Hypothesis for a universal matter/anti-matter hadron structure: symmetry, conservation of mass and energy, and the Cosmological Constant

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Abstract

The author hypothesizes a fundamental matter/anti-matter hadron structure in which all existing matter is understood to consist of quarks, anti-quarks, electrons, and positrons. If each hadron (i.e., every proton and neutron in the Universe) consists of three quarks or three anti-quarks, and sometimes a positron, then: 1) initial and continuing matter/anti-matter symmetry in the Universe is apparent; 2) the Standard Model of observable protons, neutrons, and electrons throughout the Universe results; 3) mass and energy are conserved over the life of the Universe; 4) the primary process of stellar fusion is explained; and 5) the expansion of the Universe is explained.

PACS Classification Scheme

1. Specific theories and interaction models, particle systematics; 12.10-g (unified field theories and models).

2. Properties of specific particles; 14.20-Dh (protons and neutrons).

3. Nuclear astrophysics; 26.20-Cd; (stellar hydrogen burning).

4. General relativity and gravitation; 04.20-Cv (fundamental problems and general formalism).

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I. INTRODUCTION

One of the vexing problems of modern physics is the apparent lack of symmetry under the Standard Model of the structure of the atom and the cosmology of the Big Bang.[2] In particular, an explanation of the "disappearance" of anti-matter in the observed Universe has been troubling to many.[3] Furthermore, the expansion of the Universe (and the increasing rate of expansion of the Universe[4]) has been observed but not explained,[5] and Einstein's General Theory requires a calculation of the rate of expansion of the Universe (now called the Cosmological Constant) in his field equations.[6] A fundamental explanation for these phenomena is called for.

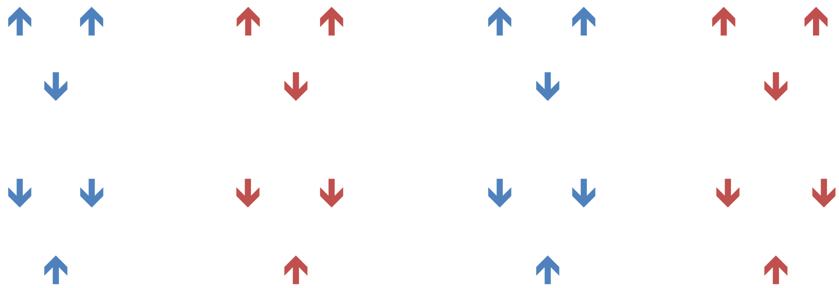
This paper is intended to hypothesize and explain a structure of matter in the Universe that solves many of the most vexing problems in physics. If all existing matter is understood to consist of quarks, anti-quarks, electrons, and positrons, then many of the fundamental problems in physics can be explained. In particular, if each hadron (i.e., every proton and neutron in the Universe) consists of three quarks or three anti-quarks, and sometimes a positron, then: 1) initial and continuing matter/anti-matter symmetry in the Universe is apparent; 2) the Standard Model of observable protons, neutrons, and electrons throughout the Universe results; 3) mass and energy are conserved over the life of the Universe; 4) the primary process of stellar fusion (including the observed composition of stars) is explained; and 5) the expansion of the Universe is explained.

This model of hadron construction is simple and elegant. If it is accurate, then the fundamental initial condition of the Universe, its current composition, and its evolution over time can be properly understood.

A. Proposed hadron structure & the Universe's initial state

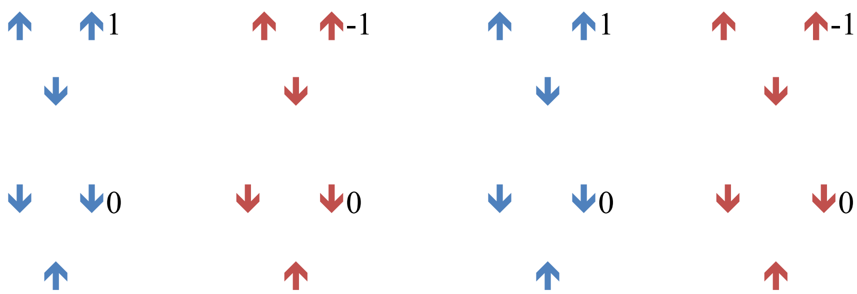
Start with a pure symmetry of three fundamental particles: up quarks (↑), down quarks (↓), and electrons (e^-); and their anti-matter opposites: up anti-quarks (↑) down anti-quarks (↓), and positrons (e^+). It is well-established that three quarks are required to form a proton or neutron -- two up and one down, or vice versa.[7] The model described in this paper posits that anti-quarks <u>also</u> can form a proton or a neutron. Under this model (hereinafter, sometimes called the "Symmetry Model"), these six particles fundamentally comprise all matter and energy in the Universe.

For the sake of simplicity, start with six up quarks, six down quarks, six up anti-quarks, and six down anti-quarks. Eight triads will result:



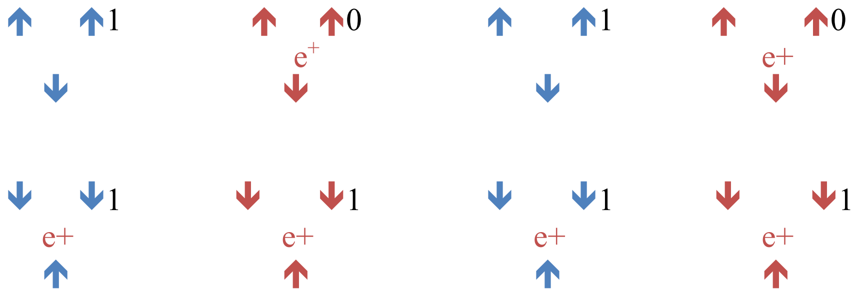
[Fig. 1 Matter and anti/matter quark triads.]

Because up quarks have a +2/3 charge, down quarks have a -1/3 charge, and up anti-quarks have a -2/3 charge and down anti-quarks have a +1/3 charge, the eight triads would have the following total charges:



[Fig. 2. Quark triads with total intrinsic charges.]

Suppose, however, that hadrons can be composed of these triads, but sometimes with a positron added -- so long as known charges (+1 and 0, i.e., protons and neutrons) result. And suppose further, in order to preserve initial symmetry, that six electrons and six positrons are added to the matrix (the six electrons, not shown, "orbit" the protons). A "Universe," therefore, that starts as six up quarks, six down quarks, six up anti-quarks, six down anti-quarks, six electrons, and six positrons, becomes:

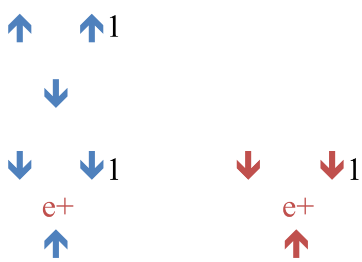


[Fig. 3. Symmetry of matter and anti-matter quark triads, with six positrons.]

The first triad (two up quarks and one down quark) cannot accept a positron, because the charge would be greater than 1. Similarly, the second triad (two up anti-quarks and one down anti-quark) must accept a positron, because the charge otherwise would be -1.

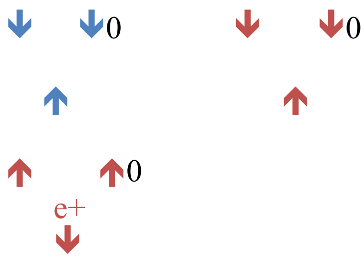
In this model, symmetry of matter and anti-matter in the initial state (six up quarks, six down quarks, six up anti-quarks, six down anti-quarks, six electrons, and six protons) results in the current observed Standard Model structure of the Universe, with six protons, six electrons, and two neutrons.

In the Symmetry Model, there are three different types of protons, one without a positron and two with positrons:



[Fig. 4. The three forms of protons.]

And there are three different types of neutrons, two without a positron and one with a positron:



[Fig. 5. The three forms of neutrons.]

When these hadrons are arranged in ordinary atomic structure (where protons can exist alone as hydrogen nuclei, but neutrons must exist bound with protons) the building blocks for the two main ingredients of the Universe, hydrogen and helium, are readily apparent. Two of the protons (probably the first and third triads, each composed of two up quarks and one down quark) would combine with the two neutrons, resulting in one helium atom. The lower four triads would constitute four hydrogen nuclei. In this way, the Symmetry Model anticipates an initial atomic "Universe" of 4 hydrogen atoms and one helium atom, all resulting from a combination of twelve quarks, twelve anti-quarks, six electrons, and six positrons. This likely initial *atomic* state preserves matter/anti-matter symmetry, conserves mass (no fundamental particle is transformed), conserves energy (the charge of each fundamental particle is preserved), and the net of the charges in the Universe is 0. Furthermore, the Symmetry Model looks like the Standard Model of our observed Universe, with protons, neutrons, and electrons readily apparent.

B. Fusion reactions and the conservation of mass and energy

By removing a positron from one of the two protons types that contain a positron, a proton can be converted to a neutron.

For example,

↓   ↓1 minus e^+ yields ↓   ↓0
e+
↑   ↑

Similarly,

↓   ↓1 minus e^+ yields ↓   ↓0
e+
↑   ↑

[Fig. 6. Conversion of protons to neutrons by removing a positron as the first step of a fusion reaction.]

Importantly, it has been observed that, when a positron is freed from its triad, a neutrino is also generated as two protons form a deuteron (a temporary proton and neutron combination -- which can then combine with another to form helium, or be added to a heaver element to create an even heavier element).[8] When the freed positrons in these reactions interact with nearby electrons, they annihilate, resulting in two gamma rays,[9] and, most likely, two neutrinos every time a single electron annihilates with a single positron. The electrical energy of the electrons and positrons annihilated is converted into the energy of gamma rays (usually, two 511-keV gamma rays) *plus* the momentum energy of the two neutrinos created in the annihilation.

In this way, the removal of a positron from a triad is the first step of fusion within stars. If two protons are converted to two neutrons, then, coupled with two existing protons, a helium nucleus can be formed. Nuclear fusion takes place, while conserving mass, energy, and overall charge. The mass of the quark triads in the reaction remains the same, and the mass of the electrons and positrons destroyed at annihilation is equal to the mass of the resulting neutrinos. Moreover, the energy of the gamma rays and the momentum of the neutrinos produced in the reaction is equal to the electrical energy of the electrons and positrons annihilated. Finally, with the annihilation of an electron to accompany the conversion of each proton to a neutron, the overall charge of the Universe is maintained at 0.

Interestingly, the fusion within a star of four protons to form one helium nucleus appears to explain the lower observable ratio of hydrogen to helium atoms in stars (including our Sun -- approximately 3:1[10]) than likely existed in the initial atomic state of the Universe (4:1). As stars fuse hydrogen nuclei to create helium, the hydrogen/helium ratio will continue to decline below 4:1. Similarly, the proton/neutron ratio (starting out at 3:1) will also decline over the life of the Universe, as protons are converted to neutrons to form higher-complexity atoms. Again, however, the overall charge of the Universe will remain at 0.

Also, with this basic mechanism -- the conversion of some protons to neutrons by removing positrons -- the formation of all the elements of the periodic table are readily understandable. Almost all of the stable constructions of the atoms of the periodic table (particularly those that are heavier than hydrogen, helium, and lithium) involve the addition of one proton and one neutron (or other integers of neutrons) to a prior element. Any time a proton is added to a prior element's nucleus, additional neutrons must also be added. These neutrons are created as a first step of a fusion reaction by removing a positron from a positron-containing quark or anti-quark triad; the resulting neutron (or, where greater than one neutron must be added to create a stable element, neutrons) can be combined with a proton, and the prior element's nucleus, to create a new element that is one atomic number higher than the initial element's atomic number.

C. Neutrinos as likely Dark Matter and Dark Energy, and the Cosmological Constant

In this Symmetry Model, extraordinary numbers of neutrinos are generated within stars, accumulating in the Universe over time. For this reason, the steadily increasing mass of neutrinos in the Universe, combined with the increasing total energy contained in the *momentum* of the neutrinos in the Universe, are good candidates for both Dark Matter[10] and Dark Energy[11] to explain the observed expansion of the Universe. The logical result of the increasing number of neutrinos created in the Universe over time is likely the Dark Energy that causes the Universe to constantly expand, and to expand at an increasing rate. In addition, the increasing numbers of neutrinos created in the Universe over time is likely the Dark Matter, which, combined with observable matter, should determine the eventual fate of the Universe.

One way to think of increasing neutrinos in the Universe from stellar fusion as the cause of the expansion of the Universe is to understand the role of gravity and momentum in curving spacetime under Einstein's General Theory. It has been estimated that electrons have a mass of 9.109 x 10^{-31} kg,[12] and positrons have a similar mass. In order to conserve the total mass of the universe, the two neutrinos generated when a positron is freed from its triad (and then annihilated with a nearby electron) must (combined) have the same mass as the electron and positron that are annihilated. Furthermore, it is estimated that neutrinos move at the speed of light.[14] Therefore, while a neutrino's mass is small, the momentum energy present when a neutrino moves at the speed of light has a significant effect on spacetime. In the General Theory, Einstein posited that the momentum energy of moving particles curves spacetime in the same way that gravity curves spacetime. As the electrical energy of electrons and positrons (which do not curve spacetime) is partially converted into the momentum energy of neutrinos (which do curve spacetime), the momentum energy of the ever-expanding number of neutrinos in the Universe likely causes spacetime to expand, consistent with the General Theory. In light of the extraordinary numbers of neutrinos generated in all the stars of the Universe, at any given time, and over time, and in light of the great speed at which neutrinos travel, the effect on spacetime of neutrino creation in this Symmetry Model is likely discernible by us as the observed expansion of the Universe.

D. Experimental follow-up

The idea of anti-matter existing "within" matter was prompted by experiments performed by Alexander Henderson, Edison Liang, Hui Chen, and others, from Rice University and Lawrence-Livermore National Laboratory. E.g., A. Henderson, et al., "Monte Carlo simulation of pair creation using petawatt lasers," *Astrophysics and Space Science* 336: 273 (2011). In their experiments, these researchers showed that paired positrons and electrons can be released from gold and platinum substrates when irradiated by high-energy lasers.

If the phenomenon observed by the Henderson-Liang-Chen team involves the removal of positrons from proton triads (whether quark or anti-quark triads), then the conversion of the substrate to lower-atomic-number elements should be detectable, assuming that sufficient protons can be converted to neutrons. To evaluate this Symmetry Model, further petawatt laser experiments should be conducted to see whether lighter elements can be generated and detected.

In addition, further experiments to determine whether the mass of neutrinos can be established with confidence should assist in evaluating the Symmetry Model.

E. Conclusion

It appears logical that the protons and neutrons of the Universe are composed of matter and anti-matter quarks, and sometimes positrons. This Symmetry Model has a number of striking implications. The model:

1) accounts for symmetry of matter and anti-matter in the Universe;
2) results in the observed Standard Model of protons, neutron, and electrons;
3) conserves mass, energy, and net charge over the life cycle of the Universe;
4) explains the mechanism for creation of the stable elements of the Universe in stars (and in supernovae) over time; and
5) explains the observed expansion of the Universe.

The model is simple and elegant. It should be evaluated and tested to determine whether it is also true.

Acknowledgements

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Reference Citations

[1]The author is also the author of "Feasibility of matter/anti-matter propulsion for generating relativistic speeds in space," *J. Space Explor*. 9(2): 162 (2020). This article is an outgrowth of that prior article concerning the nature of matter/anti-matter annihilation.
[2]U. Sarkar, Particle and Astroparticle Physics, Taylor & Frances, New York (2007).
[3]E. Sathan, "The Mystery of the Matter Asymmetry," *Beam Line* (spring/summer): 31 (2006).
[4]W. Freedman, "Measurements of the Hubble Constant: Tensions in Perspective," *The Astrophysical Journal* 919(1): 16 (September 2021).
[5] G. Lemaître, "Un Univers homogène de masse constente et de rayon croissant rendant compte de la vitesse radiale des nébuleuses extra-gallactiques," *Annales de la Société Scientifique de Bruxelles* A47: 49 (1927).
[6]A. Einstein, "Kosmologische Betrachtungen zur allgemeinen Relativitätstheorie," *Sitzungsberichte de Königlich Preussischen Akademie der Wissenschaften*, Part 1: 142 (1917).
[7]J. Trefil, From Atoms to Quarks (Rev.), Anchor, New York (1994).
[8]M. Salaris and S. Cassini, Evolution of Stars and Stellar Populations, John Wiley and Sons p. 119-21 (2005).

[9]L. Sodickson, et al., "Single-quantum annihilation of Positrons," *Phys. Rev.* 124(6): 1851 (1970).
[10]E. Chaisson and S. McMillan, Astronomy Today, 3d ed., Prentice-Hall (1999).
[11]V. Trimble, "Existence and nature of Dark Matter in the Universe," *Ann. Rev. of Astronomy and Astrophysics* 25: 425 (1987).
[12]R. Durer, "What do we really know about Dark Energy," *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 369: 5102 (1957).
[13]R. Cohen, The Physics Quick Reference Guide, 1st ed., Am. Inst. Physics, p. 55 (1995).
[14]G. Brumfiel, "Neutrinos not faster than light," *Nature* (March 19, 2012).