Composite matter/antimatter hadron structure indicated in petawatt laser experiments

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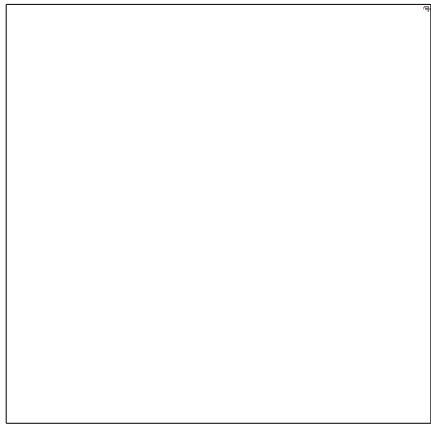
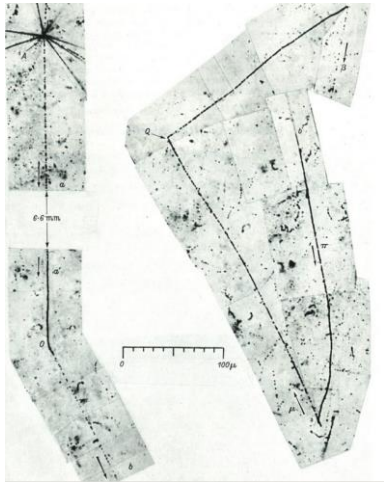
Theoretical and Experimental Background -- Matter & Antimatter

- In 1928, Paul Dirac's relativistic version of the Schrodinger wave equation recognizes solutions involving an antielectron; in 1930, Robert Oppenheimer proposed the existence of a "positively charged electron with the same mass"
- In 1932, Carl Anderson discovers positrons in cosmic rays; in 1936, describes electron/positron annihilation into 2 ½ meV gamma rays, crediting Joliot's and Thibaud's 1934 work on radioactive decay
- In 1930, Dirac anticipates existence of positrons and electrons in the "Dirac sea"; in 1934, Bethe & Heitler anticipate virtual electrons and positrons arising from the "quantum vacuum"
- In 1947, Cecil Powell, et al., discover pion, ultimately understood as a combination of a quark and antiquark, in particle collider
- In 1955, Owen Chamberlain and Emilio Segrè discover the antiproton at Berkeley Radiation Laboratory's Bevatron
- In 1956, Bruce Cork, et al., discovered the antineutron at BRL
- In 1964, Murray Gell-Mann and George Zweig theorize existence of quarks (as denominated by Gell-Mann)
- In 1964, James Cronin, Val Fitch, et al., discover CP violation for K meson decays



Positron



K meson to π^+

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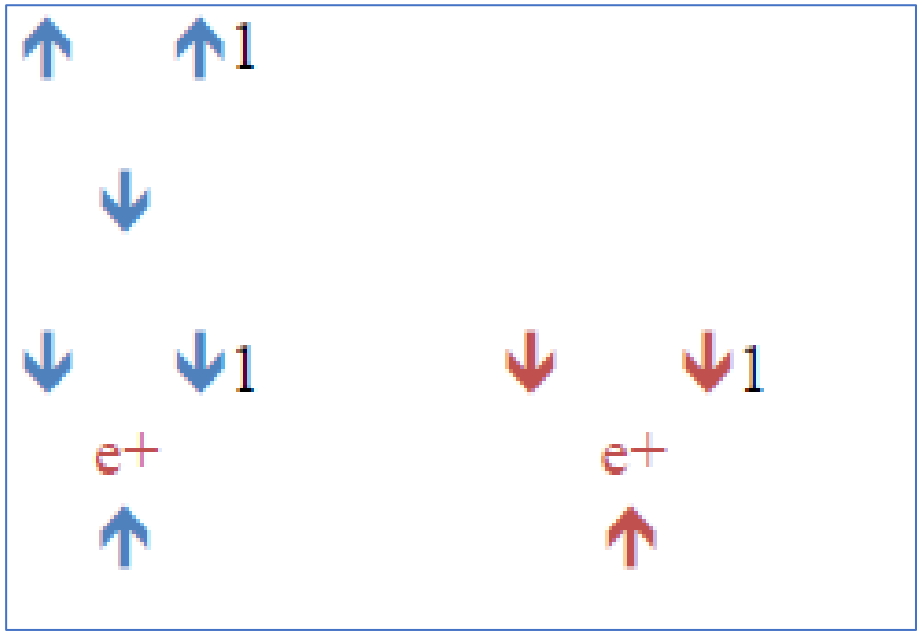
In 2008, Hui Chen and others at Lawrence Livermore National Laboratory discovered that large quantities of electron/positron pairs are generated when a high-intensity laser strikes a gold target and can be separated magnetically

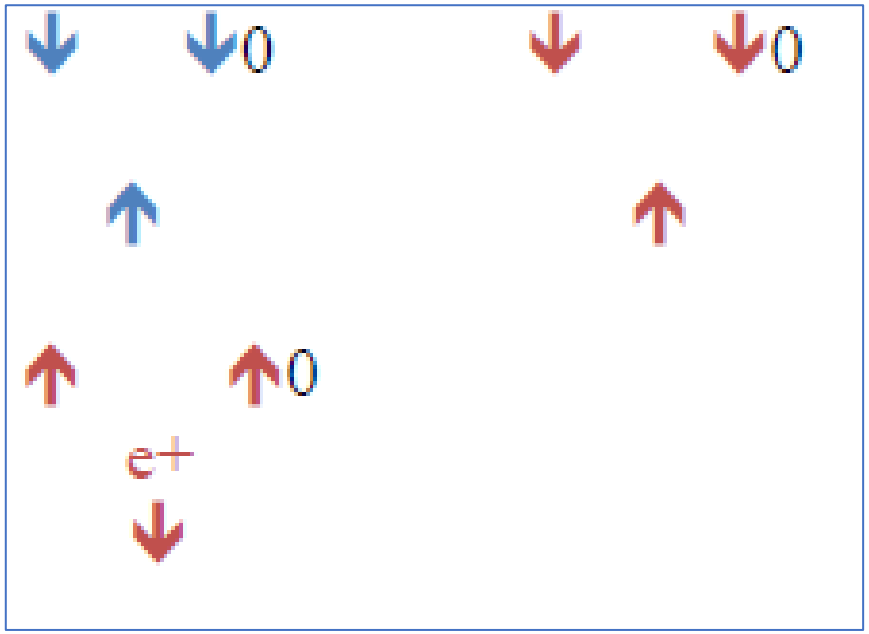
Chen understood that the electron/positron pairs arise from the Bethe-Heitler quantum vacuum

Hypothesis: Stable hadrons are composed of quarks, antiquarks, and positrons

Composite proton structures:



Composite neutron structures:



Blue indicates matter; red indicates antimatter
Arrows indicate up or down quarks or antiquarks
e^+ = positron

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Prediction from Composite Hadron Hypothesis:

If the positrons generated when high-energy lasers strike a gold target arise internally from the nucleus, then the target should transmutate

In 2015, Alexander Henderson observed at the Texas Petawatt Laser Facility that gold targets struck by high-intensity lasers are transmutated in the process -- Au is transmutated into Pt

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Implications of Composite Hadron Structure

1. 4:1 H:He ratio initial atomic structure of Universe
2. Proton-to-neutron conversion in proton-proton chain reactions is not caused by flavor change of quarks but, instead, positron ejection from protons
3. Neutrinos created as a byproduct of proton-proton chain reactions in stars cause the expansion, and the increasing rate of expansion, of the Universe
4. Beta decay (both *B*+ and *B*-) is likely an external, deterministic phenomenon caused by neutrinos interacting with nuclei

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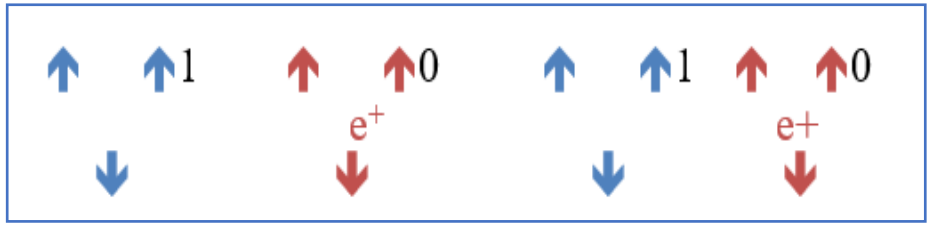
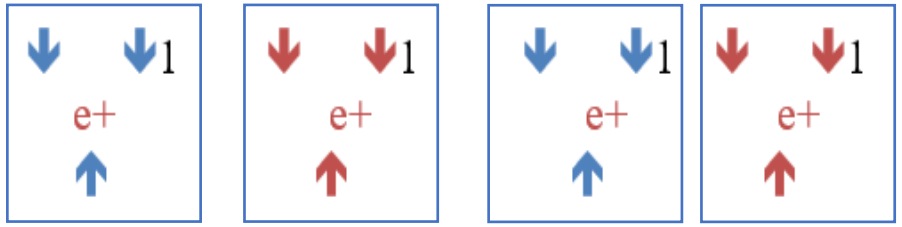
1. Initial Atomic State of the Universe

Equal numbers (in this case, six) of up quarks, down quarks, up antiquarks, down antiquarks, electrons, and positrons, reflect observed hydrogen/helium composition of stars (4:1):



= He



= 4 H

*electrons not shown

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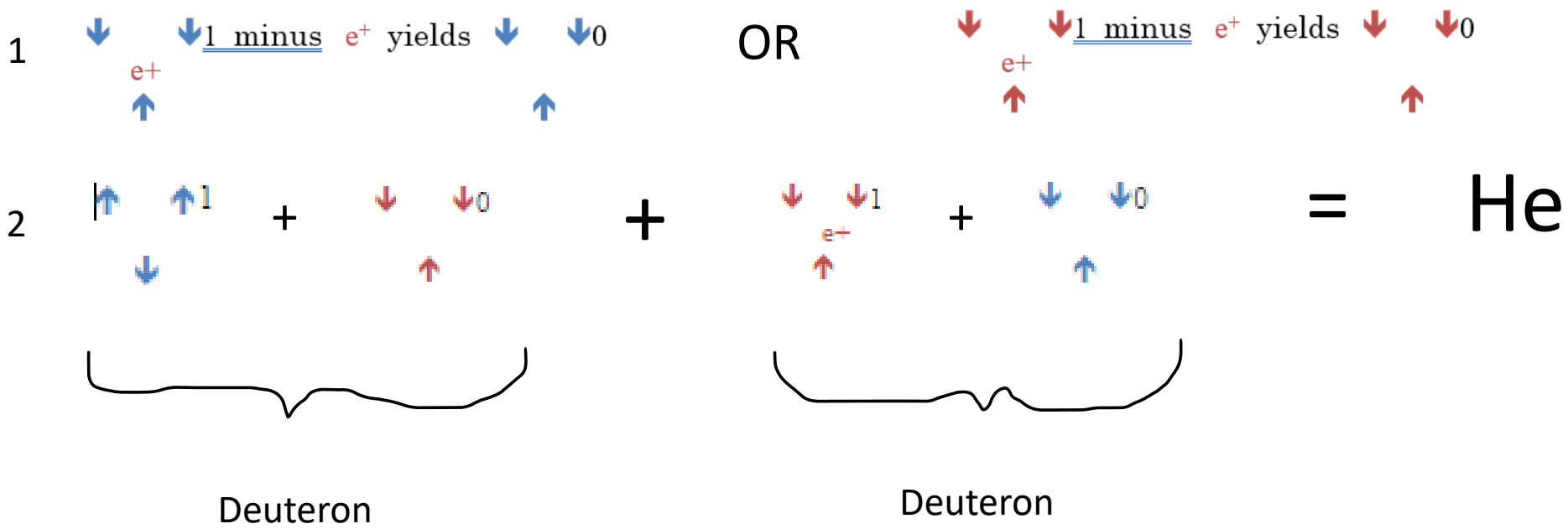
2. Proton-Proton Chain Reactions in Stars

Positrons are ejected from protons to form neutrons, which combine with protons to form deuterons, which combine to form helium nuclei



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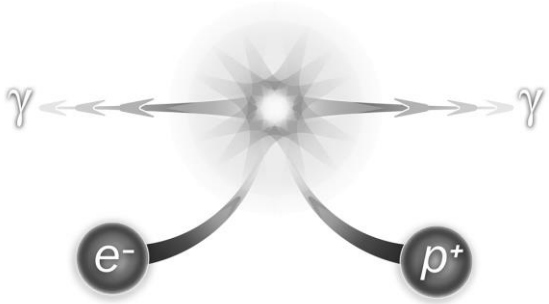
3. Expansion of the Universe

In proton-proton chain reactions in stars, positrons ejected from hydrogen nuclei encounter nearby electrons & annihilate



*p^+ = e+

1. Photons (2 511-keV gamma rays) and neutrinos are generated

2. Neutrinos, which have mass, are accelerated to nearly *c* – expanding spacetime under the General Theory

3. If stars are increasingly active in the Universe, then the *rate* of expansion of the Universe will therefore increase

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4a. Beta Decay (β+)

Within radioactive nuclei,

Similarly,

Likely cause: proton in nucleus struck by neutrino

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4b. Beta Decay (β-)

Likely cause: neutrino lyses into electron & positron, depositing positron into nucleus

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Composite Hadron Structure Is Consistent With:

- Equal amounts of matter and antimatter in the Universe
- Presence of pions (and their observed masses) in collider experiments
- Proton-proton chain reactions in stars
- Generation of positrons in petawatt laser experiments
- Observed hydrogen/helium composition of stars
- Expansion of Universe & increasing rate of expansion of Universe
- Beta decay (β+ and β-)
- Half-lives of radioactive isotopes as a 2nd-order kinetic
- Observed declining half-lives of Voyager fission generator

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Potential for Even Greater Simplicity in the Composite Hadron Structure – Pentaquarks and Tetraquarks

- Tetraquarks and Pentaquarks have been discovered at the Large Hadron Collider
  - LHCb Collaboration, "Observation of $J/\Psi P$ resonances consistent with pentaquark state in $\Lambda \rightarrow J/\Psi K^- p$ decays," *Phys. Rev. Lett*. **115**: 072001 (2015).
  - LHCb Collaboration, "Observation of an exotic narrow doubly charmed tetraquark," *Nat. Phys*. **18**: 751-54 (2022).

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Simplified Composite Hadron Structure

- Because total positive quark/antiquark charge in initial atomic state (slide 7) is 6, and the total negative quark/antiquark charge in initial atomic state is 6 (which match the positive 6 and negative 6 charges of the electrons and positrons), it is likely that the distinction of up and down quarks & antiquarks is misplaced
- May be better to think of positive quarks and negative quarks each with 1/3 of the charge of an electron or positron (equal to currently-understood down quark and down antiquark)
- Stable pentaquark and tetraquark matter/antimatter structure of hadrons is likely

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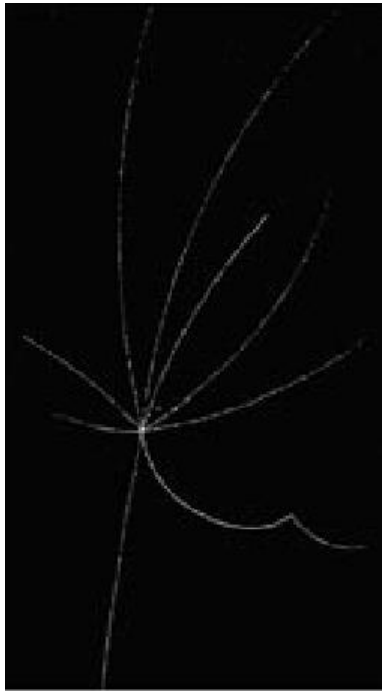
Next Steps:

1. Further testing/verification is called for
2. Implications of composite hadron structure should be evaluated:
   a. Revisit prior collider results (e.g., Bevatron results)
   b. Mathematically address presence of positrons within hadrons
   c. Further evaluate cosmological effect of composite hadron structure on evolution of the Universe
   d. Mathematically address possibility of quarks/antiquarks as simply positive & negatively charged fundamental structures (charge = +1/3 or -1/3) forming stable pentaquark and tetraquark hadrons (sometimes conjoined with a positron); i.e., currently-understood down quark and down antiquark quark are the fundamental building blocks of hadrons in the Universe



Proton/Antiproton Bevatron collision

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Thank You!

Please address questions, comments, criticism to:

mark.pickrell@albireoscientific.net

Working paper: https://hal.science/hal-04261243/document

An updated version of this working paper is exclusively under consideration at *Physics Essays*, currently in post-peer-review process

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Sources

Images

1. Positron: https://%3A%2F%2Fi.pinimg.com%2Foriginals%2F27%2Fc9%2Fd4%2F27c9d4d46dc9f37b5ce522ea42bd61f0.jpg

2. K meson to π^+: https://www.cloudylabs.fr/wp/kaoninteractions/

3. Proton/Antiproton Bevatron collision: https://indico.cern.ch/event/104466/attachments/15569/22575/The_Bevatron.pdf

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Sources

Select Publications

1. H. Bethe & W. Heitler On the stopping of fast particles and on the creation of positive electrons, *Proc. Roy. Soc. A* **146**: 83 (1934).

2. O. Chamberlain, E. Segrè, C. Wiegand, and T. Ypsilantis, Observation of antiprotons, *Phys. Rev.* 100: 947-50 (October 24, 1955).

3. H. Chen, *et al*., "Relativistic positron creation using ultraintense short pulse lasers," *Phys. Rev. Lett*. **102**: 105001 (2009).

4. J.H. Christenson, J.W. Cronin, V.L. Fitch, and R. Trulay, Evidence for the 2Π Decay of the K_2^0 Meson. *Phys. Rev. Lett*. **13**(4): 138-40 (July 27, 1964).

5. LHCb Collaboration, "Observation of *J/ΨP* resonances consistent with pentaquark state in *Λ → J/ΨK- p* decays," *Phys. Rev. Lett*. **115**: 072001 (2015).

6. LHCb Collaboration, "Observation of an exotic narrow doubly charmed tetraquark," *Nat. Phys*. **18**: 751-54 (2022).

7. S. Mertens, Direct neutrino mass experiments, *J. Phys. Conf. Series* **718** (2): 022013 (2016)

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Sources

Henderson
Dissertation

With Permission of Dr. Henderson

A.H. Henderson, “Monte-Carlo simulation and measurements of electrons, positrons, and gamma-rays generated by laser-solid interactions,” Rice University, Houston Texas (January 2015) (doctoral dissertation)

Henderson’s dataset: DOI//10.6084/m9.figshare.24319894

Henderson’s comparator:
https://www.nndc.bnl.gov/nudat3/getdataset.jsp?nucleus=196Pt&unc=nds

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