquinas in his "Summa Theologica", very competently summarised and annotated by Peter Kreeft (10), discusses the question "Whether God Exists?". He begins putting forth two powerful objections to answering in the affirmative.

Objection 1: If "God" is infinite goodness, there would be not evil.

Objection 2: If all natural things can be reduced to one principle (nature) and all voluntary things to one principle (human reason or will) "God" is superfluous.

Before coming to a direct (metaphysical) proof of God´s existence, in essence, the argument from the existence of contingent (non necessary, finite) beings, the two objections are shown to be invalid:

Objection 1, because as Saint Agustin points out, OK, "If there is God, how can there be evil?", but them, one is entitled to reply, "If there is no God, how can there be good?"

Objection 2, because one is therefore forced to reduce artificially human reason or will to nature, without any valid reason, or one is forced to reduce nature artificially to human reason or will.

In the first case, God the Creator as a single principle is substituted by an artificial "panteistic" god. In the second, by an equally artificial "solipsistic" ego ecuated to a god.

Saint Thomas, direct cosmological argument from "contingency" can be stated using his Third Way (11): "We find in nature things that are possible to be and not to be (contingent), since they are found to be generated and to corrupt…But it is impossible for these always to exist…Therefore, if everything were contingent…There would be nothing in existence (now)". We know today, with the support of the scientific facts and solid theoretical arguments, that the stars are "generated" and "corrupted" and have finite masses, the galaxies are "generated" and "corruptible" and have finite masses, and the entire universe appears as "generated" and "corruptible" and has a finite mass and a finite space-time.

The spectacular announcement by NASA´s WMAP satellite that the time elapsed since the Big Bang is $(13.7\pm0.2)10^9$ years, is an striking confirmation of the finite and contingent character of the observable Universe as a whole.

We must not worry excesively about "unobservable" universes.

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