



# **Baryon Symmetry and the Lead of Antimatter Over Matter in A Stress-Free Universe**

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## **Author's contribution**

*The sole author designed, analyzed, interpreted and prepared the manuscript.*

## **Article Information**

### **Open Peer Review History:**

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**Original Research Article**

**Received: 21/10/2023**

**Accepted: 27/12/2023**

**Published: 02/01/2024**

## **ABSTRACT**

An analysis is presented, based on the exponential stress-free model of the universe [1], in which it is shown that the rate of production of particle matter is equal to the rate of production of antimatter, which is consistent with baryon symmetry. In addition, the observed ratio of particle matter mass to total mass in the universe under baryon symmetry is used to consider the timing of the increase of matter and antimatter in the expanding universe, and it is found that, the antimatter signal leads the ordinary matter signal by about 2/3 of the time constant for the antimatter annihilation. It is also shown that the annihilation process is responsible for the initial expansion rate of the universe, and the ratio of particle mass to total mass in the universe

**Keywords:** *Net-zero stress evolution of the universe; baryon symmetry; particle to total mass ratio of the universe.*

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## 1. INTRODUCTION

The evolution of the universe under stress-free conditions has been investigated in [1] and [2] for the two forms of matter – dark matter and ordinary matter. In this paper, we extend the same investigation techniques to the third form of matter – antimatter, which has recently [3] been shown to respond to the force of gravity in the same manner as for ordinary matter.

## 2. WAVE MATTER, PARTICLE MATTER AND ANTIMATTER IN THE STRESS-FREE UNIVERSE

In the stress- free model, the evolving universe expands at the homogeneous rate [1],

$$dR/dt_R = K(t_0) \quad 0 \leq t_0 \leq \infty \quad (1)$$

where  $K(t_0)$  is the homogeneous expansion rate in which,  $t_0$  is the absolute time, and  $t_R$  is the local time at the radius (R). The homogeneous expansion rate may be regarded as due to the two components of the ordinary mass field ( $M(t_0)$ ), which are the wave mass ( $M_W(t_0)$ ), which is the dark mass left over after the formation of the particle mass ( $M_P(t_0)$ ), and the particle mass ( $M_P(t_0)$ ), which together comprise the mass,

$$M(t_0) = M_W(t_0) + M_P(t_0) \quad (2)$$

On the assumption that a growing exponential rate,

$$K_W(t_0) = K_0 \exp(\lambda t_0), \quad \lambda > 0 \quad (3)$$

exists for the wave mass ( $M_W$ ), and a decaying exponential rate occurs for the particle mass,

$$K_P(t_0) = K_0 \exp(-\lambda t_0), \quad \lambda > 0 \quad (4)$$

in which,

$$K_W(0) = K_P(0) \quad (5)$$

at the origin of the universe ( $t_0/T \rightarrow 0$ ), where T is the age of the universe, it was shown in [1] that,

$$M_P(0) = M_W(0) \quad (6)$$

which was stated to be an exact wave-particle duality, and expressions were obtained for  $M_W(t_0)$  and  $M_P(t_0)$  in [1] by substituting (3) and (4) in (1).

### 2.1 The Wave Mass ( $M_W$ ) and the Particle Mass ( $M_P$ ) in the Mature Universe

For the mature universe, which occurs at the time,  $t_0 = T$ , they are,

$$M_W = m_0 c T / \ln(1/\alpha) \quad (7)$$

and

$$M_P = m_0 K_0 T / \ln(1/\alpha) \quad (8)$$

where  $\alpha = K_0/c$ , in which c is the velocity of light, and  $m_0 = c^2 / G$  in which G is the universal constant of gravitation.

### 2.2 The Antimatter Mass ( $M_A$ ) in the Mature Universe

Antimatter may be included in the model by assuming that the antimatter decay rate,

$$K_A(t_0) = A K_0 \exp(-\mu t_0), \quad \mu > 0 \quad (9)$$

is of the same form as the particle decay rate (4) for ordinary matter, except that the decaying exponential rate ( $\mu$ ) is the annihilation rate for the antimatter due to interaction with the particle matter, and  $A > 1$  is a constant to be determined. On substituting (9) in (1), the solution for the antimatter mass, for the mature universe,  $M_A$ , obtained as in [1], is,

$$M_A = m_0 A K_0 T_A / (1 - \alpha) \quad (10)$$

in which the annihilation time constant,  $T_A = \mu^{-1}$ , is much less than the age of the universe ( $T_A/T \ll 1$ )

## 3. RELATIONS BETWEEN THE MASSES OF WAVE MATTER AND PARTICLE MATTER AND ANTIMATTER IN THE MATURE UNIVERSE

### 3.1 Baryon Symmetry

Eqs. (8) and (10) predict that the ratio of antimatter to particle matter in the mature universe,

$$M_A/M_P = B T_A/T \quad (11)$$

where,

$$B = A \ln(1/\alpha) / (1 - \alpha) \quad (12)$$

Eq. (11) is a highly significant relation, which states that for  $B = 1$ , the rate of production of particle matter ( $M_P / T$ ) is equal to the rate of production of antimatter ( $M_A / T_A$ ),

$$M_A / T_A = M_P / T \quad (13)$$

Eq. (13) is the condition for Baryon symmetry. There is no mystery here. The reason why the mature universe of which we are a part, is not eviscerated by antimatter in the twinkling of an eye, is simply one of the time scale difference between matter and antimatter.

### 3.2 Antimatter Annihilation

The short time scale of the antimatter compared with the matter ( $T_A / T \ll 1$ ) due to their mutual annihilation provides the Einsteinian energy source for the universe, and since from (13),  $M_A / M_P \ll 1$ , it also has a negligible effect on the mass dynamics. Eq. (13) is a prediction for the annihilation time constant ( $T_A$ ) in a universe in which the ratio of antimatter to matter is known. Recent observations [4] indicate the range,  $M_A / M_P \approx 10^{-14} - 10^{-15}$ . Hence, from (13),  $T_A \approx 4000 - 400$  s. In all events, (13) predicts that the greater the proportion of antimatter, the greater is its lifetime, and for a cosmic mass symmetry in which  $M_A = M_P$ , the time scale ( $T_A$ ) for the annihilation of antimatter would be identical with the age of the universe ( $T$ ).

On the assumption that  $B = 1$ , (12) yields,

$$A = (1 - \alpha) / \ln(1/\alpha) \quad (14)$$

in which  $\alpha$  can be estimated from the observed values of the age of the universe,  $T = 13.8 \cdot 10^9$  yr and the mass of the universe,  $M = 1.5 \cdot 10^{53}$  kg. Using (8), with  $M_P = \alpha / (1 + \alpha) M$ , yielded  $\alpha = 0.235$  [1], and hence on substituting for  $\alpha$  in (14),  $A = 0.53$ . This result is also highly significant, since  $A$  can be interpreted in terms of the lag ( $L$ ) of the antimatter exponential signal,

$$L = \ln A / \mu \quad (15)$$

and since  $\ln A = -0.64$ ,  $L < 0$ , which indicates that the antimatter signal leads the ordinary matter signal, which is consistent with the annihilation process for antimatter and matter outlined in Section 3.1. In this process, from (15), the lead time ( $-L$ ) would be about two-thirds of the annihilation time constant ( $T_A$ ).

Eq. (15) indicates that the annihilation process, which determines ( $L/T_A$ ) and hence  $A$ , also

determines  $\alpha$  from (14), and therefore is directly responsible for, (i) the initial homogeneous expansion rate of the universe ( $K_0 = \alpha c$ ), and (ii) the particle mass ratio of the universe ( $M_P/M = \alpha/(1 + \alpha)$ ), where  $M$  is the mass of the universe [1].

We suggest that the annihilation process is an inherent property of the universe, which in ordinary matter dynamics is manifested as the key to instability on the infinitesimal time scale which drives the macro-scale systems, as so famously characterized by Ed Lorenz through a single flap of a butterfly's wings in Brazil, which transforms the climate in Texas [5]. Stress is the compounding of such events [6]

### 4. INTERPRETATION

The results of Section 3 are ultimately a response to an unresolved problem of physics, made possible through the assumption that the universe is stress-free. In this model, the expansion of the universe occurs from a mass-free origin under net stress-free conditions. The simplest hypothesis is that the expansion is mediated by dark matter, which has a uniform density within the universe [7]. It is proposed that the emergent structure of the dark matter, which was shown in [7] and [8] to be the basis for wave and particle matter, is also the basis for antimatter (which was not considered in the earlier analysis) as is shown by the similar form of the decay relations (4) and (9). What distinguishes the evolution from dark matter, of ordinary matter and antimatter, is the absence of a growing mode for antimatter.

### 5. CONCLUSIONS

The exponential – stress model, which was originally applied in [1] to consider the relation between particle mass and wave mass, has been used here to consider also the relation between particle mass and antimatter mass. The principal prediction is that baryon symmetry occurs in which the rate of production of matter on the large scale is equal to the rate of production of antimatter on the small scale. The vastly different time scales in the two cases has led to the misconception of baryon asymmetry [9]. The good news is that this vast difference in time scale provides a mass rich, large scale universe, supported by a mass poor small scale universe, for our enjoyment.

The concept of stress, familiar to fluid dynamicists, appears to be largely absent in the myriad of papers on cosmic evolution, for example [10 -12].

### ACKNOWLEDGEMENTS

The continuing support of Charles James is gratefully acknowledged, as also are the suggestions by two reviewers for the presentation of the results of the study

### COMPETING INTERESTS

Author has declared that no competing interests exist.

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