On the separation of matter and antimatter in the early universe

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ABSTRACT. A scenario is proposed to explain the separation of matter and antimatter in the universe. It is based on the author's previous research results in general relativity theory. These are: 1) an oscillating universe cosmology with a spiral configuration and 2) the fundamental matter fields at the elementary matter level are the proton-antiproton and electron-positron pairs, bound in a particular state. During an initial explosion of any particular cosmological cycle, the proton pairs and the electron pairs are dissociated to their charged components and their gravitational rotational motion on the cosmic spiral then gives rise to magnetic fields that propagate them in opposite directions, symmetrically. At the same time, the spiral gravitational field propagates them in the same rotational direction, asymmetrically. It is the competition between the asymmetric gravitational rotational field and the symmetric magnetic fields that gives the result of separation of matter and antimatter.

RÉSUMÉ. Un scénario est proposé pour expliquer la séparation de la matière et de l'antimatière dans l'univers. Il est basé sur les résultats des recherches de l'auteur en relativité générale. Ce sont : 1) une cosmologie d'univers oscillant avec une configuration spirale et 2) les champs de matière fondamentaux au niveau des particules élémentaires sont les paires proton-antiproton et électron-positron, liés dans un état particulier. Pendant l'explosion initiale de chaque cycle cosmologique, les paires sont dissociées en leur composants chargés et leur mouvement de rotation gravitationnel sur la spirale cosmique entraîne l'apparition de champs magnétiques qui les propagent dans des directions opposées,de manière asymétrique. C'est la compétition entre le champs de gravitation, asymétrique, et le champ magnétique, symétrique, qui donne comme résultat la séparation de la matière et de l'antimatière.

1. Introduction

An interesting question in cosmology and theoretical particle physics, that has persisted ever since the discovery of antimatter in the early decades of this century, is this: why is there a predominence of matter over antimatter in our domain of the universe? A second question that accompanies this one is: If there is an equal quantity of matter and antimatter in the universe, is there another domain where there is a predominence of antimatter, and where complex structures, such as molecules, stars and galaxies are composed of antimatter rather than matter?

I would like to propose a scenario in this note that could answer these questions. It is based on earlier results from my research program in general relativity theory when it is applied to the problems of cosmology and elementary particle physics.

Let us start with the earlier result [1], that suggests that, rather than a single, isotropic, homogeneous explosion at the Big Bang (that is, the starting point of any particular cycle of an oscillating universe cosmology) the cosmological dynamics is rather in terms of a spiral (oscillating) universe. This result was derived from Fresnel integral solutions of the quaternion expression of general relativity, that I have reported in earlier publications. [2]

Clearly, the spiral, oscillating universe cosmology violates a presently held view, expressed in terms of the so-called 'cosmological principle'; yet it is entirely consistent with the requirement of the principle of general covariance, that underlies the theory of general relativity. The main feature of this cosmological model to emphasize here is that, contrary to the isotropic Big Bang model, assumed in present day theory, such a spiral dynamics is asymmetyric. It entails a rotation, in spiral fashion, in only one sense, say clockwise from a reference frame relative to a universal cosmic plane.

It should be noted that while I have specified a 'clockwise rotation' of the matter of the universe in an oriented cosmic plane, this is tied to an arbitrarily chosen 'observer's' view. There is no absolute cosmic reference frame since the entire mathematical expression of the theory is generally covariant. That is to say, from a different 'observer's' reference frame one might see that the cosmic rotation is 'counterclockwise'. It should be noted further that the isotropy and homogeneity of the conventional view of a Big Bang cosmology does not appear to allow for the asymmetry

that is required in the early universe in order to separate matter from antimatter.

The next feature of this research program that is pertinent here is the result that the only elementary particle fields are the electron and the proton and their antiparticle matter fields, positron and antiproton. All other 'elementary particle fields' are composites of these. The photon and neutrino fields (those fields that are supposed to have no mass) play the role in this theory as virtual coupling fields between massive particle fields, as we will see later on. (The continual experimental verification that the proton is stable, to very high accuracy, attests to this model, in contrast with the quark model of the 'standard model'.)

It followed rigorously in this research program, [3] that there is an exact bound state solution of the nonlinear, nonlocal field equations for the pair (proton-antiproton or electron-positron) that yields all of the empirical properties associated with pair annihilation and creation, though without actually annihilating or creating matter. The solutions of these spinor, coupled field equations for the pair in the expressions from Noether's theorem show that this bound state corresponds to null energy (relative to the energy of $2mc^2$ of the state where the particle and antiparticle would be almost 'free' of each other) and null linear momentum as well as null angular momentum, in all Lorentz frames. Still, the particles in this ground state are 'there' - e.g. they are still gravitationally sensitive and, separately, would couple electromagnetically with other charged matter.[3] Further, other charged matter would couple to these pairs, in this state, as oppositely polarized currents (that are 90 degrees out of phase) in a plane that is perpendicular to the direction of propagation of an interaction with the other (detecting charged particle matter). Indeed, the latter is observed in correlation with 'pair annihilation', and interpreted in terms of the creation of two photons, whose phases are correlated with a 90 degree difference, with a total energy of $2mc^2$ and propagating in opposite directions with a net null angular momentum. Thus, this state of the pair reproduces all of the experimental evidence associated with pair annihilation and creation, but without really annihilating and creating matter! It then followed that any region of space must be populated with a large density of such pairs.

Some physical consequences of this sea of pairs, in their (true) ground states, were found to be the following: 1) the masses of all elementary particles are due to the curvature of spacetime in their neighborhoods, as created by the pairs in which they are immersed. This is

in strict accord with the 'Mach principle' on the origin of 'inertial mass' as due to other, coupled matter. Here the latter is expressed explicitly in terms of the curvature of spacetime that represents them (in terms of the 'spin affine connection field').[4] It was found in this regard that the numerical values of the masses of the electron and muon correspond to a density of pairs that is the order of one pair per 10^{-45}cm^3. 2) The Planck spectrum for blackbody radiation is due to a sea of such pairs in a cavity, (rather than a gas of photons), in thermodynamic equilibrium with the walls of the cavity, at any particular temperature. 3) The lifetimes of excited states of atoms and molecules, etc. as due to the stimulated emission from these coupled pairs and 4) electron-proton scattering cross sections that depart from the predicted Mott cross sections for point particle electron and proton - an effect that is conventionally attributed to the mesic cloud cover of the proton, as expressed in terms of the appropriate 'form factors'.

2. A scenario for matter-antimatter separation

The mechanism for the separation of matter and antimatter in the early universe follows from a competition between the overall gravitational field, in giving rise to an asymmetric spiral motion of all of the constituent matter of the most dense configuration of the universe, at the Big Bang stage – the sea of matter-antimatter pairs in their ground states of null energy-momentum, discussed above – and the magnetic fields caused by rotating charged particles.

The scenario is as follows: In the initial stages of the early universe, i.e., at the beginning of any particular cycle, the gravitational 'explosion' (appearing as an inflection point in the oscillating dynamics) delivers 2 Gev to each of many proton pairs (out of a much greater number of pairs of the universe) and about 1 Mev to each of many electron pairs, so as to dissociate them. The positively charged protons and positrons then moving in the spiral gravitational field, say clockwise, give rise to a magnetic field B^+, perpendicular and below the cosmic plane of rotation. The dissociated antiprotons and electrons then rotate in the opposite direction, counterclockwise, in the magnetic field B^+, thus separating them from the protons and positrons.

The antiprotons and electrons, rotating in the clockwise direction in the spiral gravitational field, then give rise to a magnetic field B^-, perpendicularly oriented above the cosmic plane. This field, in turn, induces protons and positrons to rotate counterclockwise in the cosmic

plane. However, the gravitational spiral rotation is unidirectional (say clockwise) so that more protons than antiprotons move clockwise. For every proton that moves clockwise, there is an antiproton that moves counterclockwise. Thus we have a separation of the matter from the antimatter due to the competition between the asymmetrical gravitationally induced rotation and the symmetrical magnetically induced rotational forces in the early universe.

In this way, then, the spiral motion of the 'matter universe' superposes a spiral motion (in the same direction of rotation) of the separated 'antimatter universe'. Of course, there are not two separate universes, they are merely the spacelike separation of the matter and antimatter components of a single universe - components that are stars, galaxies, etc that are composed of 'matter' and components that are stars, galaxies, etc. that are composed of 'antimatter', as we will discuss below.

3. The next stage of the expansion - formation of neutrons

In this research program, whereby elementary matter fields follow from composites of the basic proton and electron and their antimatter fields, the neutron is the composite of a proton and electron, bound with an antineutrino field - a spinor field with negative helicity, $p^+ - \bar{\nu} - e^-$. The neutrino coupling is due to proton pairs in their ground states, as discussed above. [5]. It should be noted that the 'neutrino' and the 'photon' in this theory are not independent elementary particle fields, rather they are fields that play the role of electromagnetic coupling between massive particle fields. The latter result followed from a factorization of the Maxwell field formalism to a spinor form (in accordance with Einstein's advice to seek the irreducible representations of the theory for maximal information). The composite matter field that we associate with the 'neutron'is then not unlike the hydrogen atom, which is the composite $p^+ - C - e^-$, which entails the longitudinal component C of the electromagnetic vector coupling, associated with the Coulomb interaction of the proton and electron. This research has indeed indicated, in a natural way, the superposition of both the spinor and vector electromagnetic couplings from the irreducible representations of the relativity group, with the spinor coupling becoming important only at small distances (large momentum transfer between interacting particle fields, that is the order of 10^{-2} fermi.) This is the order of magnitude of the range of the weak interaction. As the universe cools further, so that the average

distance between matter field components becomes an order one hundred times larger than this, fermis, the nuclear force becomes important.

Thus we see that once the gravitationally dissociated protons and antiprotons move into their own domains of the universe, at the first stage of cooling, the protons capture electrons (from the electron bound pairs, that are in abundance at all times) to form the composite 'neutrons', via the neutrino electromagnetic coupling.

As the expansion continues and the cooling increases, the neutrons are released from the system of global matter to an 'almost free' state, and they thereby decay in accordance with the weak interaction, to a proton, electron and antineutrino coupling field. The latter, in turn, is absorbed by other matter fields. Similarly, in the antimatter region, antineutrons are created as the composites $p^- - \nu - e^+$, which then eventually decay to antiproton, p^-, positron,e^+, and neutrino ν (with positive helicity).

As the cooling continues further in the expansion, so that the average separation of neutrons and protons is the order of the nuclear force range, fermis, neutrons capture protons in the 'matter region', forming deuterons, and antineutrons capture antiprotons in the antimatter domain, forming antideuterons. The sequence then continues in each of the domains, following the thermonuclear cycle, whereby deuterons capture neutrons to form tritons, tritons interact with deuterons to form helium and neutrons, and the neutrons start the cycle over again - in the matter domain, while the same sequence happens in the antimatter domain with antideuterons, antitritons and antihelium. This proceeds until all of the stable nuclei of the Periodic Chart are formed in the matter domain, and all of these antinuclei are formed in the antimatter domain. Eventually, these nuclei attract electrons in forming the charge-neutral atoms and molecules in the matter region and similarly the antinuclei attract positrons to form charge-neutral antiatoms and molecules in the antimatter domain. In each of these domains then, as the cooling continues in the expansion, condensation points are formed where clusters of galaxies, stars and other objects of the universe are formed, leading to the matter universe as we see it, and in another region of the universe, an antimatter component of galaxies, stars, etc. that are composed of antimatter nuclei and electrons.

Of course, in each of the regions of the universe, where matter or antimatter predominate, there is still an overwhelming predominance of

matter/antimatter, in the form of proton-antiproton pairs and electron-positron pairs, in their ground states of null energy and momentum. Since these background pairs are still gravitationally sensitive, it may be speculated that they could serve to play the role of the 'dark matter' that has been evoked by astrophysicists, to explain astronomical features of the night sky, such as the rotations of the galaxies. (An additional contribution to galactic rotation is due to its internal dynamics, in accordance with the quaternion formulation of general relativity, following from Einstein's edict to express the laws of nature in terms of the basis functions of the irreducible representations of the underlying symmetry group. This is discussed further in: M. Sachs, Physics Essavs, **7**, 490 (1994).).

A prediction that follows in this theory is that antimatter galaxies must entail the decay of antineutrons to antiprotons, positrons and neutrino coupling fields with positive helicity. It is interesting to note in this regard that in the 1987 supernova explosion, neutrinos (with positive helicity) were detected, seeming to emanate from this event. This experimental result implies the interesting speculation that this supernova may have entailed the decay of antineutrons, rather than neutrons, and that these stellar components of the supernova may have been antimatter rather than matter components of the universe.

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References

[1] M. Sachs, Ann. Fond. Louis de Broglie 14, 361 (1989).
[2] M. Sachs, *General Relativity and Matter: A Spinor Field Theory from Fermis to Light-Years* (Reidel, 1982), Chapter 7.
[3] M. Sachs, *Quantum Mechanics from General Relativity: An Approximation for a Theory of Inertia* (Reidel, 1986), Chapter 7.
[4] references 2, 3, Chapter 4.
[5] reference 3, Chapter 9.

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