A New Hypothesis for the Universe: The Role of Thermal Gradients in Setting Time, Forming Three Dimensional Space and Populating with Matter and Energy.

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1. **Summary.** The universe is formed from proto-quantum field(s) (PQFs). The initiating event is the formation of a thermal gradient which establishes synchronous oscillations which describes time. Time is not quantised. Concomitantly PQFs, either directly or indirectly, differentiate into all the quantum fields required for the standard model of particles and forces, and three dimensional space. The transition of PQFs to functional quantum fields is a continuous process at the boundary of a spherical universe, a "ring of fire", necessary to maintain time.

2. **Introduction**. Notwithstanding intensive mathematical inventiveness during the twentieth century, no models substantiate a general hypothesis that the universe originated from a singularity expanding through a single event which created all matter and energy distributed in spacetime by the mechanism of inflation[1] or many modifications of this core concept. Many limitations of the singularity-big-bang conjecture are recognised, but the search for mathematical elegance is elusive.[2] Moreover, this approach is at the expense of qualitative considerations which must be encouraged as an equally important component of cosmology. So precisely how quantum mechanical descriptions[3,4,5] at the very small scale combine with general relativity[6] at the very large scale, remains the exclusive preserve of increasingly more complex conjectures. The central question demands renewed thinking to define alternative models less reliant on abstruse mathematics which in turn often throw up even more curious conclusions.

This communication is a positive acceptance of Hartle and Hawking's suggestion[7] that a "qualitative understanding is more important than precise numerical results" which fits available observations at the moment with empirical reasoning. Hartle and Hawking, renowned cosmologists, asserted that verifiable quantitative analyses should then follow. Similarly, Penrose was content to examine, initially, empirical models before embarking on a qualitative description.[8] As Hossenfelder[2] concluded, graphically and probably sadly, theoretical physicists "have concocted mind-boggling new theories, like the idea that our universe is but one of infinitely many that together form a 'multiverse'." Here the search is for simplicity, a very much more beautiful feature of the natural world, with simple mathematics being a greater satisfaction than impenetrable quantitative theories.

The orthodox position that the universe arose from a unique event — the singularity-big-bang — implies, without any need for mathematics, that the progression of the universe is a linear process. This is an inescapable conclusion from models which aim to define the *ab initio* event at time t = 0. However, as beguiling as it is to the ego of human superiority that the start is recognised, it is equally plausible that the observable universe formation is one stage in a continuous, cyclical process. For example, the quasi steady state model of universe evolution proposed by Hoyle *et al*.[9] and other models are suggestions which have the advantages of dealing with some of the accepted deficiencies of the singularity-big-bang conjecture. These models compete with the orthodox wisdom of a singularity event associated with inflation.

Alternative models must account for several interlinked factors, the principle ones being time, matter and energy formation, information retention, and universe expansion. To varying extents these four items change the perspective that the singular event was the correct, strict *ab initio* event. As a group, a qualitative understanding of these factors leads to a novel description of the behaviour of the observed universe. It demands an open mind to consider an alternative to the widely accepted orthodox description. In conformity with the singularity-big-bang and inflation model, this alternative approach says nothing about the pre-universe state and/or condition, but its value is in explaining more accurately the real events which have and are contributing to the existence and behaviour of the universe as we presently know it. It goes without saying that only a proper interpretation of current observations, eventually leading to accurate quantitative models, must be the correct way to search for the presently hidden *ab initio* event. In order to propose a new explanation for the cyclical behaviour of the universe, this communication deals with a number of factors individually, remembering that, inevitably, there is an interdependence between them.

3. **Time.** All models heretofore assume that time commences coincidentally and instantaneously at the *ab initio* event, but no consideration is given to the mechanism which originates time, nor indeed what time is. This is misleading, indeed invalid, since its omission potentially explains the failure of current orthodox models. Improper or unexplained introduction of the time dimension eliminates a criterion which must influence the primordial universe developing into the universe we recognise, critically affecting efforts to describe accurately the true process. The omission of a time mechanism is unfortunate since, from other disciplines, there is a generalised time mechanism which is applicable.

Some time-origination mechanisms postulate that heat content or changes in heat content, consistent with thermodynamic laws, are important, but none properly provide a mechanism. In particular, Rovelli[10] stated his belief that the flow of heat within quantum systems defines time. The basis of Rovelli's conjecture is that heat flowing throughout the universe is intimately linked to time because there is a real, measurable difference between the past and the future only when heat flows. For Rovelli, with his emphasis on loop quantum cosmology (LQC) as an important mechanism,[11] the significance of quantised space and time dimensions describes an interlinked quantum matrix through which heat can move thermodynamically, becoming the basis of universe time. However, to date no mechanisms have been postulated, other than time may be quantised.

Many disciplines within natural and social sciences understand a fundamental relationship first formulated by Verhulst.[12] The relationship is a polynomial logistic function describing a modified exponential relationship between time and a given parameter which self limits an unattenuated exponential function. This fundamental relationship contains a rate constant with units of reciprocal time. The quantitative model under defined conditions describes many different types of complex dynamics. May[13] utilised the Verhulst relationship for seminal advances in the behaviour of biological systems, especially population and community ecology, their growth dynamics and relationship to environmental growth-limiting factors. He demonstrated that, under certain conditions, stable oscillations in population size were modelled as a function of time. So in a reverse relationship, oscillating population changes explain the flow of time. The question is how and to what this relationship is applied.

For the purpose of discussing how May's modified Verhulst relationship is applicable to cosmology, this communication assumes the presence of quantum fields, suggested by Hartle and Hawking[14] who defined a three dimensional "ground-state wave function ….. in the quantum state of the universe that we live in because the matter wave function does not oscillate." This determination, giving a "space-like surface", was formulated to support the singularity-big-bang, but notably "cannot specify time in these states". Hartle and Hawking termed the ground state wave function a "minisuperspace" (MSS) which they envisaged was a single entity for the basis of the universe. Previously, in unpublished communications, I termed these as "quantum entities" or "proto-quantum fields" (PQF).

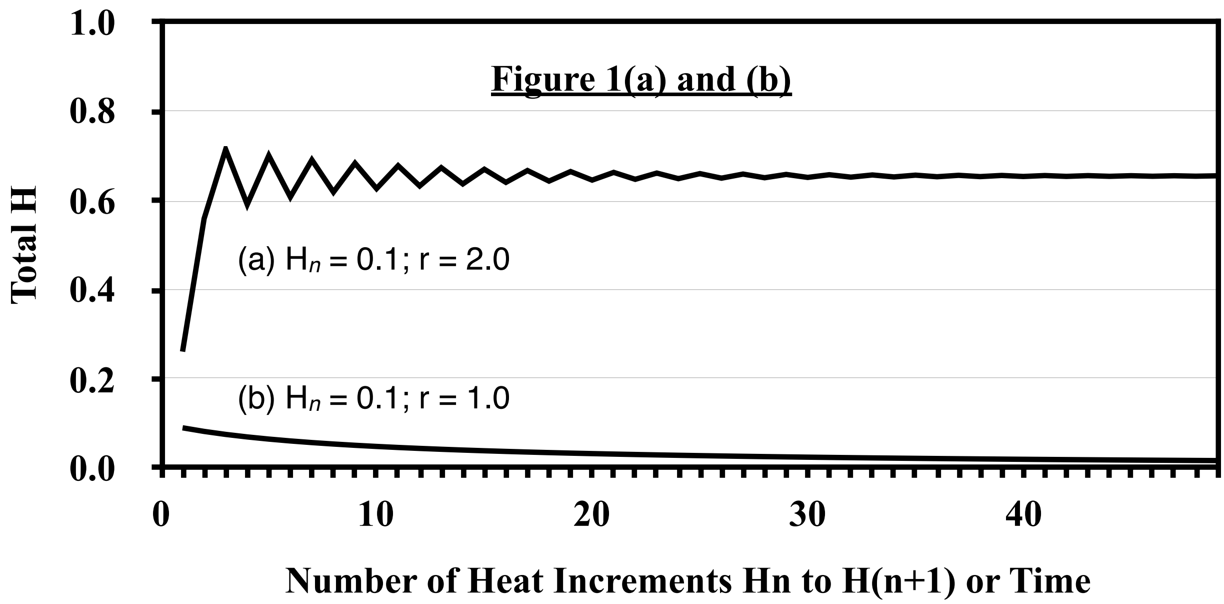
The hypothesis is that PQFs, qualitatively similar to minisuperspaces, exist in the primordial universe (or proto-universe) and continue to exist outside the known universe after the commencement of the universe. These are considered as conventional quantum fields, which adhere to all quantum rules, with an energy content but existing in a timeless environment as explained by Hartle and Hawking. Ordinarily PQFs are quiescent, behaving as ground state quantum fields, until the *ab initio* event occurs in one PQF (the prime PQF) which releases energy with the production of heat, causing the expansion of the prime PQF. The unique prime event interacts with adjacent PQFs, such that a thermal gradient forms between the prime and adjacent PQFs.

Using May's presentation of the Verhulst equation:

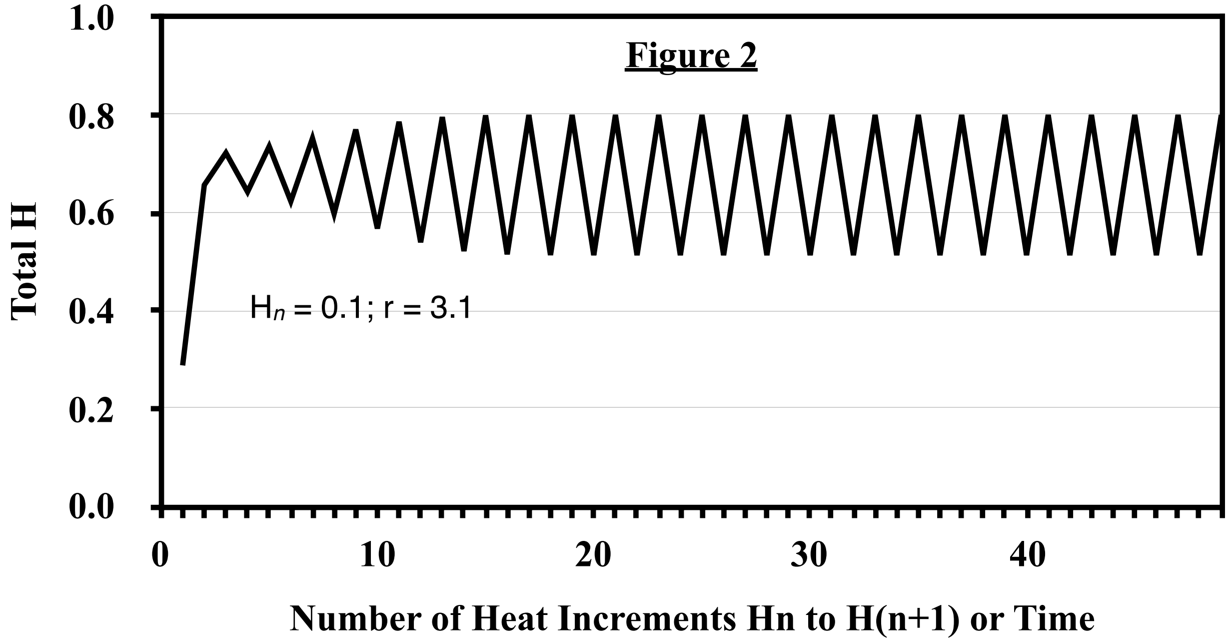
$$H_{(n+1)} = r\,H_n\,(1 - H_n)$$

where H = heat content of proto-quantum fields (PQF) (equivalent to the ground state, non-oscillating wave functions deduced by Hartle and Hawking), expressed as a ratio with a value between 0 and 1; H_n = an initial ratio incrementally increasing to $H_{(n+1)}$; and r = rate constant with units of reciprocal time for the transfer of heat between adjacent PQFs. The relationship is independent of the initial value of H_n but highly dependent on the value of r. Since H is a ratio, no quantification of the heat content of a given PQF is required for a qualitative model.

With low values of r, for example, r = 1.0 (Fig 1(a)), the heat content within a PQF is not established or maintained since the rate of heat flow is too low. There is no evidence of any oscillations. At r = 2.0 (Fig 1(b)), heat content oscillations are established transiently, ultimately decaying to a retained heat content which is greater than for r = 1.0. This difference in the heat carrying capacity of the PQFs is significant, implying that different quantitative levels of heat are retained within different PQFs without disturbing the non-oscillating quantum wave functions.



At values between r = 3.1 and 3.6, stable oscillations in heat content are achieved. Fig 2 shows the regular oscillations for r = 3.2 as a function of the rate of incremental increase in heat content. For unlimited continuous oscillations over time a continuous flow of heat is required.



Thus within the acceptable range of heat flow, PQFs stable oscillations are established, noting the following points.

(a) This hypothesis does not say anything about the existence of PQFs prior to the establishment of time-generating oscillations. In passing it is noted that for individual PQFs to exist with characteristic wave functions, there is internal heat flow derived from the wave oscillations, maintaining a process equivalent to time, which might be defined as "intra-time". If this interpretation of the behaviour of PQFs is correct, intra-time between different PQFs need not be identical, and is independent of the conventional understanding of time.

(b) Throughout the proto-universe populated with multiple PQFs three dimensional thermal gradients are established, resulting in identical oscillations — within a limited range of heat transfer rate constants, r — in all those PQFs which are influenced by the primary heat generating event in the prime PQF.

(c) The amplitude of the oscillations is constant irrespective of the precise value of r, a property which enables a fixed, constant time to be established within all PQFs exhibiting a thermal gradient. This defines a precise, common time in all quantum fields yielding same value of time throughout the universe.

Since more than one PQF exhibits the same oscillations, this form of time is defined as "extra-time". A useful analogy is the piezoelectric effect in stimulated quartz crystals which generates highly accurate, constant measurement of time.

(d) A fundamental principle of nature is a capacity to generate and maintain spontaneous order. As Strogatz has summarised: "At the heart of the universe is a steady, insistent beat: the sound of cycles in sync. It pervades nature at every scale from the nucleus to the cosmos".[15] At the particle level, he describes the role of spontaneous order delivering the property of superconductivity. This is an example of quantum synchronicity, where electrons act in linked pairs, a manifestation which is counterintuitive to the normal behaviour of electrons. So within the universe, once thermal gradients are established, interactions between quantum fields by the balancing of heat transfer preserve heat oscillations, and so time. Time is therefore congruent heat oscillations throughout all quantum fields within the universe. Synchronous behaviour within quantum fields represents a fundamental extension of a core natural phenomenon: indeed, I suggest that since time impacts every event throughout the universe, this must be the most significant manifestation natural synchronisation.

(e) The model does not require heat, and so time, to be quantised, meaning that future mathematical descriptions will be different to LQC type descriptions. Time is not a separate dimension in the sense that space has dimensions. The inevitably conclusion that the conventional space-time concept is different to its normal mathematical interpretation.

(f) With time oscillations established, the quantum fields are fully consistent with quantum rules, including the Heisenberg uncertainty principle[16] and Schrodinger's equation[17]. That is, not only is time, as we understand it, functional, but also this process completes the transition of a proto-universe populated with quiescent PQFs to a universe populated with fully functional quantum fields (section 3).

(g) It is self-evident that a continuous thermal gradient is only sustainable if there is a continuous supply of heat. If not the value of r declines leading to the termination of PQF oscillations with no time expressed by that PQF as exemplified in Fig 1.

(h) As time in the universe is functional by this mechanism, then the singularity-big-bang model must be invalid since quantum fields do not exist in the early stages of this hypothesis.

4. **Matter and Energy Formation.** The postulated explanation for universe time (section 2) concomitantly yields fully functional quantum fields. Two schema are envisaged, depending on the nature of the quiescent PQFs in the proto-universe.

   (i) Assuming all PQFs are identical **before** the *ab initio* event, then the appearance of basic fermions, bosons and three-dimensional space is the direct result of individual PQFs acquiring varying energy content, uniquely characteristic of standard model particles and forces, concomitantly with the formation of time. In the absence of any contradictory experimental evidence, three dimensional space quantum fields are also uniquely characteristic with defined, but presently unknown, energy content. The differentiation into the basic standard model quantum fields for particles and forces is a subsequent mechanism involving the transfer of energy to establish the required unique levels. An extension to this schema is that the proto-universe is a single PQF which continuously excises discrete quanta fields which become the substrate for the *ab initio* event. A useful analogy is the method of growth by budding yeasts where a proportion of the cell's mass is separated as a small daughter cell from the main larger parent cell.[18]

   (ii) Alternatively, at a higher level of complexity, the PQF fields, **before** the *ab initio* event, are a mixed assemblage of different PQFs comprising pre-fermions, pre-bosons and pre-three dimensional space, only achieving normal quantum behaviour after the heat transfer from adjacent PQFs concomitantly with the formation of time.

The model explains how the energy, matter and space components of the universe are generated, noting the following points.

(a) The formation of time occurs concomitantly with the activation of three-dimensional space quanta. It is significant that this fundamental linkage binds space and time to give the space-time form which underlies general relativity.[6]

(b) The proto-universe is populated with PQF(s) in a suitable form. There must be an infinite supply of PQFs to maintain time and the function of the universe.

(c) The formation of functional quantum fields is not a single event. It is a continuous process occurring at the boundary between the observable universe and the proto-universe, depending on the flow of heat between adjacent PQFs and the derivative quantum fields.

(d) From the outset, the universe expands from the prime PQF to form the spherical boundary with the surrounding quantum field. As expansion increases with further PQF activation, a suitable analogy is that there is a "ring of fire" with elevated temperatures, with heat feeding into the space quanta to establish the universe-wide heat gradients. The continuous process occurs at a uniform rate, with the spherical volume of space at a constant rate within the ring of fire zone. This is consistent with experimental observations that the universe is expanding.[19]

(e) For a sphere the increase in volume is a third order function ($V \propto r^3$), whereas the increase in surface area is a second order function ($A \propto r^2$). As the universe expands, the mass formed in unit time increases, but the volume increases more rapidly per unit time. The density of matter and energy declines the closer to the ring of fire that density measurements are made. However, the continuous production of matter with changing gravitational force exerts effects on the progression of matter development such that, for example, galaxies accelerate outwards towards the ring of fire.

(f) The rate of formation of functional space quanta is a function of the quantity of heat released when a PQF is activated. If the rate is less than that required to activate every PQF in its sphere of influence, then a proportion of the PQFs do not become functional quantum fields because they do not exhibit the property of time. The undifferentiated PDFs are not characteristic matter and energy as envisaged in the standard model. With reference to Fig 1a and 1b, the incompletely activated PQFs absorb some heat but not enough to achieve a completely functional state. Experimental evidence shows that only approximately 5% of the matter in the universe is deemed fully functional, able to provide analytical measurements. The remaining 95% , known presently as dark matter and dark energy,[20] equates to forms of matter and energy which are difficult to quantify and which I term "dark PQFs". Nevertheless, dark PQFs located within the time-functioning universe exhibit interactions with space quanta contributing to the observed gravitational effects.[21]

(g) For all quantum fields of normal matter, energy and forces it is assumed that once activated there is an infinite life span. This may be a reasonable assumption for "normal" time scales, but invalid over a universe lifetime. Accordingly, a continuous supply of energy, in the form of heat, flowing through the universe via the space quantum fields, is exploitable to maintain the required energy levels, provided that there is an interaction between all quantum fields each participating in the flow of heat.

(h) Cosmic microwave background radiation (CMB) is recognised as evidence of the singularity-big-bang.[22] However, there is no *a priori* reason why concomitant production of functional photons, as predicted from the functionalisation of PQFs, equally generates CMB. The overall uniformity of CMB suggests that the processes occurring in the ring of fire are remarkably constant.

5. Conclusions. The hypothesis presented here is founded on two core ideas. Firstly, the mechanism based on thermal gradients which establishes time fixed by synchronisation as a constant in all functional quantum fields, including space. Secondly, in a concomitant *ab initio* event with time, one or more PQFs continuously emerge as functional quantum fields in the same time environment. Overall this is a radical alternative to the singularity-big-bang model. In its favour, at least as it appears in a qualitative description, it describes processes and mechanisms which are consistent with observations, such as an expanding universe. As well this hypothesis removes the intractable problem of inflation with a number of conceptual difficulties that in turn generates.

It is, of course, acknowledged that the behaviour of quantum fields in a timeless environment (or at most an intra-time environment) must be quantified and mathematically modelled, but the prospects of expanding established quantum field rules is a logical expectation, as is the hypothesised transition to fully functional quantum fields.

The model also deals with another concern about the singularity-big-bang conjecture, namely how a singularity can encode the information which results in the fundamental properties of the universe. By retaining the basic quantum fields as PQFs, the structure retains the information which, under the right circumstances, can be expressed. This may be considered a reversible process allowing the universe to operate as part of a continuous regenerating cycle, similar in concept to Penrose's conformal cyclic cosmology.[8] There is merit in energy, matter and associated structure, form and function information being recycled continuously. Perhaps black holes gather matter and energy together, reducing the collected components to fundamental states before evaporating back into the universe as PQFs. It is not unnoticed that perhaps dark PQFs might be elements in the recycling process.

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