RESEARCH ARTICLE

A new cosmological model: Origin and maintenance of the universe

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ABSTRACT

Thermal and Particle Diffusion-Wave dynamics (Thermon-PDW) explain the mass sizes of Standard Model (SM) particles under steady state, non-equilibrium conditions throughout the universe. Starting with a Pre-Quantum System (PQS), a field containing Pre-Particles (PP), this mechanism leads to functional SM particles behaving according to standard Quantum Field Theory (QFT). This is a new cosmological model which discounts the Standard Model of Cosmology (SMC).

The Thermon-PDW Cosmological Model has a unique, absolute requirement for a continuous thermal flux to initiate and maintain the universe. Initially derived to explain the mass of SM particles, unexpectedly it also theoretically describes universe time, gravity and gravity waves. Qualitatively the Thermon-PDW CM alludes to: quantum entanglement; dark matter and energy; Cosmic Microwave Background Radiation (CMBR); information loss from black holes, and; cosmic web large scale structures.

Keywords: *Thermal Diffusion Wave; Particle Diffusion Wave; Steady State Non-Equilibrium; Thermophoresis; Pre-Particles; QFT; Thermon-PDW Cosmological Model*

INTRODUCTION

We wish to suggest an alternative physical origin and organisation of the universe contrasting with the Standard Model of Cosmology (SMC) [1]. The masses of Standard Model (SM) particles theoretically are generated in "ensembles" of pre-particles in a pre-universe quantum field, and thermal and particle diffusion waves whose interactions generate harmonic solutions [2-4]. The Thermon-PDW mechanism is observationally confirmed [5].

New cosmology model dependent on the canonical Thermon-PDW mechanism

However, this generates its own complication, namely, an obligatory requirement for a thermal source continuously perfusing through the universe. This constraint (and others) is accommodated by several properties of the principal hypothesis. Furthermore, if this interpretation is validated, it eliminates many difficulties due to the orthodox cosmological model, such as reverse engineering fundamental laws of physics, the initial singularity, initial high temperatures and densities and inflation. SMC as a whole may be discarded together with other model possibilities, including string theory solutions, multiverse, quantum loop theories and physics beyond the Standard Model of Particles [1, 6-7]. The property of primary, overwhelming importance for the Thermon-PDW Cosmological Model is establishing a universe-wide flow of thermal energy, explaining how this is done and what other consequences there may be.

Neglected hidden thermodynamics

There is disputed history concerning the definition of a quantum system, some of which are pertinent to a radically different understanding of the origin and operational maintenance of the universe, most particularly thermal energy which is assumed but not explicitly modelled, in other conjectures [8-14]. Some twentieth century quantum revolution founders, including Einstein and Schrödinger, were unsettled by the restrictive definitions of quantum theory. Others, especially De Broglie over many years, argued for missing factors, which he called the "hidden thermodynamics of particles". Later Bohm concluded that "it is not necessary for us to give up a precise, rational, and objective description of individual systems at a

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quantum level of accuracy" [14-16]. Theoretical ideas were neglected for lack of experimental or observational evidence which was an inevitable conclusion since, in De Broglie's era, at least 10 SM particles, required to reveal the Thermon-PDW model, were unknown. The physics world has consigned this debate to irrelevant ancient history, the more so now we have identified a theoretical basis for missing thermodynamic factors.

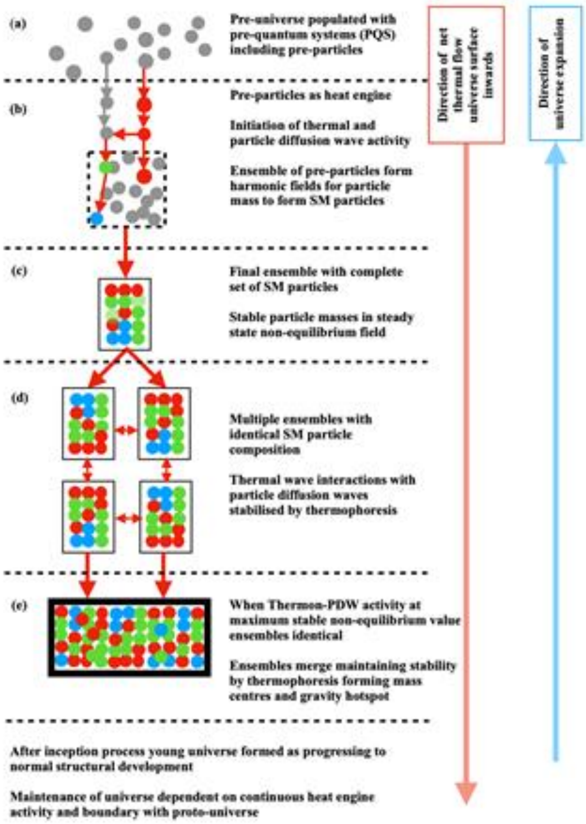

Figure 1. pre-particles; boson; lepton; quark (Figs 1 - 3 in (5)); Thermal diffusion; Initial thermophoresis; Completed ensemble at steady state; Clusters of two or more ensembles

Pre-quantum system or field in proto-universe

If the Thermon-PDW mechanism is reversed to the initiation point where t = 0, total mass = 0 and the fundamental thermal field = 0 (Eqs (17), (43) & (45) in [5]) with no particle diffusion momentum, then the residual core quantum field (the Pre-Quantum System, PQS) is entirely quiescent even though the physical structure of PQS is unknown. This is the ab initio stage which we do not recognise as a particle in the accepted sense used for SM particles in normal matter, although there is satisfactory logic for this theoretical ab initio state (see **Dark matter and energy**). This methodology is identical to the raison d'être used by Dicke et al. (possibly all cosmologists) who speculated that the initial temperature of a singularity at t = 0 + a few billionths of a second was in the order of 10^{10}K, even though the physical nature of the singularity is unknown [17].

Furthermore there are interesting later consequences for this theoretical ab initio state (see **Dark matter and energy**). This distinction is important since fully functional SM particles are only formed when steady state non-equilibrium conditions are reached.

During the early initiation phase absenting SM particles behaving as quantum fields there can be no Quantum Field Theory (QFT) mechanisms. Unlike SMC, however, the Thermon-PDW model prescribes a precise sequence of events, with rational theory, to convert non-QFT pre-particles into a SM particle (Fig 1) crucially transitioning from mass = 0 to normal mass. This is a radical change in understanding the universe: that is, beyond an active surface boundary of the universe, there is the proto-universe which is composed only of massless PP entities. Furthermore, as we justify later, the direct formation of SM particles, now with mass, is the central feature of the origin and operation of the universe. This process operates before QTF, and no ongoing relationship is necessarily presumed at this stage of knowledge development. It may not be a surprise to find that QTF has some ultimate dependence on the Thermon-PDW mechanism.

Origin of universe

Another significant difference from SMC is that identical origin events occur continuously to maintain the Thermon-PDW mechanism (Figure 1A). The mechanism is theoretically described elsewhere (Sections 4 & 5 in [5]) and is observationally supported (Section 3 in [5]). The continuous origin events to maintain thermal flow increases the local entropy in the boundary region, which is reflected in continuous universe expansion [16]. The canonical feature is the direct formation of SM particles, eliminating the speculative SMC singularity at high temperatures, high density and other associated difficulties requiring inventive guesses. Repeated origin events maintain the controlled release of thermal energy into the universe, the continued expansion of the universe and formation of SM particles with mass. The theoretical model combines thermal and particle diffusion within an ensemble to generate harmonic solutions. When the thermal framework dynamics reach the predicted steady state, essentially when there is a constant thermal flux into and out of an ensemble, the particles are also in a steady state thereby defining the SM particle mass values (Figure 1C). One or more ensembles may occupy the same region in a local environment, the multiple harmonic waves oscillate together effectively creating a cluster of mass centres (Figure 1E), theoretically distributing stabilised SM particles with quantified mass throughout the universe. The gravitational implications are discussed later (see **Gravity mechanism hidden within the Thermon-PDW model**).

An important property of the thermal framework is that under constant environmental conditions all steady state values prescribed by the model are asymptotically reached. This is an inherent feature of the core equation (Eq (17) in [5]). So changing ambient temperature has the most important and far reaching effect on the asymptotic values reached since particle migration probabilities (Pij and Pji in Eqs (6) & (9 in [5]) are temperature dependant (Eqs (11), (14) & (14) in [5]) ultimately governing the non-linear differential equation and overall Thermon-PDW model equation (Eq (17) in [.5]). Quantitative properties are observationally unknown, but theoretically include: particle diffusion distance; lag time; spatial separation of particles within the ensemble; particle hopping frequency between adjacent ensembles; diffusion coefficient and particle velocity. This enables any transient changes in temperature to eventually return to the governing thermal flux background. The presence of a star, for example, causes local changes (and different quantitative Thermon-PDW values) but returns to background universe-wide values when the star dies. This is also important when it comes to explaining why CMBR is so remarkably stable (see **Cosmic microwave background radiation**).

These events ensure the continuous flow of energy through previously formed particles, creating an interactive network (see **Galaxy arrangement in universe**). In one sense each PP activation is a random quantum event, with the same important meaning advocated by Lemaître [16]. However, its cosmological significance is only valuable when acting sequentially with multiple identical events. Applying Occam's Razor principles [19], the controlled gradual release of energy, notwithstanding the evidence of massive energy releases by a fully formed universe, is a satisfactory mechanism especially when complex conjectures, such as inflation or an initial singularity, have resisted theoretical and observational validation for decades. The Thermon-PDW-driven universe exhibits properties which are considered "steady state", used in a different way to the original use of a steady state universe in which total mass was fixed from the outset [20-22]. In the Thermon-PDW model for the universe, steady state only refers to a constant flow of thermal energy throughout the universe, maintained in a non-equilibrium state. It is this steady state meaning which determines the SM particle masses values as the universe expands. It does not mean that the total mass of the universe is in a constant steady state.

Three-dimensional space

The Thermon-PDW mechanism does not appear, after analysis to date, to include any properties or sub-models for the origin of three dimensional space but assumes that such a mechanism does exit. One obvious possibility is that pre-existing 3D-space forms within the proto-universe, but that is a theoretical step too far for now. Alternatively, a 3D-space equivalent to Hartle and Hawking's proposed "ground-state wave function ..... in the quantum state of the universe that we live in because the matter wave function does not oscillate", termed a "minisuperspace" [22]. This theory describes a "space-like surface" structure but did not "specify time in these states". In the initial stages of minisuperspace formation, the absence of oscillating wave functions is not important, nor the lack of matter wave functions, since both are added in with Thermon-PDW activation (see Universe time). How this "no boundary" solution links with the Thermon-PDW mechanism is unresolved, but we suggest that much of the previous no boundary debate is of limited value because we are advocating an obvious boundary (Figure 1A compared with Figure 1B) [23]. We expect, too, that theoretical developments will reorientate the spacetime concept, requiring reconciliation with general relativity.

Universe time mechanism hidden within the Thermon-PDW model

The Thermon-PDW model also explains universe time. Consider an ensemble containing two SM particles, or any other relationship of two or more particles, such as PP, then coupled Thermon-PDW interactions establish a diffusive density leading to the onset of thermal oscillations and energy dissipation [25]. This interaction is observed as a relative drift momentum between the two particles (Fig 6 & Section 6.3 in [5]). Assuming suitable technology is available, the differential particle movements are measurable by an external observer. This interaction constitutes universe time described at the quantum level. Theoretically universe time is measurable within asingle pre-particle or SM particle by an internal observer who can observe the evolution of diffusion (particle spreading) probability but not by an external observer. Under free time-domain diffusion there is a stationary locus of the maximum thermal energy but lateral diffusion depends on time. If the thermal activity is in the form of harmonic thermal waves (thermons), then both the maximum amplitude **and** the lateral diffusion become time-independent since both only depend on the thermal diffusion length $1/\sigma t$, (Eq 44b in [5]), which is fixed for fixed oscillation frequency.

Therefore, time appears stationary to an external observer who is not entangled in the particle oscillation cycle. The impact of internal and external observer status must have a consequence for relativity equations.

Of greater significance is that universe time is defined explicitly, sequentially emerging as unstable Thermon-PDW waves transitioning to a steady state non-equilibrium phase (Figure 1A,B). How this impacts Einstein's equations is obviously an interesting question for consideration later.

Another interesting facet of the Thermon-PDW hypothesis confirms that the passage of time, that is the so-called "direction of time", cannot be reversed. Consider that macroscopic irreversibility arises from time-reversible microscopic dynamics [26]. It follows that SM particles (analogous to a macroscopic particle) cannot be formed by reversing time (equivalent to microscopic dynamics). Putting this concept another way, the probability of reconstructing the exact same particle arrangement even in the simplest interaction of two ensembles is zero.

This model provides a solution to hidden (or missing) thermodynamics. So, it is a reasonable question to ask, for example, as did Kamenshchik et al. [28]: "Where is it [time] hidden?" We noted (see Three dimensional space) that the minisuperspace theory [23] might benefit from the expression of time by the Thermon-PDW mechanism. For example, Moreva et al. [28] argued that 3D-space hypotheses encountered difficulties caused by the "quantization of general relativity" , also encountered elsewhere [27, 28]. But Moreva et al. also proposed that universe time emerges from a sub-system of entangled quantum systems which is only recognised by an internal observer who is part of the entanglement. The universes' remaining systems are oblivious to time passing, thereby retaining a static or timeless state, and "time [as] an emergent property of sub-systems of the universe derived from their entangled nature [would be] an extremely elegant but controversial idea".

Within an ensemble, the SM particle residence time eventually reaches a maximum, $\tau_{R,f}$, at a steady state corresponding to a particle density above which all particle diffusion across all regions of space occurs with the same probabilistic time constant. Under these conditions universe time is measurable, by an external observer, caused by effective particle-to-particle attraction based on density gradients (Eqs (17) & (18) in [5]). So, in summary, universe time emerges from momentum-mediated thermal energy dissipation, diffusion and oscillation (Eqs (29), (31) & (38) in [5]) concomitantly with particle mass and gravity mechanism. It is a function of the interactions occurring between entangled quantum systems (see Interim summary conclusions).

Gravity mechanism hidden within the Thermon-PDW model

Embedded in the Thermon-PDW model are several stages which generate the "thermophoresis" phenomenon. Firstly, directly from non-linear particle density diffusion solutions in response to diffusion wave harmonic spectra, the particle density is directly linked to the environment's background thermal energy, causing particle-to-particle attraction (Eqs 17-23a in [5]). Since particle attraction occurs from the origin of Thermon-PDW functionality, this is crucial to maintaining the PPs within an interacting ensemble's harmonic solutions, retaining the essential diffusion distances to yield the SM particle mass solutions (Figure 1B). It is important to appreciate that this mechanism operates just as well with non-QFT pre-particles as QFT SM particles. Secondly, from the analysis of the behaviour of two or more pre-particles (when universe time is first encountered), then simultaneously particle diffusion and non-uniform random walks, in a thermal gradient, gives rise to thermophoresis (Figure 1B) (Fig 6 in [5]). These observations support the notion that gravity, in the form of thermophoretic attraction, is concomitantly linked to universe time and mass. Thermophoretic attraction is not necessarily what was expected previously from a quantum theory of gravity, for example, a new particle the "graviton". But nevertheless this mechanism might provide an effective basic means to enable the formation of the universe's large scale structures right down at the quantum level. Alternatively the simple thermophoresis mechanism might evolve into a more complex manifestation at the large scale.

Dark matter and energy

Dark energy is not considered for now, but dark matter is qualitatively addressed. Two mechanisms generate sub-optimal SM particle forms not recognised by an external observer. Thermon-PDW functionality has an obligatory requirement for a continuous thermal supply from an external source (see **New cosmology model**). This property is embedded in the source term N(x,t) ħω (Eqs (29, 34 & 44) in [5]). If the thermal source is switched off, the Thermon-PDW mechanism collapses, particle and mass formation cease, and the particles revert to a quiescent state equivalent to PPs in the proto-universe, but renamed dark matter. The magnitude and order of transitioning from normal matter to dark matter is unresolved because of the absence of quantitative information, and also because there is no observational evidence that in the long term SM particles always retain an ultimate dependence on thermal flux. During the transition, does universe time function terminate (or becomes ineffective) before or after thermophoretic gravity effects (or vice versa)? Questions like this may answer the apparent observation that dark matter contributes to gravitational forces on a universe-wide basis. Another of importance is that the inability to detect dark matter (not observable by external observers) directly using methods involving normal matter (externally detectable).

The second mechanism is simpler. With the universe composed of 5% normal matter (products of the Thermon-PDW mechanism) the ca 40% dark matter is PQS material subsumed into 3D-space in an orientation which precludes the formation of an embryonic ensemble. It is a matter of chance that, in a local environment, requisite PP potential diffusion distances are spatially correct. Absenting these conditions, then any 3D-space formation exacerbates the impossibility of forming ensembles to mature into complete stable non-equilibrium entities.

There is a rich opportunity to refine the impact of the Thermon-PDW hypothesis. In particular the lack of external universe time is likely the reason for the inability to use normal matter based detection methods since any interactions are neutered by particle to particle interactions and/or the local environment removes the reliance on any external time component.

Cosmic microwave background radiation

CMBR is prime evidence in favour of the SMC. This may be so, but it is not appropriate to critique either the evidence or the SMC theoretical rationale [17, 30]. Indeed a direct theoretical comparison is not possible, since the fundamentals of SMC and Thermon-PDW are different. However, CMBR as an accepted observation needs explanation in a Thermon-PDW driven universe. CMBR is an SM particle, so, as for all Thermon-PDW decomposition solutions, the final diffusion length temperature is determined by the local universe environment. The CMBR radiation temperature is remarkably uniform, precisely what is expected for thermal steady state non-linear equilibrium conditions (see **Origin of universe**) if the Thermon-PDW mechanism is uniform throughout the universe, at least within the range of the present microwave detecting equipment [31]. If photons do have mass, then the mechanism for energy transfer is the same as between any other mass particle. If CMBR has no mass contributing to on-going particle momentum and thermal oscillations, then the temperature uniformity might result from a Planck radiation energy continuum, which leaves a thermal signature in massless particles. The massless photon carries an effective mass through its momentum which, in an oscillating thermal field, behaves similarly to particles with mass [32]. Either way, CMBR is an indicator that all SM particles on a universe-wide basis behave in the same way which is compatible with Thermon-PDW concepts.

Other phenomena

- *Quantum entanglement.* Quantum entanglement is a real phenomenon [33,34]. If the Thermon-PDW mechanism is important then it is reasonable to expect that a pre-formed thermal network might be implicated in quantum entanglement activity. The opportunity for thermal transfer, momentum interaction and particle interaction is obvious.

- *Information loss from black holes.* Thermal evaporation from black holes (Hawking radiation) is presently an unresolved difficulty [35] but in a universe driven by the Thermon-PDW mechanism this is a non-issue because all forms of matter are formed without reference to any "information" contained within a black hole or anywhere else. Similarly, there is no information loss with regard to any fundamental physical "laws" such as time, gravity or QFT. Also unresolved, but of far greater importance, is what form the matter residues within a black hole take, and how "thermally-depleted quantum systems" might be recycled.

- *Galaxy arrangement in universe*. The large scale structure of the universe is based on galaxies resulting in the "cosmic web", a network of filaments and voids arranged as clusters, filaments and sheets [36]. Since the universe-wide Thermon-PDW mechanism requires the sequential and continuous transfer of thermal energy, creating mass centres which eventually evolved into stars and galaxy systems, then a linear relationship is expected. Cosmic filaments represent an historical, temporal record laid out spatially. These are fossil records of the past evolution of the universe where the different galaxy ages are embedded in the filament. Conversely voids are regions where for whatever reason the essential thermal flux has subsided below the threshold levels to sustain viable ensembles. It might be, for example, that the position of voids reveals much about the stability of filaments because the thermal flux originally destined for ensembles in the void area is sequestered by greater activity of the now fossilised record.

- *Gravity waves*. Detection of Einstein-predicted gravitational waves as fluctuations or ripples in space-time [37] can be interpreted as changes in the thermodynamic framework of the universe, since transient oscillations of both thermal waves and particle waves are expected to fluctuate as the universe-wide non-equilibrium steady state is restored.

CONCLUSION

There is sufficient modelling, quantitative and qualitative evidence to submit the Thermon-PDW hypothesis for public scrutiny. Its fate now depends on its critical evaluation and the formation of mathematical and observational data sets where the interpretation is not overly influenced by preconceived ideas from the long history of SMC. The image is of a spherical globular universe in a surrounding sea of pre-universe conditions with a content of pre-particles, expanding at the surface in response to continuous thermal activity at the boundary forming SM particles. Randomly generated, assiduously maintained by continuous thermal flux and particle diffusion, is the concomitant formation of mass, time and gravity, in turn giving rise to large-scale bits and pieces in our universe. We see no need for any fundamentally new physics beyond the Standard Model of Particles. So, future progress depends on determining the physical and mathematical structure of the pre-universe with its core quantum systems pre-particles devoid of Thermon-PDW activity.

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