Verifying Unmatter by Experiments, More Types of Unmatter, and a Quantum Chromodynamics Formula

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Abstract

As shown, experiments registered unmatter—a new kind of matter whose atoms include both nucleons and antinucleons, with a very short life span of no more than 10^{-20} sec. Stable states of unmatter can be built on quarks and antiquarks: applying the unmatter principle, obtained is a quantum chromodynamics formula that gives many combinations of unmatter built on quarks and antiquarks.

Since the publication of my articles defining "matter, antimatter, and unmatter,"[1,2] and Dr. S. Chubb's pertinent comment[3] on unmatter, new development has been made on the unmatter topic in the sense that experiments verifying unmatter have been found.

1. Definition of Unmatter

In short, unmatter is formed by matter and antimatter that bind together.[1,2] The building blocks (most elementary particles known today) are six quarks and six leptons; their twelve antiparticles also exist. Then unmatter will be formed by at least a building block and at least an anti-building block which can bind together.

2. Exotic Atom

If in an atom we substitute one or more particles with other particles of the same charge (constituents) we obtain an exotic atom whose particles are held together due to the electric charge. For example, we can substitute in an ordinary atom one or more electrons with other negative particles (say, π^-, anti-Rho meson, D^-, D_s^-, muon, tau, Ω^-, Δ^-, etc., generally clusters of quarks and antiquarks whose total charge is negative), or the positively charged nucleus replaced by other positive particles (say, clusters of quarks and antiquarks whose total charge is positive, etc.).

3. Unmatter Atom

It is possible to define unmatter in a more general way, using the exotic atom. The classical unmatter atoms were formed by particles like (a) electrons, protons, and antineutrons, or (b) antielectrons, antiprotons, and neutrons.

In a more general definition, an unmatter atom is a system of particles as above, or such that one or more particles are replaced by other particles of the same charge.

Other categories would be (c) a matter atom where one or more (but not all) of the electrons and/or protons are replaced by antimatter particles of the same corresponding charges, and (d) an antimatter atom such that one or more (but not all) of the antielectrons and/or antiprotons are replaced by matter particles of the same corresponding charges.

In a more composed system we can substitute a particle with an unmatter particle and form an unmatter atom.

Of course, not all of these combinations are stable, semistable, or quasi-stable, especially when their time to bind together might be longer than their lifespan.

4. Examples of Unmatter

From 1970 to 1975, numerous pure experimental verifications were obtained proving that "atom-like" systems built on nucleons (protons and neutrons) and antinucleons (antiprotons and antineutrons) are real. Such "atoms," where nucleon and antinucleon are moving at the opposite sides of the same orbit around the common center of mass, are very unstable; their lifespan is no more than 10^{-20} sec. Then nucleon and antinucleon annihilate into gamma-quanta and more light particles (pions) which can not be connected with one another (see References 6-8). The experiments were done mainly in Brookhaven National Laboratory (USA) and partially at CERN (Switzerland), where "proton—antiproton" and "antiproton—neutron" atoms were observed, called $\bar{p}p$ and $\bar{p}n$ respectively (see Figures 1 and 2).

After the experiments were done, the lifespan of such "atoms" was calculated theoretically in Chapiro's works.[9-11] His main idea was that nuclear forces, acting between nucleon and antinucleon, can keep them far way from each other, hindering their annihilation. For instance, a proton and antiproton are located at opposite sides in the same orbit and they are moved around the orbit center. If the diameter of their orbit is much more than the diameter of "annihilation area," they can be kept out of annihilation (see Figure 3). But because the orbit, according to quantum mechanics, is an actual cloud spreading far around the average radius, at any radius between the proton and the antiproton there is a probability that they can meet one another at the annihilation distance. Therefore nucleon—antinucleon system annihilates in any case, this system is unstable by definition, having a lifespan no more than 10^{-20} sec.

Unfortunately, the researchers limited the research to the consideration of $\bar{p}p$ and $\bar{p}n$ nuclei only. The reason was that they, in the absence of a theory, considered $\bar{p}p$ and $\bar{p}n$ "atoms" as only a rare exception, which gives no classes of matter.

The unmatter does exist—for example, some mesons and anti-mesons, through for a trifling of a second lifetime—so the pions are unmatter [which have the composition u^d and ud^, where by u^ we mean anti-up quark, d = down quark, and analogously u = up quark and d^ = anti-down quark, while by ^ means anti], the kaon K^+ (us^), K^- (u^s), Phi (ss^), D^+ (cd^), D^0 (cu^), D_s^+ (cs^), J/Psi (cc^), B^- (bu^), B^0 (db^), B_s^0 (sb^), Upsilon (bb^) [where c = charm quark, s = strange quark, b = bottom quark], etc. are unmatter too.

Also, the pentaquark Theta-plus (Θ^+), of charge $^+1$, uudds^ (*i.e.*, two quarks up, two quarks down, and one anti-strange quark), at a mass of 1.54 geV and a narrow width of 22 MeV, is unmatter, observed in 2003 at the Jefferson Lab in Newport News, Virginia, in the experiments that involved multi-GeV photons impacting a deuterium target.

Similar pentaquark evidence was obtained by Takashi Nakano of Osaka University in 2002, by researchers at the ELSA accelerator in Bonn in 1997-1998, and by researchers at ITEP in Moscow in 1986.

Besides Theta-plus, evidence has been found in one experiment[4] for other pentaquarks, Ξ_5^{--} (ddssu^) and Ξ_5^{+} (uussd^). D.S. Carman[5] has reviewed the positive and null evidence for these pentaquarks and their existence is still under investigation.

In order for the paper to be self-contained let's recall that the *pionium* is formed by π^+ and π^- mesons, the *positronium* is formed by an antielectron (positron) and an electron in a semi-stable arrangement, the *protonium* is formed by a proton and an antiproton which are also semi-stable, the *antiprotonic helium* is formed by an antiproton and electron together with the helium nucleus (semi-stable), and *muonium* is formed by a positive muon and an electron.

Also, the *mesonic atom* is an ordinary atom with one or more of its electrons replaced by negative mesons. The *strange matter* is an ultra-dense matter formed by a large number of strange quarks bound together with an electron atmosphere (this strange matter is hypothetical).

From the exotic atom, the pionium, positronium, protonium, antiprotonic helium, and muonium are unmatter. The mesonic atom is unmatter if the electron(s) are replaced by negatively-charged anti-mesons.

Also we can define a mesonic anti-atom as an ordinary anti-atomic nucleus with one or more of its antielectrons replaced by positively-charged mesons. Hence, this mesonic anti-atom is unmatter if the antielectron(s) are replaced by positively-charged mesons.

The strange matter can be unmatter if there exists at least an antiquark together with so many quarks in the nucleus. Also, we can define the strange antimatter as formed by a large number of antiquarks bound together with an anti-electron around them. Similarly, the strange antimatter can be unmatter if there exists at least one quark together with so many antiquarks in its nucleus.

The bosons and antibosons help in the decay of unmatter. There are 13+1 (Higgs boson) known bosons and 14 anti-bosons in present.

5. Quantum Chromodynamics Formula

In order to save the colorless combinations prevailed in the theory of quantum chromodynamics (QCD) of quarks and antiquarks in their combinations when binding, we devise the following formula:

$$Q - A \in \pm M3 \qquad (1)$$

where M3 means multiple of three, *i.e.* $\pm M3 = \{3\cdot k \mid k \in Z\} = \{\ldots, -12, -9, -6, -3, 0, 3, 6, 9, 12, \ldots\}$, and Q = number of quarks, A = number of antiquarks.

But (1) is equivalent to:

$$Q \equiv A \pmod 3 \qquad (2)$$

(Q is congruent to A modulo 3).

To justify this formula we mention that three quarks form a colorless combination, and any multiple of three (M3) combination of quarks too, *i.e.* 6, 9, 12, etc. quarks. In a similar way, three antiquarks form a colorless combination, and any multiple of three (M3) combination of antiquarks too, *i.e.* 6, 9, 12, etc. antiquarks. Hence, when we have hybrid

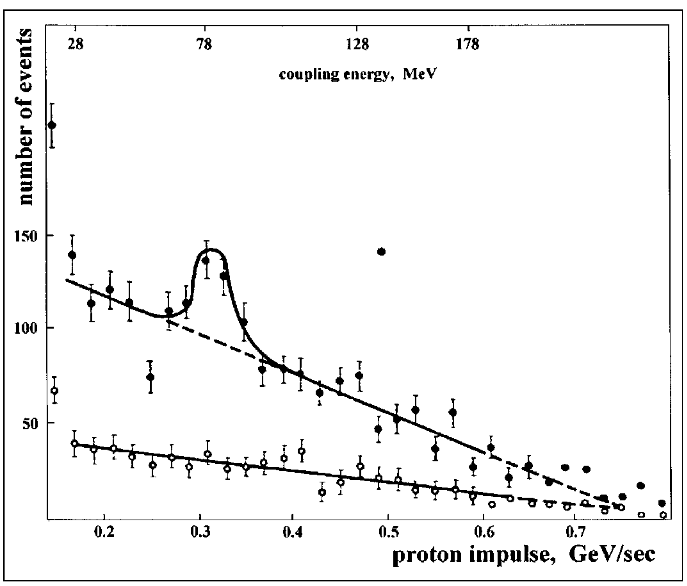

Figure 1. Spectra of proton impulses in the reaction $\bar{p} + d \rightarrow (\bar{p}n) + p$. The upper arc is the annihilation of $\bar{p}n$ into even number of pions, the lower arc its annihilation into odd number of pions. The observed maximum points out that there is a connected system $\bar{p}n$. Abscissa axis represents the proton impulse in GeV/sec (and the connection energy of the system $\bar{p}n$). Ordinate axis is the number of events.

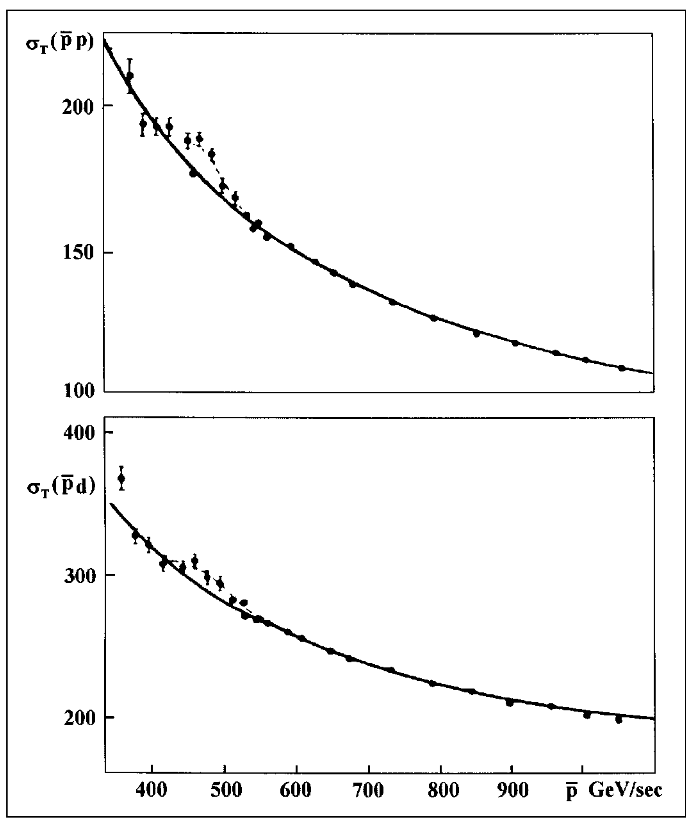

Figure 2. Probability σ of interaction between $\bar{p}$, p, and deutrons d (cited from [7]). The presence of maximum points out the existence of the resonance state of "nucleon–anti-nucleon."

combinations of quarks and antiquarks, a quark and an antiquark will annihilate their colors and, therefore, what's left should be a multiple of three number of quarks (in the case when the number of quarks is bigger, and the difference in the formula is positive), or a multiple of three number of antiquarks (in the case when the number of antiquarks is bigger, and the difference in the formula is negative).

6. Quark-Antiquark Combinations

Let's note by q = quark ∈ {Up, Down, Top, Bottom, Strange, Charm}, and by a = antiquark ∈ {Up^, Down^, Top^, Bottom^, Strange^, Charm^}. Hence, for combinations of n quarks and antiquarks, $n \geq 2$, prevailing the colorless, we have the following possibilities:

- if n = 2, we have: qa (biquark, for example the mesons and anti-mesons);
- if n = 3, we have qqq, aaa (triquark, for example the baryons and anti-baryons);
- if n = 4, we have qqaa (tetraquark);
- if n = 5, we have qqqqa, aaaaq (pentaquark);
- if n = 6, we have qqqaaa, qqqqqq, aaaaaa (hexaquark);
- if n = 7, we have qqqqqaa, qqaaaaa (septiquark);
- if n = 8, we have qqqqaaaa, qqqqqqaa, qqaaaaaa (octo-quark);
- if n = 9, we have qqqqqqqqq, qqqqqqaaa, qqqaaaaaa, aaaaaaaaa (nonaquark);
- if n = 10, we have qqqqqaaaaa, qqqqqqqqaa, qqaaaaaaaa (decaquark); etc.

7. Unmatter Combinations

From the above general case we extract the unmatter combinations:

— For combinations of two we have: qa (unmatter biquark), [mesons and anti-mesons]; the number of all possible unmatter combinations will be $6 \cdot 6 = 36$, but not all of them will bind together. It is possible to combine an entity with its mirror opposite and still bound them, such as: uu^, dd^, ss^, cc^, bb^, which form mesons. It is possible to combine, unmatter + unmatter = unmatter, as in ud^ + us^ = uud^s^ (if they bind together).
— For combinations of three (unmatter triquark) we can not form unmatter since the colorless can not hold.
— For combinations of four we have: qqaa (unmatter tetraquark); the number of all possible unmatter combinations will be $6^2 \cdot 6^2 = 1{,}296$, but not all of them will bind together.
— For combinations of five we have: qqqqa, or aaaaq (unmatter pentaquarks); the number of all possible unmatter combinations will be $6^4 \cdot 6 + 6^4 \cdot 6 = 15{,}552$, but not all of them will bind together.
— For combinations of six we have: qqqaaa (unmatter hexaquarks); the number of all possible unmatter combinations will be $6^3 \cdot 6^3 = 46{,}656$, but not all of them will bind together.
— For combinations of seven we have: qqqqqaa, qqaaaaa (unmatter septiquarks); the number of all possible unmatter combinations will be $6^5 \cdot 6^2 + 6^2 \cdot 6^5 = 559{,}872$, but not all of them will bind together.
— For combinations of eight we have: qqqqaaaa, qqqqqqqa, qaaaaaaa (unmatter octoquarks); the number of all possible unmatter combinations will be $6^4 \cdot 6^4 + 6^7 \cdot 6^1 + 6^1 \cdot 6^7 = 5{,}038{,}848$, but not all of them will bind together.

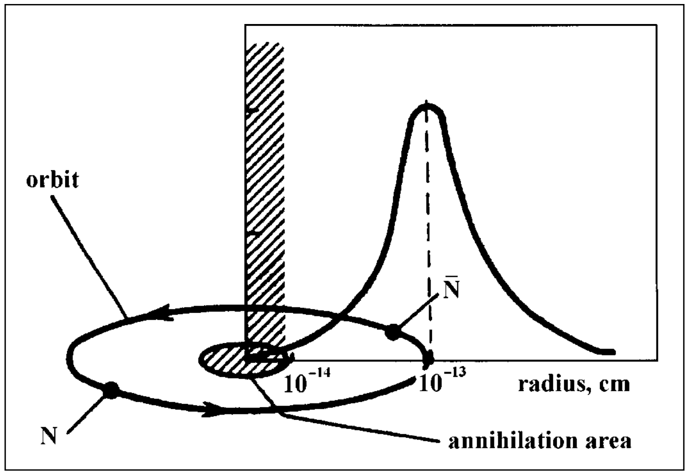

Figure 3. Annihilation area and the probability arc in "nucleon–anti-nucleon" system (cited from [11]).

— For combinations of nine we have: qqqqqqaaa, qqqaaaaaa (unmatter nonaquarks); the number of all possible unmatter combinations will be $6^6 \cdot 6^3 + 6^3 \cdot 6^6 = 2 \cdot 6^9 = 20{,}155{,}392$, but not all of them will bind together.
- For combinations of ten we have: qqqqqqqqaa, qqqqqaaaaa, qqaaaaaaaa (unmatter decaquarks); the number of all possible unmatter combinations will be $3 \cdot 6^{10} = 181{,}398{,}528$, but not all of them will bind together.

It may be possible to make infinite combinations of quarks/antiquarks and leptons/antileptons.

Unmatter can combine with matter and/or antimatter and the result may be any of these three. Some unmatter could be in the strong force, hence part of hadrons.

8. Unmatter Charge

The charge of unmatter may be positive, as in the pentaquark Theta-plus, 0 (as in positronium), or negative as in anti-Rho meson (u^d) [M. Jordan].

9. Containment

I think for the containment of antimatter and unmatter it would be possible to use electromagnetic fields (a container whose walls are electromagnetic fields). But its duration is unknown.

10. Further Research

Let's start from neutrosophy,[18] which is a generalization of dialectics, *i.e.* not only the opposites are combined but also the neutralities. Why? Because when an idea is launched, a category of people will accept it, others will reject it, and a third group will ignore it (won't care). But the dynamics between these three categories changes, so somebody accepting it might later reject or ignore it, and so on. Similarly, the dynamicity of <A>, <antiA>, <neutA>, where <neutA> means neither <A> nor <antiA>, but in between (neutral).

Neutrosophy considers not di-alectics but *tri-alectics* (based on three components: <A>, <antiA>, <neutA>). Hence unmatter is a kind of neutrality (not referring to the charge) between matter and antimatter, *i.e.* neither one, nor the other. Upon the model of unmatter we may look at ungravity, unforce, unenergy, etc.

Ungravity would be a mixture of gravity and antigravity (for example, attracting and rejecting simultaneously or alternatively; or a magnet which changes the positive and negative poles frequently).

Unforce: We may consider positive force (in the direction we want) and negative force (repulsive, opposed to the previous). There could be a combination of both positive and negative forces at the same time, or alternating positive and negative, etc.

Unenergy would similarly be a combination of positive and negative energies (as the alternating current (a.c.), which periodically reverses its direction in a circuit and whose frequency, f, is independent of the circuit's constants). Would it be possible to construct an alternating-energy generator?

In conclusion, according to the universal dialectic, unity is manifested in duality and duality in unity. "Thus, Unmatter (unity) is experienced as duality (matter vs. antimatter). Ungravity (unity) as duality (gravity vs. antigravity). Unenergy (unity) as duality (positive energy vs. negative energy). And thus also. . .between duality of being (existence) vs. nothingness (anti-existence) must be 'unexistence' (or pure unity)."[12]

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Dr. Smarandache was born in Romania and received a Ph.D. in mathematics from the State University of Kishinev in 1997. After emigration to the U.S., he continued postdoctoral studies at various universities. Smarandache worked as a software engineer for Honeywell (1990-1995) and was an adjunct professor at Pima Community College (1995-1997). In 1997 he became an assistant professor at the University of New Mexico (Gallup) and was promoted to associate professor of mathematics in 2003. Smarandache is the author of many books and has published in many journals and proceedings.

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