

TIME DISPLACEMENT AND THE BIG BANG

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For the Pleasure of

and for Helen, Kenneth, Michael and Anne.

ABSTRACT

In fairly recent times, accepted standard theory has been questioned and alternative symmetries considered. To the writer's knowledge, no suggestions have been put forward concerning a possible origin of the universe that depends on time symmetry. This paper proposes possibilities based on such symmetry to suggest the notion that the 'Big Bang' was the culmination of a process occurring before it.

Key words: Time, Big Bang, First Cause, General Relativity.

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1. INTRODUCTION

There exist a mountainous number of papers on theoretical aspects of the origin of everything with many papers covering the same ground. Many use the Relativities without question and many have a stringy/M-theory approach. Some works are just reviews whilst a few others take a novel approach such as the varying speed of light. These few then mother papers by others who criticise and in turn, those criticisms are dealt with by yet others in further works. So it goes on with occasional small steps forward when someone has an original thought.

It is perhaps unfortunate that original thoughts on major aspects are few and far between. That is not to say that some workers have good original ideas concerning some aspect of a particular topic that has the capability of being well received by peers. In that case, reputation is enhanced whereas severe peer rejection can destroy a career. Understandably, workers have to be cautious.

Many theories and models of the universe have the same feature. They do not explain how and why the origin occurred. Career safety is ensured by concentrating on aspects within aspects within aspects (repetition intended) of well-worn theories that fail to explain the how and the why. After all, no matter how well founded, who except the insane, would title a paper ‘Newton’s Laws of Motion May Now be Consigned to the Rest of the Trash’? Again, who but the insane would agree to publish such a paper? If that were to be, many would mount a criticism without even reading the work and many would do the same after reading only its Abstract. The poor author would find a note in his or her in-tray reading “My office Monday morning at 09.00 without fail and clear your desk now”.

Who then is in a position to take a contrary stand to that generally accepted and remain fairly safe? Firstly, Hawking, Gasperini, Tipler and all those other workers of highest repute and beyond reproach who seize attention whenever they publish. Secondly, those who have no reputation and/or career to lose.

In this paper, ‘Big Bang’ means the hot, dense early phase of our universe, the initial singularity, an absolute beginning of space, time, and energy.

‘Universe’ (or ‘world’) means everything (physically) in existence, ever, anywhere, the observable region we inhabit (about 27 billion light years in diameter) plus everything that has interacted or will ever or at least in the next few billion years interact with this region and any system of causally interacting things that is greatly distanced from us.

The question asked is not whether General Relativity (GR) has stood the test of time but whether it is sufficiently and intrinsically well conceived to provide a true explanation of most aspects to do with the universe, especially the origin question.

There is little point in covering well-trodden ground concerning the achievements of GR and reiterating the point that in some literature as well as television documentaries the Big Bang theory is presented as an historical fact.

GR was Einstein's theory of gravity that with little effort involved has been extended to conceive a theory of origin, but with certain problems arising. It may well be that such formulations are the best that exist at the present time. Of itself, that does not entitle 'the best there is' to be revered and elevated to the status of absolute truth unless it is the absolute truth.

The writer has already pointed out that the three tests of GR proposed by Einstein can be achieved by other means (1B). Here, one may think that any alternative method means little and does not take anything away from GR. The writer would agree, but that is not the question asked.

In physics, there are many entrenched so-called basic principles that are taken to be true. One of these is the constant velocity of light in a vacuum, but more will follow on that later. Another is conservation of energy.

Taking the view that whether the universe is single or a multitude of universes, that is all there exists. Conventionally, energy cannot escape to some other place because there is no other place. In itself, that type of reasoning justifies the conservation law. 'Law' because for the writer, that word connotes a basic truth as opposed to descriptions of physical manifestations called 'rules', 'propositions', 'theories' and the like.

Does GR violate the law of conservation of energy? If it does, everything stemming from it should be suspect.

Consider electromagnetism and charged matter in the presence of each other, the total energy-momentum tensor being

$$T^{\mu\nu} = T_{matter}^{\mu\nu} + T_{e-m}^{\mu\nu}$$

Matter will couple with the radiation in accordance with Maxwell's

$$\frac{\partial\sqrt{-g}}{\partial x^\nu} F^{\alpha\nu} \frac{1}{\sqrt{-g}} = -j^\alpha$$

In which case,

$$T_{;v}^{\mu\nu} = \rho \left(\frac{\partial u^\mu}{\partial x^\nu} u^\nu + \Gamma_{\nu\lambda}^\mu u^\lambda u^\nu \right) - j^\alpha F_\alpha^\mu = 0$$

In simple terms, what does that mean? The energy-momentum tensor of electromagnetism and matter are conserved. What then happens if there is any alteration in the speed or velocity of the matter and/or some alteration in the

wavelength or frequency of the radiation? The next question is to ask why there should be any alteration? The answer is that alteration is brought about by spacetime curvature. The result is that independent of any existing gravitational field, energy conservation is violated.

Without the momentum, stress and energy of the gravitational field being properly defined by GR, caution is required when predicting processes at the time of the Big Bang.

It is a matter of history that the ‘heretic’ Galileo was punished for criticising the held beliefs at the time. As everyone knew well, the Sun circled the Earth. In modern times, the achievements of GR have generated its monopoly and criticisms of it are sometimes akin to Eric Laithwaite’s suggestion that Newton’s laws of motion may need to be re-examined. We all know that the ‘Titanic’ was built to be an unsinkable ship.

It is known that the cosmic background radiation is not smooth but has a granular appearance. It is also known that there are large voids between galaxies and clusters of galaxies. GR cannot account for these because it is a field theory and applications to the cosmos are founded on an isotropic and homogeneous medium and for the writer, it is no excuse to argue that our universe is very nearly isotropic as well as homogeneous. It may well appear that way on a small scale but it is certainly not that on the large scale.

Taking it as true that the expansion of the universe is accelerating and caused by the ‘cosmological constant’, the gravitational attraction between two separating masses would require a positive constant which, beyond some critical separation, would need to suddenly increase in value to provide the acceleration..

Einstein told us that matter tells spacetime how to curve and spacetime then tells matter how to move. It should be remembered that ‘spacetime curvature’ is synonymous with ‘gravitational acceleration’.

The deSitter solution to the general equation places matter density as zero. The result is a universe possessing gravitational acceleration but devoid of matter. Admittedly, the deSitter solution is not applicable to our universe but shows that for such a hypothetical universe, the presence of matter is not required and gravitational acceleration will exist regardless of it. That means there exists a non-unique solution to the general equation. That is usually passed off as ‘a special case that does not occur in nature’.

GR fails to indicate what type of universe we live in. The theory contemplates a universe that is either static, forever expanding or oscillating, all depending on the value of the cosmological constant.

Concerning the question of the origin, it is widely admitted by theoreticians that GR and conventional mathematics break down as the origin is approached. That necessitates extrapolation to $t = 0$ using mathematics that is neither applicable nor justifiable at $t = 0$. The reason for the breakdown is simple. GR represents spacetime as a smooth (hydrodynamic) continuum. In addition, GR completely ignores quantum effects that dominate in the physics of the very small. The same applies at the end of the universe in the so-called proposed 'Big Crunch'.

A critical examination of cosmology is that of M.J. Disney (2) and the Abstract to his paper is worth setting out.

“It is argued that some of the recent claims for cosmology are grossly overblown. Cosmology rests on a very small database: it suffers from many fundamental difficulties as a science (if it is a science at all) whilst observations of distant phenomena are difficult to make and harder to interpret. It is suggested that cosmological inferences should be tentatively made and sceptically received.”

His section on pathologies of cosmology is also worth quoting. Because the number of practitioners per relevant observation is ridiculous, “...the same old things have to be said by the same old people...over and over again. For instance “Cold Dark Matter” now sounds to me like a religious liturgy which its adherents chant like a mantra in the mindless hope that it will spring into existence.

...working on the faintest objects ever observed ... by definition [means] they contain the least information ever detected...statistical studies of faint objects can keep a career going for ages without the need for a single original thought – or indeed a genuinely clear result.”

To summarise, what is the legacy of GR. That is, where are we now with it?

Robertson and Walker used their own metric for an isotropic and homogeneous universe requiring absolute time (3) and in such a universe, the Hubble constant and the age of the universe are absolutes

Gödel showed that an isotropic, homogeneous, rotating, non-expanding universe will have closed time-like curves and Raychaudhuri (4) achieved the same but with the universe expanding even with a cosmic microwave background radiation (5)(6)(7)(8).

The cosmology arising from GR includes a preferred frame, absolute time, absolute space, isotropy and homogeneity. It may be rotating or not but it is expanding, having arisen from a Big Bang. Most importantly, the Big Bang is the single creating event, the origin of space, the start of time and is 'the first cause'. In that scenario, to ask what there was before the Big Bang is as

meaningless as asking “what is North of the North Pole” or, “what is the most Western point on the Earth?” There was no ‘before’.

If the Big Bang is taken seriously as a matter of belief, that does not admit any question concerning ‘the before’. With an element of suspicion, the question becomes valid and of interest. Indeed, it may be that the concept of time is not intrinsic to the universe but is one of many human creations used to measure what we see. If that is the case, the universe would make no distinction between what we call ‘the before’ and ‘the after’ but human notions of physics would.

The task here is to attempt to establish structure that supports solitonic radiation as set out in (1A). In that work, there were just two basic criteria, those being that the universe is a very simple system and, nothing unreal can exist. These criteria will remain adhered to.

Wherever possible, the writer will attempt to ‘paint’ mental images and visualise what is going on using the simplest of language and in everyday terms. The reason for that is to avoid conclusions sometimes seen in papers based on some final equation or set of equations that when put into words sound ridiculous.

Before proceeding, the writer will take it that the origin of the universe as contemplated by GR is accurate and it matters not (at the moment) that GR is incapable of getting very near to the primordial singularity. It is now asked what alternatives there are, in very simplistic language.

Alternative 1: Imagine a certain state of affairs persisting for a certain clock time. Never mind the details. That physical system evolved to a state where it underwent a phase transition and now endures in that new phase under the physical circumstances in which it finds itself. Could that phase transition have been the Big Bang?

Alternative 2: The original physical system still persists today without undergoing any transition, it having evolved from the simple to the apparently complicated but with a simple basis.

In those alternatives, the question of the cause of creation of the physical system remains to be answered. The question is what was there (if anything) before the Big Bang? The alternatives for that are

Alternative 3: Before the system, there was nothing and suddenly, there was a Big Bang.

Alternative 4: The system had always been present and always will be. This reasoning follows the Continuous Creation theory of Hoyle in that the universe is eternal.

Alternative 5: The system evolved to a point where either it became unstable or interacted in some way resulting in a Big Bang.

At the moment, the writer merely suggests without preferring any alternative or suggesting anything more.

The paper by Ponce de Leon titled 'Equivalence Between Space-Time-Matter and Brane-World Theories' (9) shows that two apparently different theories are the equivalent of each other. On the one hand there is the Randall-Sundrum braneworld description and on the other, the induced matter theory formulated in 5-space without any compactification of the extra dimension.

The induced matter scenario is due to Wesson (10) who showed that in 5-space, concepts of mass, length and time as well as matter fields arise from the extra dimension without loss of symmetry and with GR in 4-space being recoverable.

One braneworld description (11) envisages our universe as a brane, being a domain wall on the bulk. The bulk is a black hole in 5-space (AdS_5). Matter interactions are on the brane whereas gravity can also propagate on the 11-D manifold by way of closed strings. The fields of the standard model are due to strings whose endpoints are confined to the 10-D hypersurface of the brane and the manifold on one side of the brane is the mirror image of the manifold on the other side of the brane (Z_2 symmetry).

In 'The Big Bang as a Phase Transition' by Liko and Wesson (12) a solution to the induced matter theory can generate a simple braneworld cosmology. As the reasoning is fully set out in that paper, suffice to say that classically, the Big Bang appears as a first-order thermodynamic phase transition or in a quantum sense, a discontinuity in a Higgs-type scalar field (First Alternative).

Having pointed to shortfalls of GR, this is an opportune point to consider why cosmologies founded on it are so seductive.

To avoid the question of the first cause, Einstein established a geometry he found most suited, that being the geometry of a universe that always was and always will be, that is, static. Then, he used that preferred geometry based on a dust model to establish the energy-momentum tensor needed to produce it. To keep the universe static, the cosmological constant was introduced. The problems arose when Friedmann omitted the constant and produced three expanding models for three different curvatures, all of which showing a beginning in the finite past. Expansion was then confirmed by Hubble.

Gamow et al showed that the origin must have been very dense and very hot with thermal radiation still visible today. The Big Bang theory then dominated over others after Penzias and Wilson detected that supposed visible radiation predicted, with just about the correct temperature. COBE data showed the

correct spectrum with small temperature fluctuations of the correct magnitude to grow into galaxies and clusters.

If GR is correct, there is no way in which the initial singularity can be avoided, whether the model is uniform or not. In GR, time and space had a moment of creation with no moments before because there was no before.

Taking matters a step forward, for galaxy formation, the initial event could not have been exactly uniform with no fluctuations. How could that initial event be so fine tuned to produce all we see about us as well as us? Taking a step backwards, at some moment positive of $t = 0$, density was Planck density whereas at $t = 0$, density was infinite.

All GR tells us is that without a proper theory of quantum gravity, there is a point beyond which we cannot go and asking what caused the Big Bang has no answer. Adhering to GR paints the picture of the universe starting with a bang and ending with a crunch with nothing before and nothing afterwards. Very symmetrical since the universe starts and ends in a singularity. Of course, there exist bouncing universe (cyclic) models that give cold comfort to generations in the far future.

For the writer, all other aspects are side issues (such as inflation) that attempt to clear up problems in the basic model.

The reader can now understand the seductiveness of GR because cosmological models based on it have predictions that are apparently backed up by observations and measurements. In fact, GR is so seductive, its cosmology is often presented as fact and many cosmologists will not readily depart from it, either because of the 'Never Criticise Newton's Laws syndrome' or because there is nothing else worth talking about, or both.

One may now think that GR cannot be fair game for criticism. The reason that it is such fair game is due to one basic flaw that runs throughout the theory. The speed of light in a vacuum is not a constant.

The writer maintains that if the speed of light at the creating event was $c = 1$, there is no reason to say that c will endure as unity until the end of the universe. The speed of light may well vary over time but it can be made to depart from the usually quoted measurement when between Casimir plates and in controlled experiments, (13)(14), to cite just two references. However, make an observation or perform an experiment and c will have a specific value at that moment that may or may not be that usually quoted to many decimal places.

To digress slightly, the same can be said of Special Relativity and in this respect, Einstein's thought experiments using a train carriage, differently placed observers, a light clock etc. are also seductive because the algebra is so simple it cannot be wrong, or so is thought. SR holds that the faster we move, the more

time is slowed. The faster we move, the more our dimension in the direction of motion will decrease and the more our mass will increase, at least, according to a non-moving observer. All the while, we (in the moving frame) notice nothing strange. When asking how that can be so, the answer usually turns on the counterintuitive results of simple algebra that should be believed.

If very simple algebra is correct and should be believed, apply that reasoning to what follows.

Albert sits in a chair with a very long rope tied around his waist and holds a clock. The other end of the Albert rope is tied around the waist of Oppy, a fast runner, who holds a clock perfectly synchronised with Albert's clock.

Oppy has another rope of the same length as Albert's rope tied around his waist with the other end tied around Albert's waist. Thus, both Albert and Oppy are joined by two ropes each tied around their waists and if Oppy runs away from Albert, both ropes will play out. Both ropes have ink markings on them every metre.

Oppy runs away from Albert with velocity v and both ropes play out.

Capital letters denote quantities for Oppy and small case letters that for Albert.

When Albert's rope plays out to marking x at length x_1 , an automatic device by the side of Albert sends out a light beam at time t_1 to Oppy. Then, $t_1 = \frac{x_1}{v}$. As regards Oppy's rope, the same length has played out at T_1 with

$$x_1 = X_1,$$

$$t_1 = T_1 = \frac{x_1}{v} = \frac{X_1}{v}$$

Because the light signal takes a finite time to reach Oppy, that occurs at time T_2 with

$$T_2 = T_1 + \frac{x_1}{c} = T_1 + \frac{X_1}{c}$$

The time taken for the light signal to reach Oppy is $T_2 - T_1 = \frac{x_1}{c}$.

During that finite time, Oppy was still running and his rope was playing out by a length $X_2 - X_1 = v[T_2 - T_1] = v\left(\frac{x_1}{c}\right) = v\left(\frac{X_1}{c}\right)$.

The total lengths of ropes played out are

$$x_2 = X_2$$

$$X_2 = X_1 + \frac{vX_1}{c} = X_1 \left(1 + \frac{v}{c}\right) = x_1 \left(1 + \frac{v}{c}\right)$$

At $x_2 = X_2$ the ends of the ropes are reached and Oppy cannot continue running. The same amounts of ropes have been used and

$$T_2 - T_1 = t_2 - t_1 = \frac{x_1}{c} = \frac{X_1}{c}$$

Showing that the times are not related to v . That means c is independent of v in the moving frame of reference.

2. FROM THEORY TO VISUALISATION AND VICE VERSA

The writer emphasises that without a working theory of quantum gravity, the question of the First Cause will remain unanswered. Within the general scope of what is already known or theorised upon, the writer intends to present a slightly alternative ‘picture’ to that of creation according to GR, and of necessity, it will have many unknowns and raise more questions than it answers.

(A) WHAT HAPPENS IF THE UNIVERSE IS ROTATING?

Looking at the Sun, the Earth, all the planets and natural satellites, nebulae, other stars, galaxies and everything else shows they all have one common feature. Nothing is static. Everything rotates about some axis. Why should the entire universe be different?

Consider the basic model of a rotating universe considered by Gödel (15). This is the original without the addition of expansion.

When a cosmological model is constructed, if the major masses are perfectly static, the result is simultaneity relative to their world lines. It is that which connects rotation to considerations of time. In other words, simultaneity has nothing to do with any coordinate system in a rotating universe but only if it is homogeneous. The metric in cylindrical coordinates is

$$4a^2 \left[dt^2 - dr^2 - dy^2 + (sh^4 r - sh^2 r) d\phi^2 + \frac{2}{\sqrt{2}} sh^2 r d\phi dt \right]$$

If the $-dy^2$ is dropped, the result is h_{ik} . Because of the rotation, $d\phi^2$ changes its sign for large values of t resulting in closed timelike lines. If the universe is homogeneous, matter has equidistant world lines and light rays are orthogonal to the axis of rotation and are circles arriving at a later time than when they left. The equidistant worldliness means no redshift of distant matter.

That shows a coordinate-free representation where a relativistic spacetime is regarded as a structure (M, g_{ik}) where M is a connected, smooth, 4-dimensional manifold and g_{ik} is a smooth semi-Riemannian metric on M having a signature $(+, -, -, -)$.

In actual fact, M is R^4 that can be decomposed as a metric product so that (M, g_{ik}) becomes R and (R^3, h_{ik}) with the signature of h_{ik} being $(+, -, -)$. If h'_{ik} is the $(+, -, -)$ metric on R^3 , it is of constant positive curvature in $h_{ik} = h'_{ik} + t_i t_k$, where $t^i = h'^{ik} t_k$ is a unit timelike Killing field with respect to h'_{ik} .

Going from h'_{ik} to h_{ik} is achieved by stretching the metric by $\sqrt{2}$ in the direction of Clifford parallels, those being the integral curves of the Killing field, t^i .

Now introduce a free scale parameter, a , and it can be shown that the constant curvature of h'_{ik} is $\frac{1}{4a^2}$. For coordinates x_0, \dots, x_3 overall of R , the metric used was

$$a^2 \left(dx_0^2 - dx_1^2 + \frac{1}{2} e^{2x_1} dx_2^2 - dx_3^2 + 2e^{x_1} dx_0 dx_2 \right)$$

If the $-dx_3^2$ is ignored, it can be said that the result is applicable to any hyperplane of constant x_3 . Ignoring that term gives a reduced metric of another structure being (R^2, h_{ik}) with the metric

$$a^2 \left(\frac{1}{2} dx_0^2 - e^{x_1} dx_0 dx_2 - dx_1^2 \right) + \frac{a^2}{\sqrt{2}} [dx_0 + e^{x_1} dx_2]^2$$

The first portion including the round brackets determines h'_{ik} and the rest is just t^i . Then

$$h'^{ik} = \frac{1}{a^2} \left[-2e^{-2x_1} \left(\frac{\partial}{\partial x_2} \right)^2 + 4e^{-x_1} \left(\frac{\partial}{\partial x_0} \right) \left(\frac{\partial}{\partial x_2} \right) - \left(\frac{\partial}{\partial x_1} \right)^2 \right]$$

and

$$t' = h^{ik} t_k = \frac{\sqrt{2}}{a} \left(\frac{\partial}{\partial x_0} \right)$$

By a complete map definition from \mathbb{R}^3 into \mathbb{R}^4 , it becomes clear that (\mathbb{R}^3, h'_{ik}) is a complete manifold with constant curvature $\frac{1}{4a^2}$.

Finally, $(x_0, x_1, x_2) \mapsto (u_0, u_1, u_2, u_3)$, so the equations of GR can be solved for a perfect fluid or dust as the source of energy.

The result is a universe with closed timelike curves (CTCs). It has already been mentioned that further work using a rotating and expanding model shows no difference with respect to CTCs.

That the universe could have been created from nothing can be defeated by specific arguments that will not be considered now. Neither will quantum tunneling be considered now. Taking it that universe had to be created from something, that something may have been the universe itself but only if CTCs exist that play a part in the creation process. Loosely speaking, view a universe with CTCs (because it rotates) and take it back in time. Ultimately one will see only a region occupied by CTCs.

It is tempting to visualize the process of creation as matter moving back in time (like some time-machine) to some time where nothing exists, causing at the least a quantum fluctuation that starts an evolving process. For now, where that matter moves from is not relevant, nor is when it moves to. Possibly, it can travel from a state before any Big Bang, from the Big Bang itself, subsequently or even from the Big Crunch, taking it that the 'Bang' and the 'Crunch' are viable possibilities.

In Gödel space there are CTCs everywhere but in Misner space, there is at least one region containing no CTC and those regions with CTCs are separated from those without by Cauchy horizons containing closed null geodesics.

(B) CLOSED TIMELIKE CURVES

Hawking and Penrose's singularity theorems do not apply if the Universe has or has had CTCs. If a compact Lorentzian spacetime undergoes topology changes, there 'must' be CTCs in that spacetime (16, 17).

In GR there exist many solutions with CTCs but vacuum polarization of quantum fields in a spacetime with CTCs diverges as the Cauchy horizon is approached. That means that a spacetime with CTCs may be unstable against vacuum polarization since when the renormalized energy-momentum tensor is

put back into the Einstein equations with quantum corrections to the energy-momentum tensor of matter fields, the back-reaction produced can distort the spacetime geometry so much that a singularity can appear and destroy the CTCs.

Hawking proposed the chronology protection conjecture that the laws of physics do not allow the appearance of CTCs once a spacetime has a Cauchy horizon. However, Einstein's equations are local and the energy-momentum tensor may diverge only at the Cauchy horizon where quantum gravitational effects are thought to become important. That is because a quantum barrier may form where the metric has complex values of a complex geometric region rather than a Cauchy horizon generated by closed null geodesics.

By quantum processes, matter may tunnel from the region without closed causal curves to the region with CTCs (or vice versa), and the spacetime itself can also tunnel from one side to the other side of the quantum barrier (18).

Li (19) has shown that the appearance of an absorber in a spacetime with CTCs may make the spacetime stable against vacuum polarization. Based on known physics, Li argues that material will become opaque for waves/particles that have very high frequency or energy where absorption caused by various types of scattering processes becomes important. Based on calculation of the renormalized energy-momentum tensor and the fluctuation in the metric, Li argues that if an absorbing material with appropriate density is introduced, vacuum polarization is smoothed out near the Cauchy horizon. Hence the metric perturbations caused by vacuum fluctuations are very small and a spacetime with CTCs can be stable against vacuum polarization.

Such opaqueness would certainly be in existence very soon after the Big Bang.

Other workers have found that the renormalized energy-momentum tensor in various spaces is well behaved or even zero, even at the Cauchy horizon (20, 21, 22, 23, 24).

Kay, Radzikowski, and Wald have proved two theorems that imply that the usual quantum field theory cannot be directly extended to a spacetime with CTCs because of difficulties arising when attempting to define quantum field theory on a spacetime with a compactly generated Cauchy horizon. These results say that in order to create CTCs it would be necessary to enter a regime where quantum effects of gravity dominate.

The Cauchy horizon is also called a chronology horizon. A chronology horizon is called 'future' if the region with CTCs lies to the future of the region without closed causal curves. A chronology horizon is called 'past' if the region with CTCs is in the past of the region without closed causal curves. A future chronology horizon may be classically unstable unless there is some diverging effect near the horizon. The argument for that is any wave packets propagating in the future direction will congregate on the future chronology horizon and destroy it because of the infinite

blue-shift of the frequency (energy) seen by a timelike observer near a closed null geodesic on the horizon.

If there is some diverging mechanism near the horizon, the amplitude of the wave packet will decrease with time due to this, and thus it may cancel the effect of the blue-shift of the frequency, making the energy finite and rendering the future chronology horizon classically stable.

In multiply connected de Sitter spacetime and in Misner space, there are no diverging mechanisms. A light ray propagating in de Sitter space will focus rather than diverge. Hawking (25) has given a general proof along the lines that any future chronology horizon is classically unstable unless light rays are diverging when they propagate near the chronology horizon. One way to cause an instability is by perturbing an electron in the vicinity of the future chronology horizon. The retarded wave will propagate to the future causing the instability. In Hawking's proof, replace a future chronology horizon with a past chronology horizon and the proof breaks down. For that, a wave packet propagating toward the future near the past chronology horizon will suffer a red-shift instead of a blue-shift. Therefore, according to Hawking's argument, a past chronology horizon is classically stable in a world with retarded potentials.

If the universe started with a region of CTCs, but there are no CTCs now, that early region of CTCs would be bounded to the future by a past chronology horizon, and that horizon would be classically stable in a world with retarded potentials, such as our world.

(C) KRASNIKOV TUBE

Alcubierre (26) showed that it is possible within the framework of general relativity to warp spacetime in a small 'bubble-like' region so that a particle within that bubble may move with arbitrarily large speed relative to nearby observers in flat spacetime outside the bubble.

The model involved a spacetime metric, with $c = G = 1$, given by

$$ds^2 = -dt^2[1 - v^2 f^2(r_0)] - 2vfr_0 dxdt + dx^2 + dy^2 + dz^2$$

where $v = \frac{dx_0}{dt}$ and $r_0 = \sqrt{[x - x_0t]^2 + y^2 + z^2}$

The function f satisfies $f \approx 0$ for $r_0 > R + \delta R$, and $f \approx 1$ for $r_0 < R - \delta R$, where R is the bubble radius and δR is the half thickness of the bubble wall. In the limit $\delta R \rightarrow 0$, f becomes a step function so that spacetime is flat outside of a spherical

bubble of radius R centered on the point $\vec{r}_0 = (x_0(t), 0, 0)$ moving with speed v along the x -axis, that being measured by observers at rest outside the bubble.

Here v is an arbitrary function of time which need not satisfy $v < 1$, so that the bubble may attain arbitrarily large superluminal speeds as seen by external observers. Space will be flat in the region within the bubble where $f = 1$ because for $f = 1$, a local inertial coordinate system is obtained by the transformation $x' = x - x_0(t)$. Hence an object moving along with the center of the bubble, whose trajectory is given by $x' = 0$ will be in free fall.

The Alcubierre ‘warp drive’ has the drawback that a particle at the centre of the warp bubble is causally disconnected from the outer wall of the bubble.

Alcubierre questioned whether the metric is physically realizable, since the corresponding energy-momentum tensor involves regions of negative energy density and so violates the weak energy condition (WEC).

Everitt (27) showed that a straightforward extension of the Alcubierre metric leads to a spacetime with CTCs. Regions with negative energy density are allowed in quantum field theory (28, 29) but Ford and Roman as well as others (30, 31, 32) have proven inequalities that limit the magnitude and duration of negative energy density and it is unlikely that stable Lorentzian wormholes can exist. Similar conclusions were arrived at by Pfenning and Ford (33) with regard to Alcubierre’s ‘warp drive’.

Krasnikov’s (34) ideas differ from that of Alcubierre but nevertheless allow superluminal travel. Even though the theories have differences, the Krasnikov and Alcubierre metrics share a number of properties. In particular, like the Alcubierre metric, the Krasnikov metric implies the existence of CTCs, and the associated energy-momentum tensor violates the WEC. All in all, the Krasnikov and Alcubierre spacetimes are not physically realizable without the use of exotic matter

In two dimensions a single Krasnikov tube allows superluminal travel backward in time in one direction along the x -axis, and does not lead to CTCs. In 4-space, assuming that Krasnikov tubes can be established, imagine that a particle travels from the A to B along the x -axis in a Krasnikov tube stretching between A and B. It would be subsequently possible for the particle to return from B to A outside the tube or within another tube identical to the first but running in the opposite direction but not overlapping with the first tube running to B.

To overcome the causal disconnection of Alcubierre’s theory, any modification of the spacetime to allow superluminal travel necessarily occurs in the causal future of the launch point of the particle. Then, the metric has the feature that the time for a one-way trip to a distant point is limited by restrictions of special relativity, but the time for a round trip may be made arbitrarily short.

Additionally, inside the tube, the spacetime is flat but with the light cones opened out to allow superluminal travel in one direction, as seen by observers outside the tube. The creation of a single Krasnikov tube in 4-space does not involve any CTC formation.

This sub-section has been kept brief and only to raise the possibility whether the formation of a Krasnikov tube with exceedingly thin walls of exotic matter might serve to time transfer matter/spacetime backwards to a pre-Big Bang era. In the conditions prevailing in the first three seconds of the Bang, the writer cannot see any reason as to why the exotic matter aspect would present a problem. The only problem seen is the aspect of special relativity. Whatever may appear to be transferred backwards in time by virtue of what appears as faster than light motion only appears to be that in the frame of reference of a non-moving observer located near to the Bang.

(D) SUPERLUMINAL

Permit a review of experimental work concerning apparent superluminal group-velocities as originally proposed by Sudarshan (35).

The special theory of relativity can be generalized so as to accommodate superluminal objects and these non-restricted versions of SR are sometimes called “extended relativity”.

Objections against tachyons are based on the opinion that it would be possible to send signals into the past. This is the argument. A tachyon, T , which appears to a first observer O as emitted by A and absorbed by B , can appear to a second observer O' as a tachyon T' that travels backwards in time with negative energy. However, by applying the ‘reinterpretation rule’, T' will appear to the new observer O' as an anti-tachyon emitted by B and absorbed by A , and therefore traveling forward in time, even if in the opposite spatial direction. That way, every motion towards the past and all negative energy disappear.

Put simply, the reinterpretation principle means that signals are carried only by objects which appear to be endowed with positive energy. That eliminates any information transfer backwards in time – and – it abandons the human conviction that a judgment about what is cause and what is effect is independent of the observer. In fact, in the case examined above, the first observer O considers the event at A to be the cause of the event at B . By contrast, the second observer O' will consider the event at B as causing the event at A . All the observers will see the cause happen before its effect.

If we require the phenomena to obey the law of (retarded) causality with respect to all the observers, we cannot also demand the description details of the phenomena to be invariant. That is, in that case, we cannot also demand the invariance of the cause and effect labels.

Different experimental sectors of physics seem to suggest the possible existence of faster-than-light motion.

It appears that m_0^2 of muon-neutrinos as well as electron-neutrinos is negative indicating, in classical terms, an imaginary mass and tachyonic (36). On that, experimental data has accumulated since 1971.

In Galactic Micro-quasars there is apparent superluminal expansions observed in the core of quasars (37) and, in the so-called galactic microquasars (38).

Evanescent waves and ‘tunneling photons’ in tunnelling processes show that the tunnelling time evaluated as a simple ‘phase time’ as well as analysis of the wavepacket behaviour, does not depend on the barrier width if the barrier is opaque. This is the Hartman Effect and implies superluminal and arbitrarily large group velocities inside long enough barriers (39).

The Schrödinger equation in the presence of a potential barrier is mathematically identical to the Helmholtz equation for a propagating electromagnetic wave.

If the propagation is, for instance, down a metallic waveguide along the x-axis and there exists a barrier height greater than the electron energy, that corresponds for a given wave frequency to a waveguide of transverse size lower than a cut-off value. It means that a segment of smaller guide behaves as a photonic barrier to the wave. The wave will then assume within the guide an imaginary momentum or wave-number and as a consequence, becomes exponentially damped along x. In other words, it becomes an ‘evanescent wave’.

Experimental evidence showing that ‘evanescent waves’ travel with superluminal speeds has been documented from 1992 by G.Nimtz et al. (40) , R.Chiao, P.G.Kwiat and A.Steinberg (41), A. Ranfagni and colleagues (42), and other workers. All have verified that tunnelling photons travel with superluminal group velocities.

In these experiments one meets a substantial attenuation of the considered pulses during tunnelling or during propagation in an absorbing medium. Using suitable devices, such as a gain doublet, observations have been reported of undistorted pulses propagating with superluminal group-velocity with a small change in amplitude (43).

The most interesting experiments of this series are with two barriers, for example, with two gratings in an optical fiber or with two segments of

undersized waveguide separated by a piece of normal-sized waveguide. For the frequency bands for tunnelling far from resonances, it was found that the total crossing time does not depend on the length of the intermediate (normal) guide and so the wavepacket speed along it is infinite (44, 45).

This agrees with predictions of Quantum Mechanics for non-resonant tunneling through two successive opaque barriers being the tunneling phase time. That time depends on the entering energy and has been shown to be independent of the distance between the two barriers (46).

It should be realized that conventional interpretations of the generalized Hartman Effect should not be regarded as unphysical. Whenever an object moves at infinite speed with respect to a certain observer, it will appear to that same observer as the anti-object traveling in the opposite space direction. Appearances lead us to the most physical and conventional sort of interpretation but negative times is a prediction of relativity itself on the basis of ordinary postulates such as helicity of 1 (photon) and -1 (anti-photon).

Quantum interference effects can produce dielectrics with refractive indices very rapidly varying as a function of frequency so that they show quantum induced transparency. The group-velocity of a light pulse propagating in such a medium can decrease to very low values, either positive or negative, with no pulse distortion.

Experiments have been performed both in atomic samples at room temperature and in Bose-Einstein condensates. These show the possibility of reducing the speed of light to a few meters per second. Negative group velocities have been reported that imply a propagation with superluminal speeds thousands of times higher than hitherto obtained experimentally in the presence of such an electromagnetically induced transparency for light moving in a rubidium condensate.

With the work of Bateman, all general wave equations admit wavelet-type solutions with sub-luminal group velocities, being soliton-like solutions. That is so even if they are linear equations. Subsequently, superluminal solutions were found that propagate as localized, non-diffracting pulses as undistorted progressing waves. These waves have the property of self-reconstructing themselves after obstacles are encountered smaller than their aperture size, that is, smaller than the width of the antenna generating them which would be enormously larger than their wavelength.

Using extended relativity, it has been found that whilst the simplest subluminal object conceivable is a small sphere, or a point as its limit, the simplest superluminal objects turn out to be an X-shaped wave or a double cone as its limit that travels without deforming in an homogeneous medium. Since 1993, X-shaped waves have been found as solutions to the Maxwell and to the wave equations.

(E) EKPYROTIC

If the pre-universe is hidden from us, either it is beyond any conceivable horizon or it remains in some higher dimension. In the ekpyrotic scenario, spacetime is overall 5-dimensional, but with one dimension not extending indefinitely, but being a line segment (an orbifold). The endpoints of the orbifold are two (3+1)-dimensional boundary branes with all matter and forces localized on the branes. However, gravity can propagate in the whole spacetime so is not localized. Our universe is one of the boundary branes and whilst the branes are far apart, can interact with the other brane only by way of gravity. Thus, the branes are of 4-space but the whole is 5-space.

In theory, it is assumed that the two branes attract each other by gravity so that they approach each other. It can be shown that the branes will flatten enormously as that happens. Eventually, the two branes pass through each other (in much the same way as colliding galaxies do not actually collide but largely pass through each other).

From the standpoint of an observer on one brane, the brane interaction appears as a Big Bang and for matter and radiation to be produced, the branes must be inelastic. Quantum fluctuations ripple the branes so that exact collision at all points on the branes does not occur simultaneously, but these points do collide at some time. Brane collision results in heat but uneven brane collision means that some regions collide sooner and have more time to cool, and some regions that collide later, have less time to cool (inferred from COBE data).

Once the branes have passed though each other, distance becomes nearly stabilized and the branes very weakly attract each. The distance between the branes increases and slows until they approach each other again and the whole process repeats.

This model says that the Big Bang was not a single event and time exists prior to brane collision and will continue to exist with causal connection over exceedingly large distances. In addition, with almost flat branes, it explains why our universe is flat to a high degree. If our universe exists on one brane, what of the other? Of course, both branes and the void between constitute the entire universe and the other brane is so far beyond the observable horizon, for all practical purposes its red-shift is infinite. Nevertheless, it still exists.

At present, the writer is unaware whether the ekpyrotic model where both branes rotate about their own axes and also about a common point has been investigated. In fact, the whole topic is relatively new and has not been investigated to any great extent.

One benefit of the ekpyrotic scenario is in visualization. In the conventional pre-space followed by post-Big Bang space, it is easy to visualize a progression

from one form to the other. Now, the visualization can be one of interaction between two (possibly more) objects. In both models a Big Crunch is not admissible, just a series of Big Bangs with each one, presumably, destroying everything formed before it. In both, the question of the First Cause is not answered.

An interesting aspect has been investigated by Gregory et al (47). In a 5-dimensional model with one 3-brane and an infinite extra dimension, what happens when matter escapes from the brane and propagates into the bulk to arbitrarily large distances such as when a particle decays to two and one accelerates away from the brane?

In the linearized theory, the metric induced by these particles on the brane does not obey the 4-dimensional Einstein equations and corresponds to a spherical gravity wave propagating along the 4-dimensional future light cone. The 4-dimensional space-time left behind the spherical wave is flat, so the gravitational field induced in the brane world by matter escaping from the brane disappears in a causal way.

Four-dimensional gravity may emerge as a low energy effective theory in models with non-compact extra dimensions. One aspect of this scenario is that ordinary matter may reside on a 3-brane embedded in higher-dimensional space. Another key point is the existence in a class of models of a bound state of a multi-dimensional graviton localized near the brane. Even though gravity at short distances is higher-dimensional, this bound state dominates gravitational interactions in the brane world at large distances and gives rise to four-dimensional behavior of the gravity force experienced by matter residing on the brane.

Modifications of the theory include models with a metastable graviton bound state or more than one very light four-dimensional graviton. These models predict violations of the four-dimensional Newton's law at ultralarge distances. If the extra dimensions are non-compact (and there is no reason why they should be compact), energy may leak from the brane into the bulk. Another possibility is that besides ordinary matter, there exist particle species that are not trapped to the brane at all. Pair creation of these particles would also lead to the transfer of energy from the brane to the bulk. The same role may be played by Kaluza-Klein gravitons whose interactions with the brane matter are weak but non-vanishing.

The possibility that energy is carried away from the brane to arbitrarily large distances in the bulk seems, from the 4-dimensional point of view, to be in conflict with locality, causality, and the 4-dimensional Newton law. Changing mass in a finite region of 3-dimensional space would seem to result in an instantaneous change of the gravitational potential everywhere in that space. By this argument, an observer living on the brane would immediately realize that energy had been emitted from the brane to the bulk, no matter how far away this

event occurred. There are several possible resolutions of this apparent paradox. Three of them being:

:

(i) In (1+1) dimensions, energy non-conservation is consistent with locality, causality and the long-range character of forces analogous to gravity. Even though the reasons for this property are peculiar to (1+1) dimensions, one may wonder whether a similar consistency may be possible in (3 + 1) dimensions.

(ii) The bulk geometry in the Randall–Sundrum model and its analogues is anti-deSitter, so particles leaving the brane accelerate away from the brane. Their energy increases as they move away, and one may wonder whether this effect could compensate for the decrease of the strength of gravitational interactions of these particles with matter on the brane. In that case, the mass measured through gravitational forces by an observer on the brane, would remain constant. The particles continuously accelerating in the bulk would behave, from the 4-dimensional point of view, as dark matter particles of fixed mass which participate in gravitational interactions in a standard way.

(iii) Gravity in the RS model is guaranteed to be effectively 4-dimensional only as far as interactions of matter residing on the brane are concerned. There is no argument that implies that the effective 4-dimensional description is valid for gravity induced by bulk matter. In other words, the gravitational field induced on the brane by particles moving in the bulk need not obey the 4-dimensional Einstein equations, so the discussion of possible conflict between causality and Newton’s law may not apply.

In the paper, Gregory et al make a decision between these possibilities by calculating, in the linear theory about the RS background, the gravitational field of a pair of particles escaping from the brane and propagating in the bulk.

It was shown that option (i) has nothing to do with the RS model. Possibility (ii) would be realised if the graviton bound state were the only relevant mode, that is, if the zero mode approximation were reliable. However, the zero-mode approximation is in fact not adequate to the problem in question and the Kaluza–Klein tower of gravitons plays an important role. When KK states are included in the analysis, the outcome is option (iii).

The final picture is that the particles moving away from the brane produce a spherical gravity wave on the brane which expands in 3-dimensional space with the speed of light. The 4-dimensional space-time left behind this spherical wave is flat, whereas in front of this wave the 4-dimensional metric is of the usual Schwarzschild asymptotic form, in accordance with causality. The spherical gravitational wave itself does not obey the four-dimensional Einstein equations, so the gravitational effects of particles moving in the bulk are intrinsically higher-dimensional, even if these effects are measured by an observer residing on the brane (47).

The writer comments that linearized theory confirms what arises intuitively. Anything on the 3-brane will be subject to some speed limit. Anything moving to arbitrary large distances in the bulk could not do so in ordinary 4-space and within a reasonable time-span unless zero-point energy were either non-existent or very small, so permitting superluminal motion. In any case, there is no reason as to why 4-space relativistic equations should be applicable in higher dimensions as confirmed, but nevertheless quite intuitive.

If matter (the paper contemplates a mass of $2m$ dividing) disappears from the brane in a causal way by say, particle pair creation, it is also intuitive to expect the positive particle to have the future light cone whilst the negative part has a past light cone, or vice versa depending on the terminology of matter created under those particular conditions. It is assumed that the Gregory et al paper contemplates the escape of positive matter into the bulk and therefore, by implication along conventional lines, the negative particle will annihilate with some other positive particle or spontaneously dissolve into the continuum. If it were that the negative particle escapes, it would have a past light cone. Conventionally, the spontaneous creation of one of a pair with negative energy and a past light cone would shift it into the past whether it had motion at its inception or not. To an observer, the disappearance of the negative particle into time would appear as annihilation. By the same token, the surviving particle of a Hawking pair should not demonstrate backwards in time transfer unless that survivor was the negative partner.

(F) ANTIMATTER

The advantage of proposing new symmetries rests in the possibility of discovering new physics. For a long time, entropy has dominated thinking concerning an apparent non-symmetry of time, but what if time is completely symmetrical?

Seductive reasoning has been followed so far as time is concerned. Because mathematics describing the universe is symmetric in time, then the universe itself must be symmetric in time. The writer stands by a view that the word 'must' must never appear in any proposition or conclusion because that word closes off every other possibility.

A person is born and matures. Running the film backwards, time reverses and runs backwards. That person grows progressively younger and ends up back in the mother's uterus. Are the laws of biology, chemistry and physics reversed? Even if they were, there is no mechanism that can produce an exact time-reversed copy of the past. All particles in the past are unique and are not the same as particles in a time-reversed universe, their wave-functions are different. On the other hand, no processes that in any way resemble the reverse of the existing laws can find and exactly manipulate those unique (but

indistinguishable!) particles needed to exactly reverse the history of their own movements. There is no time symmetry.

What is symmetry? According to Feynman's explanation of Weyl symmetry, anything will be symmetrical if it can be subject to a certain operation and it appears exactly the same after the operation.

In the case of time we apparently have no way in current theory to meet Weyl's definition. The solution for time-reversal is not the reversing of mathematics to produce a train of time-reversed events. Reversing the events needs 'strange physics' to retain exact time-reversed events and without 'strange physics', reversing the ordinary laws produces different events because that is not a symmetry operation.

The Big Bang theory takes it for granted that spacetime and the included mass-energy expanded only in one direction in time, say $t+$. Any time symmetry in physics is assumed to have the effect that all equations are reversible in time. If time is symmetrical along the time axis, with the Big Bang at $t = 0$ on the spacetime axes, two universes result, both expanding into the same space but in opposite time directions. In the $t+$ and the $t-$ universe all laws operate in the same way and no observer in either universe could distinguish in which one he was. Because entropy would increase as time proceeds the Weyl criterion is satisfied.

The Feynman-Stueckelberg Interpretation of antimatter states that all the properties of antimatter are consistent with the view that antimatter and matter are identical except that their particles move in opposite directions in time. That is a viewpoint that appears to rest on the eminence of Feynman especially after the use of that interpretation in his published works on quantum electrodynamics. In order to make time non-symmetrical, physicists largely prefer antimatter particles to proceed in $t+$ time rather than to hop about in time.

As late as three years before he died, Feynman stated (in his book 'QCD') that "every particle in Nature has an amplitude to move backwards in time, and therefore has an antiparticle". Feynman's view was based on Einstein's version of Lorentz invariant symmetry plus the final probability of some quantum event was the square of the sum of the amplitudes of all possible paths to the result. All possible paths include time reversed paths as well as superluminal paths. It is worth noting that for Feynman, calculations based on unlikely and complex paths and including these into the overall theory increased the accuracy of QCD.

The writer takes it for granted that personal prejudices have to be discarded and antiparticles move backward in time is a matter of physical reality.

At times $t+$ and $t-$ very close to $t = 0$, equal amounts of matter and antimatter are created. Close to Planck time after or before $t = 0$, there should be an equal probability of finding any particle or antiparticle on either side of $t = 0$ and the probability of a particle or antiparticle being created on one side or other side of

$t = 0$ being found on the other rapidly decreases as spacetime expands. The progression of time displacement from $t = 0$ would increase while the extent of quantum uncertainty in time would not.

At times very near $t = 0$, antimatter can undergo two possible fates. Quantum uncertainty makes matter transfer from the t^- side to the t^+ side and then it moves forward in time. Annihilations then contribute to matter on the t^+ side. If not that, antimatter leaking from t^+ to t^- moves backwards and after annihilations contributes to the antimatter t^- side of $t = 0$. The result is every part of spacetime in the very early universes on both sides of $t = 0$ is repeatedly traversed by particles in both directions in time. That says both universes either side of $t = 0$ have interacted. Again, meaning that both universes are identical or very nearly identical in structure. Most importantly, the electromagnetic photon is its own antiparticle so it should propagate in this way under time reversal.

(G) GENESIS

We have reached a position where it would be better to have a complete description of quantum gravity than not. At present, that lays in the future.

The First Book of the Old Testament sets out the procedure of creation although there are many difficulties in the interpretation of the original language used. Nevertheless, the writer is of the opinion that anything that is capable of shedding even the minimum light on the problem is worth having. For mere convenience, the language of Genesis and scientific terms will be mixed, the reader being aware of which is which.

In the beginning, God created the heavens and the earth. Now the earth was formless and empty, darkness was over the surface of the deep, and the Spirit of God was hovering over the waters. And God said, "Let there be light," and there was light. God saw that the light was good, and He separated the light from the darkness. God called the light "day," and the darkness he called "night."... the first day.

The first day involves the emergence of the separation of light and darkness from the formless void of the pre-universe. That corresponds to the emergence of the current asymmetrical dual universe, the light universe and the now dark pre-universe that no longer or still exists. Why should the pre-universe still exist? If the Big Bang operated as an alteration in phase of the entire pre-universe, that would no longer exist in its former form. However, for now, the words of Genesis will be followed in that there was a separation of one thing into two, there being no mention of anything being destroyed.

Here, it will be taken that the pre-universe was formless and without structure but was not dark prior to the formation of the asymmetrical duality. Post-Big Bang, the pre-universe still exists as dark.

For a pre-universe to exist in that form, it would need to support electromagnetism and maybe gravity but that does not mean to say that gravity as such was in existence. If it was and one were to subscribe to the notion of dark energy, the still existing gravitating pre-universe would provide a suitable candidate because gravity would be the only connection between both universes.

If 'void' means matterless, that does not preclude the presence of non-material fields. Taking it that a formless, void universe is simple, which fields would be the most likely to exist? Those that suggest themselves are the strong force, the gravitational force and charge.

Admittedly, the application of our physics to such a pre-universe is fraught with danger. Ignoring that for the moment, it is often said that our universe has zero vacuum energy. If that is so, the pre-universe had high vacuum energy. We know that the deSitter solution of GR describes a void universe such as that contemplated in the pre-universe so that aspect is not inconsistent. However, without matter, what would be charged? The only candidate would be light. Without anything radiating, from where would that light emanate? Of course, those questions are rhetoric.

The second day involves the separation of waters from above and below the expanse. Here, the 'expanse' is taken to mean the interface between the light universe and that which is still without form and now dark. Whilst that may be interpreted as the separation of dark matter and baryonic matter from above and below the interface, the writer does not think so because the first day description gives the descriptions 'formless' and 'void'. If that were the case, no dark matter existed and nothing has changed. Rather, the so-called separation was nothing more than the hiding of the pre-universe from the universe with light, than delving into dark matter, having the interface charged or anything else. There is of course the possibility that the separation of the waters resulted in a spontaneous compactification of the dark pre-universe. If so, that would remain hidden from us but with different topology than hitherto.

The third day involves the separation of sea and land where organisms appeared. However this and subsequent days will not be considered.

The ambiguous Hebrew grammar has the alternative that heaven and earth already existed in a formless and empty state, to which God brought form and order. That joint universe before form and order transpired would be the pre-universe. For such a scenario, the universe is Hoyle-like and 'creation' is reduced to a change in form or some phase change. Even so, that interpretation does not explain how the formless and empty state underwent a change. One thing is certain. God has the best sense of humor ever encountered by the writer.

In the beginning, God created two branes composed of 4-space. Now the void between was formless and empty and everything was embedded in 5-space, darkness was over the surface of the inter-brane void, and the Spirit of God was hovering over the whole. And God said, "Let there be light," and the branes collided. God saw that the light was good, and He separated the branes from the darkness of the newly arising inter-brane void. God called the light "day," and the darkness he called "night." ...the first day.

The above is no better than saying 'And God said "let there be a Big Bang" and there was a Big Bang, and God saw it was good' and serves only to demonstrate the difference between evidence and belief.

Taking the words of Genesis more literally, what can be concluded? God created time and so is outside of time, an observation reiterated many times in some form or other in the scriptures.

FIRST PROPOSAL

For the moment, let us suppose the possibility of matter and/or a portion of spacetime moving back in time to create the universe. For now, the mechanism is not important but also let us suppose that time is an inherent property both before and after creation.

The question is whether matter and/or spacetime moving back in time is a one-off event or is a common occurrence permitted by some law or laws of physics.

For simplicity and for the purposes of discussion only, the creation is at $t = 0$. Events occurring after the Big Bang are t positive (higher numbers meaning later in time) and anything transpiring before the creating event are t negative (smaller numbers meaning earlier in time).

As a one-off event, at $t = 100$ say, matter and/or spacetime moves to $t = -100$ say, producing an effect that ultimately or almost instantaneously triggers creation of our universe by, call it, a Big Bang.

As a most certain one-off, either matter and/or spacetime moves from $t = 0$ to $t = -50$ or radiation moves from say, $t = 0.0000001$ to $t = -75$. Whichever, that will happen just once.

As a common occurrence, at $t = 100$ or $t = -10$ say, matter and/or spacetime moves back to say $t = -100$ causing an effect. Then, at $t = 110$ matter moves back to $t = -200$ causing an event. Does this -200 event serve to trigger creation, and is the -100 a triggering event capable of surviving to produce its own universe or a potential triggering event that may produce a universe if not obliterated in the cataclysmic event caused by the -200 event?

Now contemplate that process as continuous, taking place in every part of the t positive universe where conditions allow appropriate physics to operate.

Superficially, the answer seems to be that if material of some description can pop up at the same places or different places in t negative time to create their own spaces, all being transferred from different t positive times, either they will create their own universes, compete to form a universe or be obliterated in just one Big Bang resulting from the first event that can reach the 'winning post'.

The reason why that conjecture is superficial is because if the process of transfer from the now to the then were continuous, there would be no requirement for a Big Bang or indeed, any creating event. The universe would be complete from $t = \text{minus infinity}$ to $t = \text{plus infinity}$. Whether that model universe expands would depend on the relative rates of matter creation with matter transference. In fact, this idea is a Hoyle-like model with time travel (Fourth Alternative). That avoids the question as to where the very first electrons and protons came from.

The writer has said that the universe should be a simple system (1A), so simple that it is capable of functioning for billions of years without developing a 'fault'. Does that proposition necessarily apply to creation? Not if there was a one-off event. Such an event by definition is incapable of repetition because of the physical conditions prevailing at the time. That indicates time transference of material only from, call it, the Big Bang itself or very soon afterwards. The question is by what mechanism that requires time before the Big Bang could that be achieved?

Without any reliable physics at the moment the initial singularity of the conventional Big Bang appeared, no progress can be made but such physics, whilst interesting, is not required. On the other hand, the first three seconds is replete with literature and, if time transference of stuff then existing was by means of CTCs, the appropriate regions have long since vanished as a result of inflation and expansion.

Visualising in 5-dimensions or more is not within the realm of the human brain. Therefore the procedure is to let the mathematics unfold and accept the interpretations. In attempting to form a mental picture of a situation in some higher-dimension, that is undesirable because equations are hardly mental pictures and require interpretation that can lead to a multiplicity of choices.

As has already been stated, only the simplest of choices will be preferred unless simplicity gives absurd results. Here, a simple choice may have complicated technical problems but those will lay in mathematical methodology.

It is now an opportune stage to review what appears as worthwhile and in no particular order. The reader has coped with CTCs, Krasnikov tube, past and

future light cones, quantum tunneling, superluminality, non-compactified Kaluza-Klein space, an ‘initial’ state that was void and a possible rotating universe. There is sufficient theory present to contemplate the possibility of matter/energy/radiation moving from a time just after the Big Bang to some time before the Big Bang and if required, exotic matter and energy very soon after the Bang would not be in short supply.

The writer intends to use terms that may be thought of as somewhat vague. Without further definitions, ‘stuff’ means material, radiation, plasma and the like in existence very soon after the occurrence of the Big Bang in conventional theory. ‘Bubble’ and ‘disc’ describe the shape of a packet of ‘stuff’. ‘CTC’ means a CTC *and* some other method involving temporal transfer.

It is difficult to imagine a 5-dimensional non-state such ‘the void’ in Genesis and the writer has given up trying. Mental pictures naturally lead to a three-dimensional view, like looking at something from a high window. In a state such as that contemplated, there is nowhere for the high window to be. The reader can be assured that the writer has tried with resulting slight loss in equilibrium.

In 2004 Ken D. Olum and Allen Everett published ‘Can a circulating light beam produce a time machine?’ arXiv: gr-qc/0410078v1. Their paper appeared as an answer to the earlier work of R. L. Mallett (2003) Found. Phys. 33, 1307.

Mallett found a solution to the Einstein equations in which closed timelike curves are present in the empty space outside an infinitely long cylinder of light moving in circular paths around an axis.

Olum and Everett took the idea and showed that for physically realistic energy densities, the CTCs occur at distances from the axis greater than the radius of the visible universe by an immense factor. They also showed that Mallett’s solution has a curvature singularity on the axis, even in the case where the intensity of the light vanishes. That is not the solution obtained by starting with Minkowski space.

If Mallett’s axially symmetric circulating cylinder of light has radiation energy density ρ and the z -axis is the symmetry axis of the cylinder, the solution is intended to approximate the solution in the physically meaningful case of a light beam carried by a wave guide of finite length, L , spiraling around the z -axis.

The radial distance, r , from the axis of the cylinder is taken to be equal to the radius of the cylindrical region containing the spiral.

That approximation should be valid for $r < L$ where L is the length of the spiral along the z -axis.

Mallett established that in the region exterior to the cylinder, a plane of constant z contains circular CTC enclosing the cylinder of all radii $r > r_{\min} > r_0$ being the radius of the cylinder.

The CTCs occur even if r becomes arbitrarily small, although in the limit $r \rightarrow 0$, r_{\min} , the minimum radius of the CTCs $\rightarrow \infty$. This result seems unphysical because it is difficult to believe that a gravitational source of arbitrarily small mass could distort space so drastically as to cause the formation of CTCs.

As the full mathematical analysis can be found in the references given, there is no point setting it out here. Mallett concludes that one of his equations implies that traversing a circle at sufficiently large r allows one to traverse a CTC and return to the same point in space at an earlier time. Also, the Cauchy horizon enclosing the region containing CTCs extends to infinity and is thus not compactly generated. Therefore, the theorems of Tipler and Hawking requiring violation of the weak energy condition can be evaded, and CTCs can exist without the presence of regions of negative energy density.

Olum and Everett partially accepted the results and pointed to a serious practical problem. They said that Mallett's metric is not the metric that one would get by starting from Minkowski space and establishing a circulating cylinder of light. It is true that it is almost everywhere a solution to Einstein's equations with the proper source, but at the origin $r = 0$ there is a line singularity so that the metric used describes a cylinder of light circulating in a spacetime which is pathological even without the light. It is thus unlike the spacetime of van Stockum studied by Tipler (see references in the Olum and Everett paper), that does go to Minkowski space as the source is removed.

With further thought, Olum and Everett show that there is a modified metric and it is straightforward to compute the connection and curvature from that metric and demonstrate the properties:

1. Except for $r = 0$, it is a vacuum solution of Einstein's equations but it is not flat anywhere and it has a curvature singularity at $r = 0$.
2. The paths $r = \text{constant}$, $z = \text{constant}$ means there are null geodesics, so the light does not require any external apparatus to keep it in circulation because the light is circulating on the geodesics of the background metric, that is, it is in orbit around the singularity.
3. The length of the circle with $z = \text{constant}$, $r = \text{constant}$ shows that a photon can traverse this loop in either direction in time. Thus at large distances the elapsed time is arbitrarily small as compared to the distance traveled. Therefore it is not surprising that a small modification of this metric yields CTCs.

It therefore appears that the closed timelike curves appearing from Mallett's metric are the result of starting with a pathological spacetime instead of Minkowski space. There is no reason to believe that CTCs could be produced in the laboratory, even if sufficient technology existed to control a density of electromagnetic radiation so large as to have measurable gravitational effects.

What the writer says is that shortly after the Big Bang, the r of the universe would be small, energy density would be high and CTCs could easily form along the lines above discussed so that a cylinder of light could appear at some earlier time in the same spatial position it had after the Big Bang occurred. With further thought, would we be talking about light as such or would we be talking about an amount of high energy, high density radiation? It does not matter.

For an observer looking along the CTC at the point of temporal departure, it also does not matter if the packet of energy suddenly disappears or disappears with an infinite red-shift. For another observer at the point of temporal arrival, it also does not matter whether the packet suddenly appears or arrives with an infinite blue-shift. All that is important for the purpose here is the temporal transfer of a packet of stuff capable of acting as a trigger.

PROPOSAL: In the beginning a void existed that was nothing, a zero, with no physical features, no physical dimensions and in which time was existent. Then high energy radiation appeared.

SECOND PROPOSAL

Mathematical treatment of this aspect is hardly required as the situation is both logical and intuitive. The appearance of some form of 'stuff' starting in a frame of reference located in n -dimensional space ($n = \text{whatever}$) would have also 'frame-dragged' the portion of space in which it was located to its temporal destination.

If the conventional Big Bang theory is adhered to, any packet of stuff in its space and time that exists after the Big Bang singularity appeared would be subject to physics. Time for it would run and entropy increase no matter where and when it found itself. The packet would occupy a bubble volume or a disc area describable by some coordinate system in whichever number of dimensions appropriate. One question is whether temporal transference along a CTC has the effect of destroying conventional physics. There is nothing in the literature to establish the answer one way or the other.

Intuitively, unless the CTC is capable of exerting some physical deforming force or any other physical change on an object, a man traversing such a curve will not arrive at his temporal destination as a reptile. A CTC is no more than a path in space connecting two points that just happen to exist at different clock times. Whilst not very appropriate to that being considered here, people fly from Paris to New York and in effect, travel backwards in clock time. They do not board

the aircraft as humans and alight in New York as dinosaurs. It is realised that there may well be a difference between clock time, Newton's absolute time and discrete time expressed as q-ticks. Suffice to say that it is the writer's opinion is that the physical effects in following a CTC is no different from following a geodesic from Paris to New York.

Primordial helical motions influence magneto-hydrodynamical processes in the early plasma as well as cosmological perturbation dynamics. Cosmological gravitational waves (GWs) propagate without significant interaction after they are produced and various mechanisms for GW generation have been studied.

Helical turbulence generates circularly polarized stochastic GWs and primordial polarized GWs might be generated from quantum fluctuations accounting for the gravitational Chern-Simons term. GWs are generated by the transverse and traceless part of the stress-energy tensor $T_{\mu\nu}$.

Remembering that the material in question is a super-dense almost opaque fluid, the stress-energy tensor has to apply to that fluid. Note that the writer is most certainly not happy with that. Also, at present, a relativistic model cannot be made and only a non-relativistic model can be used.

With p as fluid pressure, ρ as energy density, $u(x)$ fluid velocity, fluid enthalpy constant and $i \neq j$,

$$T_{ij}(x) = u_i(x)u_j(x)(p + \rho)$$

Using Fourier space, the TT part of the stress-energy tensor is

$$\Pi_{il}(k, t) = \left[P_{il}(k^*)P_{jm}(k^*) - \frac{1}{2}P_{ij}(k^*)P_{lm}(k^*)T_{lm}(k, t) \right]$$

Here, $P_{il}(k^*)$ is the projector onto the transverse plane. Because turbulence is stochastic in form, the induced GWs should be also stochastic and if there is a parity breaking in the source, circular polarization should be present.

This is raised only to provide a suggestion for a triggering mechanism concerning the formation of a solitonic/dilatonic lattice and at the same time, it is realised that overall there is little merit on account of a lack of a relativistic and full quantum description.

PROPOSAL: Time started to run and physical dimensions came into being. Lattice formation was triggered by a gravitational wave. A lattice structure became established in the 'bubble/disc' that expanded. The lattice structure was solitonic/dilatonic and was self-replicating causing further expansion..

THIRD PROPOSAL

The conditions after the Big Bang have been examined in a large amount of literature. Suffice to say that in the conditions then prevailing, there were plenty of opportunities for ‘stuff in their frames’ to follow more than one CTC prior to the time when specific prevailing conditions acted as a cut-off in CTC formation. That opens the possibility of a multitude of ‘bubble/disc’ formations pre-Big Bang.

If the time for CTC formation was short, the ‘bubbles/discs’ would emanate from a smaller region than if the time for CTC formation were long, leaving alone the characteristics of CTCs as to how many, for how long, where, etc. Whichever, there may have been merger of closely spaced ‘bubbles/discs’, collisions and separated bubbles/discs would be single or in groups.

Frame-dragging involves every feature of what is doing the dragging as well as every feature of what is being dragged. That includes gravity and charge.

Here, the writer thinks that if gravity arises as the effect of the zero-point field on sub-atomic particles as soon as they are created from solitonic fluctuations (1A), ‘bubble/disc charge’ is one factor capable of causing rotation (by interaction between two or more) because in each ‘bubble/disc’, conditions have not yet become favourable for the emergence of sub-atomic particles. The ‘bubbles/discs’ are too hot.

Even simpler and the more likely is that many packets of post-Big Bang ‘stuff’ closely spaced arriving in almost the same location would collide with glancing collisions resulting in rotation.

PROPOSAL: At some point, the lattice ‘bubble’ commenced rotation. If it was a disc, it commenced rotation. If a bubble, it might flatten to a disc in sufficient time.

FOURTH PROPOSAL

There is no concern with gravity other than a gravitational wave previously mentioned if (1A) is followed, and for the purposes of simplicity, the approach here will be neither relativistic nor a quantum one.

Bearing in mind that the density of the ‘stuff’ contained within a ‘bubble’ is almost that before temporally displaced. A matchbox may well contain sufficient of that material with the equivalent mass of at least a few galaxies. If the ‘bubble’ has mass M and charge Q and, the ‘particles’ of which it is composed have mass m and charge q , it follows that

$$\frac{Q}{m} \neq \frac{q}{M}$$

Assume that the ‘bubble’ has a total charge to mass ratio $\alpha = \frac{Q}{\sqrt{GM}}$ where G is a constant. It will be hydrodynamically stable, if α is in the order of unity, which is almost certainly not the case. The only particles that can be added to a bubble’ are other ‘bubbles’ with the same or higher α . If the colliders have a larger α , the maximum limit for α will increase.

Imagine a rotating bubble filled with a hot substance located in a void. Because of the pressure within the ‘bubble’, it expands and as it expands, the ‘stuff’ cools.

There are now two possibilities. Either the ‘bubble’ continues to expand and cool until its substance dissipates itself, or, it evolves. Remembering that the ‘bubble’ is not single in isolation and others exist, it is submitted that there may be some ‘bubbles’ that dissipate but there will be others that evolve. The question is by what mechanism.

Take it that the ‘stuff’ of the ‘bubbles’ is isotropic and homogeneous at any moment and in sufficient amount for the ‘bubble’ not to quickly expand only from internal pressure and dissipate. Here, if the ‘bubble’ were self-gravitating, the model would follow that of the collapse of a rotating dense nebula. For such a nebula, self-gravity overcomes expansion with material in the ‘centre’ of the nebula becoming hotter with decreasing size until a protostar forms. If the ‘bubble’ is not self-gravitating, only charge is appropriate.

In the first case, the ‘stuff’ of the ‘bubble’ requires sufficient time to cool so that sub-atomic and atomic particles can form, that is, follow the Big Bang model for early nucleosynthesis before gravity becomes evident (1A). According to standard theory, the time period for that would be so long, the ‘bubble’ would follow the evolution of our universe before collapsing (Big Crunch). If it were not for the great likelihood of a Bang in our past, we might well be living in an evolving ‘bubble’.

The simplest model is that when ‘stuff’ is temporally displaced, ‘stuff A’ may not be quite the same as ‘stuff B’, especially if from different locations near the time of any cut-off conditions post our Big Bang. It is then conceivable that the net charge of each ‘bubble’ would be different. Following the usual rules, similarly charged bubbles would repel each other to expand, cool and dissipate

whilst unlike net charged ‘bubbles’ would attract each other. Unlike charges would arise from the nature of each ‘stuff’, that is, whether predominantly positive ‘stuff’ or ‘anti-stuff’.

It is now easy to visualize but not easy to describe mathematically because the scenario is one of an n-body problem. In fact, it can be called the era of gamma ray bursts. Imagine several charged particles acting upon each other from different ‘distances’. If there were a large ‘gravitating’ centre particle with equidistant other ‘gravitating’ particles, these others would be radially attracted. But that is not the case. ‘Bubbles’ of opposite charge will attract each other and annihilate if they can come close enough to each other, in a massive gamma ray burst. It is thought that this will not happen because approaching ‘bubbles’ of positive and negative material will leak portions of themselves from their boundaries facing each other. These portions attract each other and annihilate. The resulting shock wave of radiation pressure then drives both bulks apart. The void in which they are has no zero-point energy that serves to provide any local speed limit.

Depending on the number of ‘bubble interactions’, it is envisaged that what will remain are two ‘bubbles’ of positive and negative material so widely spaced that to all intents and purposes they have no effect on each other.

Whether the remaining structures are spherical or flat, the material within would show differential rotation. But would the bubbles collapse? They would not. The pressure within acting towards the interface with the void together with whatever passes for a mechanical outward radially directed force, the presence of the void itself and the self-replicating nature of the ‘bubble’ contents would defeat the ‘bubble’ from following any collapsing nebula model.

Whilst the matter/anti-matter charge is likely to predominate, it should be remembered that magnetic helicity can be generated during an early epoch of the universe (48).

PROPOSAL: There are no conditions that will cause mechanical collapse of a ‘bubble’ no matter what its shape. Bubbles of matter and anti-matter become widely separated and need not contain identical amounts of material.

FIFTH PROPOSAL

A phase transition has been previously mentioned in the context that the Big Bang may well have been just that. Although evidence exists that phase

transitions occurred soon after the Big Bang, the time being considered remains pre-Big Bang.

Let it be proposed that ‘bubbles/discs’ undergo a phase change at some point. Conventional mechanism for that requires a high energy symmetry phase spontaneously breaking to a low energy symmetry phase that can lead to the formation of topological defects.

Because ‘bubbles’ would have expanded and cooled even to a tiny extent, any alteration in phase directly leading to a Big Bang is excluded since it would necessitate a lower energy state spontaneously breaking to a higher energy state.

PROPOSAL: The ‘bubbles/discs do not undergo any direct phase change so as to be responsible for the conventional Big Bang.

SIXTH PROPOSAL

It is widely accepted that the Big Bang was largely symmetrical and exhibited a smooth spherical uniformity of everything from the singularity. That applies to particles and their antiparticles. It then follows that the Big Bang should have resulted in equal amounts of matter and antimatter followed by their instantaneous mutual annihilation and therefore no universe. That cannot be correct and the widely held view is more positive matter than negative matter so that after annihilations, the universe remaining had net predominance of positive matter. That means the original symmetry was slightly skewed in favor of matter and that places it conflict with a purely symmetrical Big Bang.

Rather than blindly accept that matter and antimatter must annihilate with each other, the conditions for that should be questioned. One condition is the magnitude of their proximity. The other condition is the duration of proximity if magnitude is sufficient for annihilation. There are secondary considerations such as the Coulomb Effect, escape velocity and whether annihilation energy can be transported away from the site of any annihilation. With skewed particle symmetry and such conditions, the notion of large-scale annihilations in the early universe should be treated with caution, especially as antimatter is a fact in the present universe.

PROPOSAL: Bubbles/discs formed that were largely of positive matter and negative matter as a result of both types of matter being temporally displaced, self replicated and expanded.

SEVENTH PROPOSAL

The fate of both ‘bubbles/discs’ was not dissipation into the void but the formation of two large (by self-replication) flat, expanding regions of n-dimensional spacetime ($n = \text{whatever } n \text{ was in the frame dragging}$) with a small thickness to area ratio. Once the gamma ray burst era was finished there remained only two bubbles/discs composed of particles and antiparticles. In effect, these structures were the surfaces that are the endpoint branes in a theory similar to the ekpyrotic theory.

EIGHTH PROPOSAL

The finally structures so evolved interacted causing a Big Bang. Shortly afterwards, conditions formed where stuff/spacetime was temporally displaced to an era prior to the Big Bang.

3. DISCUSSION

The writer does not intend to defend the aforementioned eight proposals ‘to the death’ with pages of appealing to reason, logic and mathematical wizardry. Rather, the writer will let a few others do that, but not ‘to the death’.

Gasperini writes “String theory can (in principle) describe gravity at all curvature scales, and can be applied to cosmology to look back in time beyond the Planck epoch. The duality symmetries of string theory suggest a cosmological picture in which the imprint of a primordial, pre-big bang phase could still be accessible to present observations. The predictive power of such a scenario relies, however, on our ability to connect in a smooth way the pre-big bang to the present cosmological regime. Classical radiation back reaction seems to play a key role to this purpose, by isotropizing and turning into a final expansion any state of anisotropic contraction possibly emerging from the pre-big bang at the string scale.” [Abstract to a paper (49) written for the 1999 Awards of the Gravity Research Foundation, and selected for Honorable Mention].

Gasperini and Veneziano (50) say “If the history of the Universe can be continued backward in time past the big bang, new possibilities arise for a causal evolution to have produced a big bang with the desired characteristics.

The actual pre-big bang scenario presented in this report is just one possible realization of the above general idea. Since, as we shall see, it is easy to generate a phase of pre-big bang inflation driven by the kinetic energy of the dilaton (somewhat in analogy with kinetic-inflation ideas..., we will discuss), as the simplest possibility, a minimal cosmological scenario, which avoids making use of standard (i.e. potential-energy-driven) post-big bang inflation...

The main difference between the string cosmology and the standard inflationary scenarios can therefore be underlined through the opposite behaviour of the curvature scale as a function of time... As we go backward in time, instead of a monotonic growth (predicted by the standard scenario), or of a “de-Sitter-like” phase of nearly constant curvature (as in the conventional inflationary picture), the curvature grows, reaches a maximum..., and then starts decreasing towards an asymptotically flat state, the string perturbative vacuum. The big bang singularity is regularized by a “stringy” phase of high but finite curvature, occurring at the end of the initial inflationary evolution.

We should warn the reader, from the very beginning of this review, that this scenario is far from being complete and understood in all of its aspects, and that many important problems are to be solved still. Nevertheless, the results obtained up to now have been encouraging, in the sense that it now seems possible to formulate models for the pre-big bang evolution of our Universe that fit consistently in a string theory context, and which are compatible with various phenomenological and theoretical bounds.

The dilaton is, undoubtedly, one of the most important ingredients of the pre-big bang scenario illustrated in this paper. Indeed, the dilaton implements the duality symmetry, controls the strength of all interactions, sustains the initial inflationary evolution, contributes to the amplification of the quantum fluctuations (and, in particular, to the production of seeds for the magnetic fields), leading eventually to the formation of a cosmic background of massive scalar particles. All such effects are typical of string cosmology and represent the “imprint” of the pre-big bang scenario with respect to other, more conventional, inflationary scenarios.”

In (51), “In conclusion, we have shown that the bubble distribution resulting from a first order phase transition has a universal character and has a coordination number that we have determined analytically. The analysis shows that a triangular lattice in two dimensions and a face centered cubic lattice in three dimensions are the regular lattices that come closest to the bubble lattice. The study of percolation on the bubble lattice also supports this finding and we have found the critical percolation probability for the bubble lattice in both two and three dimensions. The result shows that infinite domain walls and strings

will be produced in three dimensions. Finally we have applied our results to the void lattice in the large-scale structure of the universe and, based on some general assumptions, predict an average of 13.4 neighbors to a void.”

The Abstract to (52) reads, “In recent papers, a model of a two-sheeted spacetime $M_4 \times Z_2$ was introduced and the quantum dynamics of massive fermions was studied in this framework. In the present study, we show that the physical predictions of the model are perfectly consistent with observations and most important, it can solve the puzzling problem of the four-dimensional localization of the fermion species in multidimensional spacetimes. It is demonstrated that fermion localization on the sheets arises from the combination of the discrete bulk structure and environmental interactions. The mechanism described in this paper can be seen as an alternative to the domain wall localization arising in continuous five dimensional spacetimes. Although tightly constrained, motions between the sheets are, however, not completely prohibited.”

The question now remains, what was the cause of the very first Big Bang if there were and will be a series of these in the past and in the future?

Firstly, it is envisaged that temporal displacement to t^- can occur only when conditions are in the t^+ state, that is, from a Bang and not a Crunch.

Secondly, an observer in the void would see a blaze of radiation in its own frame of reference emanating from the observer’s future.

Thirdly, the cause of that radiation is the Big Bang and the cause of the Big Bang is the emergence of that radiation.

Fourthly, notions of a cause producing an effect apply only to conditions where time runs in one direction. When time is capable of running in ‘both directions’, there is nothing to prevent a cause being its own cause and an effect being its own effect. As it is taken that such temporal displacement can occur only under the conditions of the initial singularity and very soon afterwards, it is trite to argue what two observers would see as ‘cause’ and ‘effect’ as that is reduced to a semantic exercise.

To answer the question posed, a series of Big Bangs is not envisaged. What is envisaged is a single event of temporal displacement making the Big Bang its own mother.

CONCLUSION

Having cited an overall minimal number of papers that time displacement of material from after the Big Bang to a time before the Big Bang is theoretically possible, eight proposals were made highlighting likely stages of pre-evolution of the universe proceeding in time towards the Big Bang itself. Whilst not replete with mathematical analysis, this paper attempts to explain the theory in the simplest language and most certainly raises more questions.

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