Composite matter/antimatter hadron structure indicated experimentally at the Texas Petawatt Laser Facility

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Abstract: It has been theorized that, at the Universe's inception, there were equal amounts of matter and antimatter. One of the great mysteries of modern physics is the asymmetry between the amount of matter and the amount of antimatter apparent in the Universe. Here it is shown that, when a high-energy laser strikes a gold target, the gold is transmutated to platinum. This experimental result indicates that hadrons are actually composite particles containing both matter and antimatter. The implications of this new model of hadron structure are significant, impacting our understanding of cosmology, proton–proton chain reactions in stars, the expansion of the Universe, and beta decay in radioactive isotopes, among other key topics in physics. © *2024 Physics Essays Publication*. [http://dx.doi.org/10.4006/0836-1398-37.4.270]

Résumé: Il a été émis l'hypothèse qu'à la création de l'Univers, il y avait des quantités égales de matière et d'antimatière. L'un des grands mystères de la physique moderne est l'asymétrie entre la quantité de matière et la quantité d'antimatière apparente dans l'Univers. Ici, il est démontré que lorsqu'un laser à haute énergie frappe une cible en or, l'or est transmuté en platine. Ce résultat expérimental indique que les hadrons sont en réalité des particules composites contenant à la fois de la matière et de l'antimatière. Les implications de ce nouveau modèle de structure des hadrons sont importantes et ont un impact sur notre compréhension de la cosmologie, des réactions en chaîne proton-proton dans les étoiles, de l'expansion de l'Univers et de la désintégration bêta des isotopes radioactifs, entre autres sujets clés de la physique.

Key words: Hadron Structure; Antimatter; Quarks; Cosmology, Beta Decay; Proton–Proton Chain Reactions.

I. INTRODUCTION

It has been theorized that, at the Universe's inception, there were equal amounts of matter and antimatter.[1] One of the great mysteries of modern physics is the apparent asymmetry between the amount of matter and the amount of antimatter here.[c)] At the subatomic level, it has been demonstrated that there exists a fundamental matter/antimatter asymmetry;[2] Cronin and Fitch received the Nobel Prize for this important discovery.[3]

Fairly recently, high-energy laser experiments have demonstrated that large quantities of positrons and electrons may be generated when a high-energy laser strikes a gold target, and these paired particles can be easily separated magnetically.[4] Based on this surprising experimental observation, it was hypothesized that a composite hadron model containing both matter and antimatter can result in ordinary, observed matter.[5] This composite hadron model was motivated by the contrast between the theory of gross matter/antimatter symmetry in the Universe and our observation of apparent matter/antimatter asymmetry, in conjunction with the recognized *subatomic* asymmetry of matter and antimatter.

The composite hadron model predicts that transmutation of the targets in high-energy laser experiments will take place. As it turns out, in experiments conducted at the Texas Petawatt Laser Facility by Dr. Alexander Henderson, and now published for the first time here, it has been shown that gold is transmutated to platinum when positrons and electrons are ejected from a gold target stuck by a high-energy laser.

Dr. Henderson's experimental result indicates that the composite hadron model is correct. The implications of this model are significant, impacting our understanding of cosmology, proton–proton chain reactions in stars, the expansion of the Universe, and beta decay in radioactive isotopes, among other important topics in physics. In addition to being predictive, the composite hadron model is consistent with multiple fundamental astronomical and experimental observations, including some of the key mysteries left unanswered by the Standard Model. These mysteries include the apparent gross matter/antimatter asymmetry in the Universe; the expansion of the Universe and the increasing rate of expansion of the Universe; and the dark matter in the Universe that affects observed galaxy rotation.

Further evaluation of the composite hadron model, mathematically and experimentally, is called for.

II. BACKGROUND

Paul Dirac's anticipation of the existence of antimatter is a monument of theoretical physics. In 1928, in trying to

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c)"The Big Bang should have created equal amounts of matter and antimatter. So why is there far more matter than antimatter in the universe?" CERN, available online at https://home.cern/science/physics/matter-antimatter-asymmetry-problem, accessed September 6, 2024.

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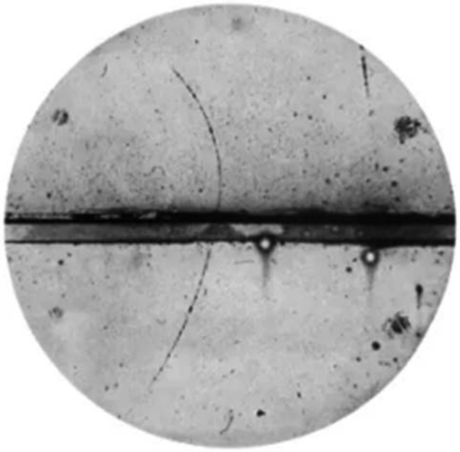

FIG. 1. Positron cloud track.[d]

understand the quantum dynamics of hydrogen's emission spectra, he derived mathematically a model of electron behavior that corresponds to the observed spectra.[6] He also noted that a positively charged electron would result in the same mathematical results.[7] Shortly thereafter, Carl Anderson and Seth Neddermeyer discovered the positive electron (which Anderson called a "positron") in their cloud chamber when examining cosmic rays at high altitudes (Fig. 1).[8]

Dirac received the Nobel Prize in 1933 for his work related to atomic theory,[9] and Anderson won the prize in 1936 for his discovery of the positron.[10]

Dirac also theorized that electron/positron pairs could spontaneously arise out of the "Dirac sea."[11] About that same time, Hans Bethe and Walter Heitler theorized that electron/positron pairs could be generated by high energies of electromagnetism interacting with a nucleus.[12] The process of electron/positron generation near nuclei is usually called the Bethe–Heitler process. Heitler theorized that electron/positron pairs were generated out of the "quantum vacuum," akin to the Dirac sea.[13]

Other antimatter components were discovered at the Lawrence Radiation Laboratory at the University of California in the 1950s. In 1955, using the "Bevatron" (a high-energy particle accelerator), Owen Chamberlain and Emilio Segrè, along with Clyde Wiegand and Thomas Ypsilantis, demonstrated the existence of the antiproton.[14,15] In 1956, also at the Lawrence Radiation Laboratory, Bruce Cork, Glen Lambertson, Oreste Piccioni, and William Wenzel discovered the antineutron.[16]

As our discovery of antimatter particles developed, our understanding of matter also deepened. In 1964, Murray Gell-Mann theorized that protons and neutrons are composed of subcomponents,[17] which he ultimately called "quarks."[18] Richard Feynman nominated Gell-Mann and George Zweig in 1977 for the Nobel Prize in Physics for their contributions to quark theory.[19]

In Gell-Mann and Zweig's quark model, "up quarks" have an electric charge of $+2/3$, and "down quarks" have an electric charge of $-1/3$. Hadrons are composed of quark triads: Two up quarks and one down quark for a proton, and two down quarks and one up quark for a neutron.

With the quark model in place, prior experimental results demonstrating the existence of pi mesons[20,21] were understood to exhibit a combination of quark and antiquark pairs.[22] The idea that antiquarks could be present, in some way, in nuclei was first advanced based on this observation. About that time, it was also discovered that k-mesons (quark/antiquark composite particles) degrade asymmetrically, depending on their quark and antiquark subcomponents. With this discovery (i.e., "CP violation"), it was shown that the subatomic behavior of matter and antimatter component particles is not symmetric.

III. RECENT HIGH-INTENSITY LASER EXPERIMENTS

A. Observation—Paired-particle generation by high-energy lasers

In 2008–2009, Hui Chen and others on her team at Lawrence Livermore National Laboratory, along with others from Rice University and the University of Rochester, demonstrated that large quantities of electron/positron pairs are generated, and can be separated magnetically, when a high-energy laser strikes a gold target. It was understood, in agreement with Bethe and Heitler's theoretical understanding, that the positrons generated in these high-energy laser experiments arise from the quantum vacuum.[23] Of great significance is the fact that Chen and her team were able to easily magnetically separate the electron/positron pairs generated by her laser. Under current theory, virtual particles that arise from the quantum vacuum cannot be easily separated.[24]

B. Hypothesis—Composite hadron model

Because the electron/positron pairs in Chen's experiments were easily separable, the assumption that the positrons generated in high-intensity laser experiments arise from the quantum vacuum was questioned. Rather than arising from the quantum vacuum, it was theorized that the positrons generated when petawatt lasers strike gold targets are *pre-existing* within the gold targets. Assuming that positrons have already existed within the gold target's nuclei, it was theorized that quark *and antiquark* triads can pair with positrons to form neutrons and protons (as we understand them). The resulting structures of protons are presented in Fig. 2.

The resulting structures of neutrons are presented in Fig. 3.

Because the hadron structure hypothesized in this model involves a composite structure composed of matter and

[d]"The discovery photograph of the positron, the positive version of the electron and the first antimatter particle to be discovered. The cloud chamber photo was taken in 1932 by US physicist Carl Anderson. It shows the track of a positive particle that enters the chamber from below. The particle is known to be positive because of the way it bends in the chamber's magnetic field; and it is proved to be moving up the picture because it loses energy and curves more in the magnetic field after traversing the 6 mm thick lead plate in the middle." Science Photo Library caption, negative available at https://www.sciencephoto.com/media/1221/view/discovery-photo-of-the-positron-1932) (public domain image).

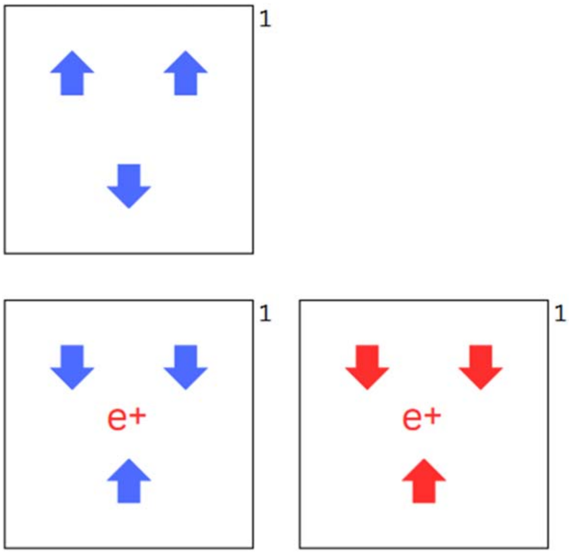

FIG. 2. (Color online) Matter/antimatter proton structure. Blue indicates matter; red indicates antimatter. A positron is indicated by e+.

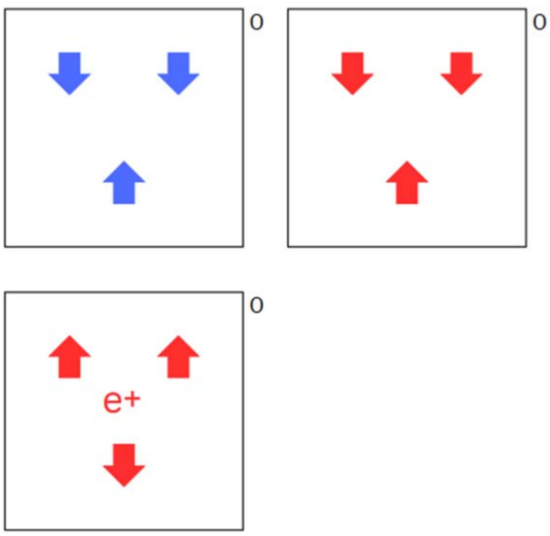

FIG. 3. (Color online) Matter/antimatter neutron structure. Blue indicates matter; red indicates antimatter. A positron is indicated by e+.

antimatter, it has been denominated the composite hadron model.

Under the Standard Model, it is understood that protons transform to neutrons, and neutrons transform to protons, by a flavor change of the quarks in the hadrons. For example, it is currently understood that, for a neutron to transform into a proton, a quark changes its flavor from a down quark to an up quark.[25] In the composite hadron model, in contrast, it is understood that quarks do not change flavor; the transformation of a proton to a neutron, or a neutron to a proton, is effected by a removal or an addition of a positron to the hadron.

Because of this difference in understanding of the nature of proton–neutron transformation, the composite hadron model predicts that the generation of positrons in a high-energy laser experiment will transmutate the high-atomic-mass target.

C. Experiment—Transmutation of gold to platinum by high-energy laser

As it turns out, the transmutation of gold to platinum when a high-energy laser strikes a gold target was demonstrated in 2015 by Alexander Henderson of Rice University, working at the Texas Petawatt Laser Facility (located at the University of Texas in Austin, Texas).[e] As part of his doctoral research into electron/positron pair production when a petawatt laser strikes various targets, Dr. Henderson observed the transmutation of gold to platinum. He described this observation in his doctoral dissertation, but this observation was not published until now.

Dr. Henderson's methods are described in detail in his dissertation. In summary, a high-intensity laser was used to strike various targets, including gold targets. Production of positrons and electrons was detected. After irradiation by the laser, the gold targets were analyzed spectroscopically, and platinum was detected in the targets.

The datasets generated and analyzed during Dr. Henderson's study are available in the figshare depository, DOI//10.6084/m9.figshare.24319894, with permission of Dr. Henderson. In addition, the datasets for comparison of Pt spectra, used by Dr. Henderson, are located at https://www.nndc.bnl.gov/nudat3/getdataset.jsp?nucleus=196Pt&unc=nds.

Dr. Henderson's experimental observation of transmutation of gold targets is historically significant because it is the first recorded instance of human-induced transmutation of an element by photons.

D. Conclusion

Dr. Henderson's observation of transmutation indicates that the composite hadron model is correct. The composite hadron model correctly predicted that high-intensity lasers generating positrons from a high-atomic-mass target will transmutate the target. Under the Standard Model, in contrast, the electron–positron pairs generated in high-energy laser experiments should arise as virtual particles from the quantum vacuum and should not transmutate the targets.

IV. IMPLICATIONS OF THE COMPOSITE HADRON MODEL

The implications of the composite hadron model are profound. Our understanding of the formation of the Universe, its evolution, and its eventual demise/rebirth are likely to be impacted by the basic matter/antimatter composite hadron structure of this model.

[e]"In our experiments, we measured photo-activation of gold and copper targets, as well of carbon atoms in the glue used to affix some targets, using a scintillator after the shots. Photo-activation occurs when gamma-rays interact with a nucleus and a free neutron. In many cases, the resulting nucleus is unstable and will decay over time after the laser shot." A. H. Henderson, "Monte-Carlo simulation and measurements of electrons, positrons, and gamma-rays generated by laser-solid interactions," Rice University, Houston, Texas (2015) (doctoral dissertation), available at https://repository.rice.edu/server/api/core/bitstreams/b45abb11-6bf1-42e5-960f-481dc4b60582/content.

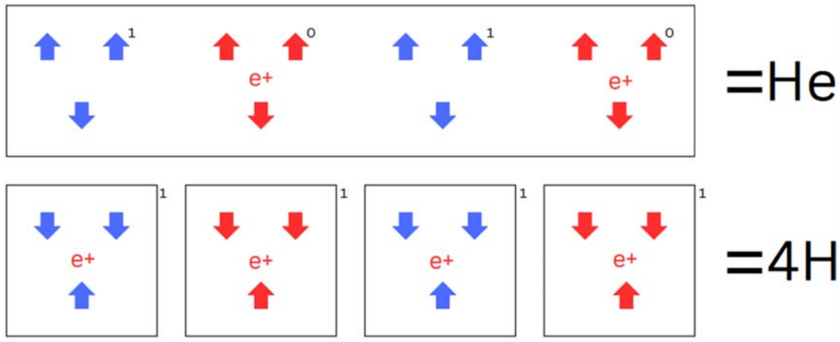

FIG. 4. (Color online) Quark triads with positrons. Electrons are not shown. Blue indicates matter; red indicates antimatter.

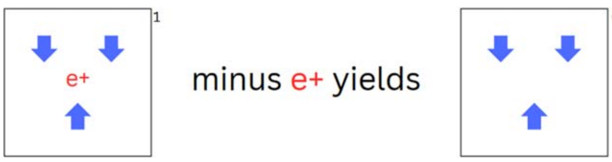

FIG. 5. (Color online) Conversion of quark proton to quark neutron. Electrons are not shown. Blue indicates matter; red indicates antimatter.

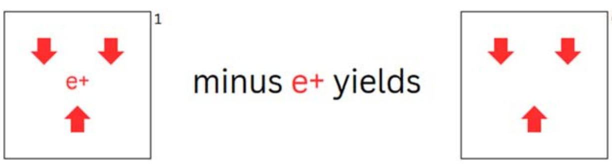

FIG. 6. (Color online) Conversion of antiquark proton to antiquark neutron. Electrons are not shown. Blue indicates matter; red indicates antimatter.

A. Cosmology—Initial atomic state of the Universe

For the sake of simplicity, assume that, at the time at which hadrons began to form in the Universe, there were equal amounts of up quarks, down quarks, up antiquarks, down antiquarks, electrons, and positrons. If positrons can be added to quark and antiquark triads, then a "Universe" that starts as six up quarks, six down quarks, six up antiquarks, six down antiquarks, six electrons, and six positrons (the lowest repeatable number of units) would exist in nuclear format, as shown in Fig. 4.

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 antiquarks and one down antiquark) must accept a positron, because the charge otherwise would be −1. Isolated neutrons are unstable, so here they are coupled with protons to form a helium nucleus. When these initial hadrons are arranged in ordinary atomic structure (where protons can exist alone as hydrogen nuclei, but neutrons must exist bound with protons in atoms) the building blocks for the two main ingredients of the Universe, hydrogen and helium, are readily apparent. In this way, the composite hadron model anticipates an initial atomic Universe of four hydrogen atoms and one helium atom, all resulting from a combination of twelve quarks, twelve antiquarks, six electrons, and six positrons. This likely initial atomic state of the Universe preserves gross matter/antimatter symmetry, preserves the nature of fundamental particles (fundamental particles do not transform from one flavor to another), conserves energy (the charge of each fundamental particle is preserved), and the net of the charges in the Universe is 0. Furthermore, the composite hadron model looks like our observed Universe, with protons, neutrons, and electrons readily apparent.

This model is consistent with the observed helium/hydrogen ratios in stars.[26]

B. Proton–proton chain reactions in stars

By removing a positron from one of the two proton types that contain a positron, a proton can be converted to a neutron (e.g., see Fig. 5).

Similarly, an antiquark proton can be converted to an antiquark neutron by ejecting a positron, as shown in Fig. 6.

With this mechanism, the composite hadron model explains the proton–proton chain reaction in stars. A proton is converted to a neutron by removal of a positron; the neutron and a proton are fused to form a deuteron; and then two deuterons are fused to form a helium nucleus (Fig. 7).[27]

The initiating cause of the ejection of the positrons from hydrogen nuclei is unknown. It may be induced by photons, as in Earth-based laser experiments. It may be induced by

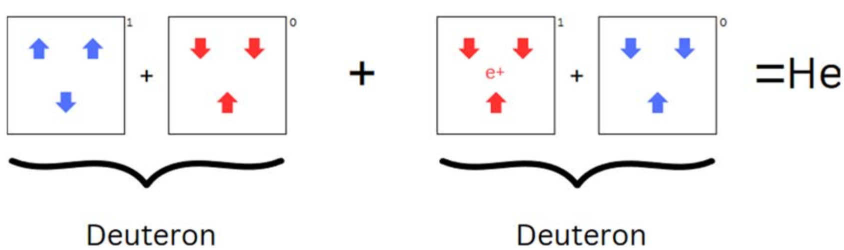

FIG. 7. (Color online) Proton–proton chain reaction in stars (one example).

neutrino bombardment (similar to radioactive decay, discussed below), or there may be some other initiating cause in the extreme temperatures and pressures inside the cores of stars.

As stars fuse hydrogen nuclei to create helium, the hydrogen/helium ratio will continue to decline below the original ratio of approximately 4:1. Similarly, the proton/neutron ratio (starting out at approximately 3:1) will also decline over the life of the Universe, as protons are converted to neutrons and deuterons are created to form higher complexity atoms.

C. Cosmology—Expansion of the Universe, dark energy, and dark matter

Every time that a positron is ejected from a proton to form a neutron/deuteron, the positron is available to strike a nearby electron. When it does, the electron and positron are annihilated, resulting in two 511-keV gamma rays and at least one neutrino. With this mechanism, most of the light in the Universe likely starts as gamma rays generated in the core of stars. In addition, the neutrinos generated in proton–proton chain reactions are accelerated to nearly the speed of light.[28] Because neutrinos possess some mass, though extremely small[29] (it has recently been estimated that the rest mass of the neutrino is between zero and .8 eV),[30] the effect of their acceleration likely causes the observed expansion,[31] and increasing rate of expansion,[32] of the Universe under Einstein's general theory.

Furthermore, neutrinos, which have mass but are virtually undetectable with current technology, are a prime candidate for a large portion of the dark matter that explains the observed-but-unexplained rate of galaxy rotation.[33] Because the transformation of a proton to a neutron in proton–proton chain reactions is the principal event for all nuclear fusion in stars, and because neutrinos are so unreactive, the combined mass of all the neutrinos generated since stars began to shine is a likely candidate for the moiety of dark matter in the Universe.

D. Beta decay

With the proton–proton chain reaction as the basic mechanism of element creation in stars, protons are converted to neutrons, form a deuteron, and then deuterons fuse to form helium and heavier elements. In supernovae, even heavier elements are created, including some radioactive elements. One feature of radioactivity is beta decay, in which radioactive elements "decay" into other elements. The composite hadron model explains the basic mechanism of beta decay in a way that is different from the Standard Model.

In the Standard Model, beta decay involves an alteration of the number of protons (either $+1$ or -1) in a radioactive isotope without changing the number of leptons.[34] There are two basic kinds of beta-decay reactions, $\beta-$ and $\beta+$.

In typical $\beta+$ reactions, a proton in the nucleus is converted into a neutron, and a positron and electron neutrino are emitted. It is understood that the conversion of the proton to a neutron is effected by a flavor change of one of the quarks in the neutron triad, transforming an up quark into a down quark.[35] In typical $\beta-$ reactions, a neutron in the nucleus is converted into a proton, and an electron and an electron antineutrino are emitted. It is understood that the conversion of the neutron to a proton is effected by a flavor change of one of the quarks in the neutron triad, transforming a down quark to an up quark.[36] In the composite hadron model, in contrast, the transformation of protons to neutrons involves the release of a positron. It does not involve flavor alterations of quarks.

$\beta+$ reactions are the easiest to envision. As with a proton–proton chain reaction in a star, in a $\beta+$ reaction, removal of a positron from a proton results in a neutron quark or antiquark triad, and the positron is emitted. As in proton–proton chain reactions in stars, two 511-keV gamma rays are generated, along with a neutrino, and a proton in the nucleus is converted to a neutron. Sometimes, the positron interacts with an electron within the atom, and the positron is not emitted from the atom—this is the mechanism of beta-decay electron capture.[37]

A key question in the composite hadron model is the initiating cause of the expulsion of the positron from the proton in beta decay. It is likely that the initiating cause is an external neutrino striking a proton, ejecting the positron within. This explanation has an attractive feature, in light of the nature of the half-lives of radioactive isotopes. If the composite hadron model is correct, and, particularly, if the beta-decay model within the model is correct, then our understanding of the weak force should be re-examined. Instead of being an inherent, internal aspect of nuclear decay, beta decay now appears to be an external, deterministic, physical phenomenon. As with the half-life of drugs within the human body, where metabolism/catabolism is a function of chemical interactions with the drug based on drug and substrate concentrations (i.e., a second-order kinetic),[38] beta decay in the composite hadron model is likely a function of interactions between radioactive nuclei and neutrinos based on their concentrations. Hence, the nonlinear half-life observation of nuclear decay over time for each given radioactive isotope is a function of the probability of external interactions rather than an internal-to-the-nucleus weak force process as currently understood.

Taken in this light, the famous paradox of Schrodinger's cat has new meaning. In that thought experiment,[39] a cat is placed in a box and a poison can be triggered by an event of radioactive decay. As it turns out (and unknown to Schrodinger), the cat's box is permeated by billions of neutrinos per second, any one of which (at a very small probability) can trigger the radioactive decay that will kill the cat. The radioactive decay, while a function of the probability of a neutrino/nucleus interaction, remains a deterministic physical process. Apparently, as Einstein asserted to Max Born, God does not play dice with the Universe.[40]

Furthermore, based on the performance of the radioisotope thermoelectric generator on the Voyager spacecraft, it has been observed that the radioactive decay of the isotopes in that craft has not been as fast as half-lives on Earth would indicate.[41] As the probe travels away from the Sun, the half-life of the radioisotope in its generator is apparently lengthening, extending the life of the generator. This is consistent with the composite hadron model. As the spacecraft travels away from the Sun's neutrino flux (by operation of the inverse-square law), its power generator's radioactive decay is more and more likely to be initiated by interstellar neutrinos rather than neutrinos from the Sun.

Finally, $\beta-$ reactions are probably analogous to a mirror process of $\beta+$ reactions and electron/positron annihilation. Instead of ejecting a positron from the nucleus, a neutrino probably strikes the nucleus and, in a process that is the opposite of electron/positron annihilation, lyses the neutrino into a separate positron and electron. The positron enters a neutron in the nucleus, increasing the nucleus' charge by 1, and the electron joins the atom's electron cloud.

V. THEORETICAL AND EXPERIMENTAL SUPPORT FOR THE COMPOSITE HADRON MODEL

Questioning some of the foundations of the Standard Model is, of course, a daunting prospect. In evaluating the plausibility of the composite hadron model, it is critical to recognize that the composite hadron model is consistent with some key experimental observations and theoretical predictions, including:

- The theoretical prediction of gross matter/antimatter symmetry in the Universe.
- The observed apparent gross matter/antimatter asymmetry in the Universe.
- Matter/antimatter asymmetry at the subatomic scale.
- The presence of antimatter, such as pion matter/antimatter pairs, in collider experiments (as shown by Lattes *et al*).
- The observed basic hydrogen/helium ratios in stars.
- Proton–proton chain reactions in stars.
- The expansion of the Universe, and the increasing rate of expansion of the Universe.
- The observed 511-keV signature of the Milky Way.[42]
- The slower-than-expected rate of rotation of galaxies due to dark matter.
- Beta decay, both $\beta-$ and $\beta+$, as well as electron capture in beta decay.
- Radioactive decay as a second-order kinetic.
- The extended life of the power generator of the Voyager spacecraft as it has traveled away from the Sun.

The composite hadron model not only predicted the previously unheard-of transmutation of elements by photons, as demonstrated in Henderson's experiments, but it is consistent with, and reasonably explains, some of the fundamental observations about the Universe that are currently unexplained by the Standard Model. For this reason alone, the composite hadron model should be seriously considered and evaluated further.

VI. FURTHER SIMPLIFICATION OF THE COMPOSITE HADRON MODEL

It has been observed that quarks can exist as pentaquark combinations and as tetraquark combinations.[43] With this in mind, and taken to its logical extent, the composite hadron model can be simplified to understand quarks and antiquarks as simply positive or negative particles, each possessing 1/3 of the charge of a proton or electron. Instead of quark triads—as understood since Gell-Mann and Zweig—protons and neutrons are likely composed of combinations of positively charged particles with 1/3 the charge of a positron and negatively charged particles with 1/3 the charge of an electron (currently called down antiquarks and down quarks, respectively), and sometimes a positron. Rather than up or down quarks, or up or down antiquarks, there are only 1/3-charge down antiquarks and $-1/3$-charge down quarks in this simplified composite hadron model.

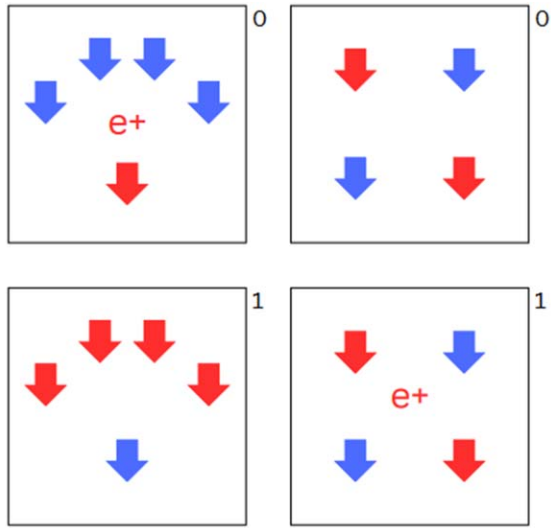

FIG. 8. (Color online) Hadron structures in simplified composite hadron model. Red denotes down antiquarks (1/3 charge) and blue denotes down quarks ($-1/3$ charge). Electrons are not shown.

In this very simple model, a neutron may be a tetraquark composed of two down quarks and two down antiquarks. A neutron can also be a pentaquark containing four down quarks and one down antiquark that also contains a positron. (Consistent with Cronin and Fitch's experimental results, but for some unknown reason, there appears to be a fundamental subatomic asymmetry in which a pentaquark of four down quarks and one down antiquark does not form a stable antiproton.) Also in this simplified model, a proton can be a pentaquark of four down antiquarks and one down quark, or a proton can be a neutron tetraquark that also contains a positron (Fig. 8).

In the smallest repeatable unit of this model, six electrons and six positrons (with a total charge of 6 and -6, respectively) would combine with down antiquarks having a total charge of 6 and down quarks having a total charge of -6 (i.e., eighteen 1/3-charge down antiquarks and eighteen $-1/3$-charge down quarks) to give us the Universe of four hydrogen atoms and one helium atom described above, only without up/down quarks and up/down antiquarks (Fig. 9).

VII. FURTHER EVALUATION OF THE COMPOSITE HADRON MODEL

A. Mathematical modeling

First and foremost, mathematical evaluation of the model is vital. With positrons incorporated into neutrons and protons, what would the resulting nuclear forces look like, mathematically? Furthermore, with more $-1/3$-charge down

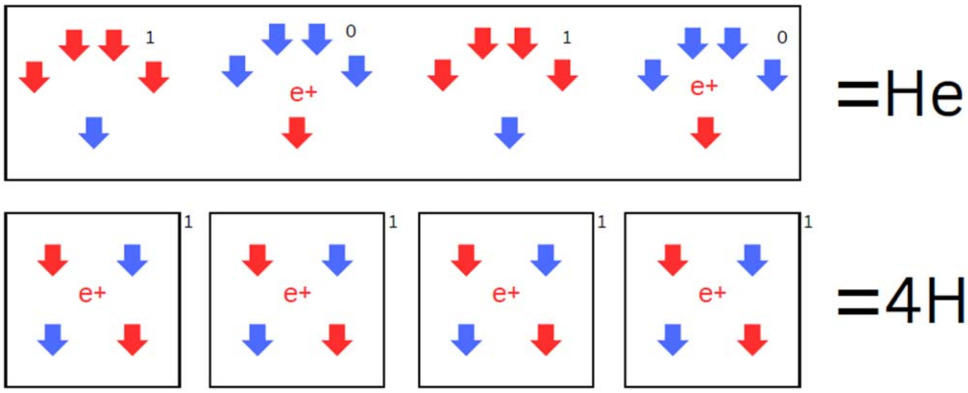

FIG. 9. (Color online) Initial atomic structure of Universe in simplified composite hadron model. Red denotes down antiquarks (1/3 charge) and blue denotes down quarks (−1/3 charge). Electrons are not shown.

quarks in neutrons and protons than are contemplated in the Standard Model, what would the resulting nuclear forces look like, mathematically? Under the Gell-Mann quark model, only three quarks have to be accounted for within protons and neutrons, and deuterons contain only six quarks. In the simplified composite hadron model, in contrast, neutrons can be composed of four or six charged particles, and protons are composed of five charged particles. With deuterons and higher complexity nuclei, the mathematical complexity only grows. The many-body problem[44] is obvious.

Two mathematical starting points may help.

First, in the 1960s, while the Gell-Mann quark model was being developed, theoreticians, particularly Moo-Young Han and Yoichiro Nambu, explored the possibility of unitary-charge (as opposed to fractionally charged) particles within the nucleus.[45] Due to experimental results regarding the masses and charges of quarks, mesons, and pions, this mathematical approach was abandoned. In the composite hadron model, by adding unitary-charge (+1) positrons to quark and antiquark structures, which are themselves, for this purpose, collectively charged in their conformations as −1 or 0, the single-charge mathematics of Han and Nambu may be of revitalized utility.

Second, there are mathematical benefits to adding positrons and more −1/3-charge down quarks to nuclei when modeling the electromagnetic forces, and the necessary countervailing strong force, there. Compared to a system with only up and down quarks, adding positrons to nuclei—due to the positron's comparatively low mass, its comparatively higher charge magnitude, and the sign of its charge—will affect the overall energy dynamics in nuclei. Similarly, with more −1/3-charge down quarks inside the nuclei under the composite hadron model, down quarks' charge contrast from the positively charged particles within each nucleus will affect the strong force energy required to stably hold the nucleus together, as compared to the Gell-Mann model with only up quarks and down quarks. While the many-body problem of calculating the forces within nuclei remains challenging, the fundamental nature of positrons and down quarks that are added to nuclei in the composite hadron model should ultimately reduce the strong force necessary to hold hadrons together in stable structures.

FIG. 10. Bevatron image of an antiproton/proton collision.[f)]

B. Retrospective review of collider experiments

One beneficial way to evaluate the composite hadron model is to retrospectively review early collider experiments. Excellent examples are the collider experiments at the University of California's Bevatron. In one such experiment, an antiproton (in the composite hadron model, in this case, an antiquark pentaquark neutron stripped of a positron) collides with a proton (Fig. 10).

The observed result of the collision is a cascade of at least eight charged particles, four negatively charged, and four positively charged. One of the positively charged particles has a visible decay event (in the lower right portion of the image) in which it decays into a positively charged particle and a neutral particle. That decay is likely, in its simplest explanation, the decay of a positively charged pion ($\prod^{+}$) into a down antiquark and a neutral pion ($\prod^{0}$). Because the neutral pion is, at its most reduced, a composite of a down quark and a down antiquark, this figure appears to show ten charged particles (five positively charged and five negatively charged) generated in the collision of an antiproton and a

f)"The [] picture is a bubble chamber image. – The antiproton enters from the bottom." Image available at https://indico.cern.ch/event/104466/attachments/15569/22575/The_Bevatron.pdf, accessed September 6, 2024 (Lawrence Berkeley National Laboratory)(public domain image).

proton. With hindsight, this experimental result is entirely consistent with, and supportive of, the simplified composite hadron model.

Thousands of other collider results from the Bevatron are archived at the University of California. It would be beneficial to evaluate the composite hadron model by examining the emulsions from the Bevatron experiments that still exist, with this hadron model in mind.

C. Measurement of radioactive half-lives

As indicated by the increasing half-life of the radioactive isotope in the Voyager power generator, it appears that radioactive decay will slow as an isotope travels away from the Sun. The isotope is affected less and less by neutrinos emitted by the Sun because of the inverse-square law. It is possible to test this hypothesis by measuring the half-lives of isotopes, for example, on Mars as compared to the Earth. Outside our solar system, it appears that the Voyager spacecraft is already "measuring" the interstellar neutrino flux. If data from Voyager are not sufficient for the task, then Mars-based experiments—to the extent that they show radioactive half-lives that are different from those on Earth—would also necessarily measure the interstellar neutrino flux.

VIII. CONCLUSION

Alexander Henderson's observation of transmutation of gold to platinum by photons is of singular historical import. His experimental results are also supportive of the composite hadron model, which itself is consistent with significant heretofore-unexplained astronomical and experimental observations. The implications of the composite hadron model, if accepted by the physics community, will affect a host of current topics in physics, including expansion (and the increasing rate of expansion) of the Universe, the cosmological constant, dark matter, dark energy, the mechanism of beta decay, strong force and gluon operation within nuclei, charged-particle structures within nuclei, and many other key physics topics. Further evaluation of the composite hadron model, including its most simplified version, is called for.

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Dr. Alexander Henderson's observation of transmutation of gold to platinum when the gold target is struck by a high-energy laser is documented in his Rice University Ph.D. dissertation, available at https://repository.rice.edu/server/api/core/bitstreams/b45abb11-6bf1-42e5-960f-481dc4b60582/content.

Dr. Henderson's methods are detailed in the dissertation.

The datasets generated and analyzed during the current study are available in the figshare depository, DOI//10.6084/m9.figshare.24319894, with permission of Dr. Alexander Henderson. In addition, the datasets for comparison of Pt spectra, used by Dr. Henderson in the current study, are located at https://www.nndc.bnl.gov/nudat3/getdataset.jsp?nucleus=196Pt&unc=nds.

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