Charge-invariance legitimates *non-annihilating natural charge-inverted antihydrogen*

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Following chemical and physical evidence, we now give theoretical evidence for the reality of natural non-annihilating charge-inverted H-states. Annihilative anti-hydrogen experiments at CERN result from a convention, imposed on the charge distribution in natural H, which contradicts and overrules the essence of charge-invariance ***C****.*

Chemical [1] and physical [2-3] evidence exists for *natural non-annihilative* H̲, different from *artificial annihilative* H̲ [4-7]. Artificial H̲ has a positron bound to an antiproton [4-7]; normal H has an electron bound to a proton. The interest in H̲ stems from a too restrictive convention on the charge distribution in normal H. In this neutral 2 unit charge system, charge-invariance **C** guarantees a free assignment of charges: PN (positive, negative: +; -) is as valid as NP or anti-PN (negative, positive: -; +). Charges in H are assigned to P and N by convention. With **C**, 3 equivalent algebraic forms apply

$$\text{(i) } 0 = e^+ + e^- = e^- + e^+;\ \text{(ii) } e^+ = -e^-;\ \text{(iii) } 0 = e^+ - e^+ \qquad (1a)$$

whatever the nature of the sub-particles to which charges are assigned. **C** allows a permutation of P and N, which returns the identity *for point-like charges* after a rotation of (multiples of) 180° or π, as opposed to classical rotations, returning the identity after a rotation of (multiples of) 360° or 2π. In (1a)(i), the mirror plane crossed *by point-like charges* is perpendicular to the Coulomb field axis. This critical **C**-angle

$$\alpha_C = \pi/2\ (90°) \qquad (1b)$$

is an exact quantitative criterion to look for permutations in ***C****-system* (1a)(i). A transition from NP to PN is a rotation by 180°, meaning *a rotation with zero angular momentum* to be understood *with radial velocities* (see below). But **C** is just one dichotomy for complementary 2 unit charge systems like H [8]. For instance in 1D, **C** and **P** (parity) are degenerate *with left-right symmetry for mutually exclusive states*. Space-time coordinates for left- and right complementary parts (chiral behavior [9]) are

$$\text{chirality: left L: } (-x,+y,+z,+t);\ \text{right R: } (+x,+y,+z,+t) \qquad (2a)$$

meaning that a 3D Cartesian reference frame for a unit like H is *either* left- *or* right-handed: the two cannot apply simultaneously. The frames *are as mutually exclusive* as states PN and NP. Discrete symmetry parity (**P**) obeys coordinates

$$\mathbf{P}\text{: P(+): } (-x,-y,-z,+t) \text{ and P(-): } (+x,+y,+z,+t) \qquad (2b)$$

a switch which inverts left into right *and* vice versa. **P** respects the freedom allowed by **C** for conjugated charges (1a). **P** warns that, if only option PN were chosen by convention, **C**-option NP must not be forgotten. Expressing **C** in a 1D Coulomb field with variable x gives

C: PN: (-x, +t), (e^+; e^-); NP,anti-PN: (+x, +t), (e; e^+) (2c)

a mathematical equivalent of (1a). Dichotomies (2a-c) in 1D are only degenerate if measurements on vertices are *simultaneous* (+t). Spin-dichotomies **S**, appearing as corrections to *rotations with non-zero angular momentum*, also obey generic scheme (2c), since

S: S(↓): (-x) and S(↑): (+x) (2d)

In 1D, differentiating between **C** and **S** is not necessary, if absolute spin ±1/2 is not required. A common 1D element in all symmetries (2a-d) is a stick of length |2x| in vector notation

$|2x| = -\mathbf{x} + \mathbf{x} = +\mathbf{x} - \mathbf{x}$ (2e)

Without vector calculus, 2 correlated x-values vanish identically when added as in (1a)(i) since

$0 = +x - x = -x + x$ (2f)

which places constraints on the physics behind symmetries (2a-d). In fact, scaling charges in (1a) and lengths in (2e-f) with units of the same physical dimension, gives

$0 = +n - n = -n + n$ (2g)

a permutation of conjugated algebraic numbers. With +1 added at either side of (2g), we get

$+1 = +n + (1-n) = -n + (1+n)$ (2h)

two equivalent, perfectly allowed and mathematically correct numerical equations without physical constraints:*(2g) and (2h) are system and/or physics independent*. With (2h), an absolute first principle interferes with symmetries (2a-d): *additive complementarity* [8a,c]. The two different forms in (2h) illustrate *the associative law of addition*, seemingly without physical implication. Symmetries (2a-c) are now generalized *in a trivial way* but a further discussion is meaningless, since critical n-values in (2h) cannot be obtained [8]. Even the *nature* of n is free: it can be any number, real or complex, composite or not [8]. *The trivial character of additive complementarity (2h) is probably the reason why its implications for physics and its symmetries or dichotomies (2a-d) were overlooked* [8]. With (2g-h), *the* equation behind symmetry is indeed *trivial* 0=0 for *nothing* (as *trivial* as 1=1 for *something*).

To illustrate this, we *first* consider stick (2e) of length |2x| with grip G and pointer P. The *trivial* notation with either GP or inverted PG, i.e. anti-GP, leaves the length as well as all other properties of the stick unaffected. The laws of physics to describe the stick are invariant for a switch from GP to PG: *(2e) applies without restriction, validating the laws of physics under translation*. A *second* example is the falling cat [10], which rotates with *zero angular momentum* (a permutation) *without annihilation also.*

With (2f), annihilation enters the scene. For stick (2e), a connection with annihilation is meaningless. Vector calculus refers to algebra around the origin. Normalized stick |2x|, line segment 0; +1, is +1=+1/2+1/2, a parallel 1D alignment of 2 vectors pointing in the same direction. For an annihilating system, a translation on an axis cannot undo the anti-particle's negativity –x in the positive world (it is an intrinsic property of an antiparticle). The length of the same stable stick should then be given by (2f), *indicating annihilation*, because of the anti-parallel 1D alignment. For particle-antiparticle pair (2f), a zero (the origin) is *unfolded* [9] symmetrically, which secures annihilation on the spot as soon as the unfolding force is removed. *Annihilation is connected with algebra around absolute origin 0 but not around local origin +1, as in the case of the stick* (see below). *Denoting a stick as GP instead of PG can never be a cause for annihilation.* In mathematics, the transition from GP to PG is a sign inversion of axis +x to axis –x, a (discrete) permutation governed by critical angle (1b). Permutations (2) in physical systems are *rotations with zero angular momentum* the importance of which can never be overestimated [10] (see below).

With (2a), *left and right cannot annihilate either*, as a division in complementary left and right parts is *a generic result of -system independent- additive complementarity* [8]. Convention allows *left* to be called *anti-right* as in (2a) but this *anti cannot be associated with annihilation* (2e): left and right are complementary and must remain so to return unit +1 [8].

A convention *overruling* **C** (2c) can only be justified if there is conclusive evidence that only *one* charge distribution can exist: either +1 (PN) *or* inverted –1 (NP), *anti-PN. Its sole advantage is that it removes the ambiguity with the freedom of choice for charges guaranteed by **C*** (1a). The convention imposed on H, e^-p^+ or NP [8], means that 2 charges are assigned *exclusively* to 2 complementary sub-particles electron and proton in that order. This conventional *negative electron; positive proton H-model* is, however, justified by data. When H-size r_H goes to infinity, dissociation (ionization) invariantly gives a negative electron and a positive proton, which validates the H-convention. However, this convention uses an extrapolation of evidence for charge distribution NP at $r_H=\infty$, an unbound perturbed state, to the bound, unperturbed equilibrium state at $r_H=r_0$, resulting in configuration negative electron; positive proton or NP (e^-; e^+) and, in doing so, excludes PN or anti-NP (e^+; e^-). The consequence is dramatic as state PN (anti-NP) *is forbidden by convention only*, although **C** (1a) does not impose any exclusion. *Only convention rules out natural non-annihilative* <u>*H*</u>. In line with **C**, one could have assigned a positive charge to the electron and a negative one to the proton, *but this was forbidden*. But is the extrapolation at the basis of this convention reliable? Taking for granted that information collected *for an unbound system at infinite separation* also applies rigorously *for the bound state at r_0* could be an error. *A missing element may be rotation with zero angular momentum* (see below). Extrapolating information for long range ($r=\infty$) behavior to short range ($r=r_0$) can be misleading. The proof is given by neutral charge-conjugated chemical bonds X_2, with dissociation products 2 neutral atoms X + X. This *correct* long range information suggests that *covalent bonding* applies for equilibrium X_2 at r_0, the basis of Heitler-London theory [11]. *Surprisingly enough, this is not so*: for 300 bonds, this is simply a *trompe l'oeil* [12]. Lower order molecular spectroscopic constants α_e and

$x_e\omega_e$, describing accurately the potential energy curve (PEC) of X_2 *at* r_0, can only be rationalized with an *ionic* asymptote at r=∞ or dissociation products $X^+ + X^-$, 2 charge-conjugated ions instead of 2 neutral atoms X+X [12]. So, the H-convention NP violating **C** for H at r_0 using information related to r_H=∞ can be too restrictive indeed. If extrapolating information is a *trompe l'oeil* for 300 molecules [12] it can be a *trompe l'oeil* for H too. State PN, allowed by **C** can not be excluded for H just by convention *on the basis of a misleading extrapolation of long range behavior*. Theoretically at least, this opens the way for natural non-annihilating $\underline{H}$: *convention NP as only state for H can be too restrictive an application for and in contradiction with first principle **C**.*

Excluding one state weighs on the usefulness of **P** (2b), a discrete switch for a transition between two states. With the H-convention valid, switch **P** becomes superfluous although it respects the mutually exclusive nature of NP and PN. The validity of **P** suggests to look for a transition between the 2 states it describes, NP *and* PN, at a critical point, say a critical size r_C for system H. But fixing the H charge distribution as NP (e^-p^+), contradicting **C**, generated an interest in the charge inverted state PN (e^+p^-). *Physicists* working on annihilative $\underline{H}$ [4-7] are in fact looking for a *mysterious artificially created* charge-inverted state PN, *forbidden by a convention of physicists. Maybe it would have been better to find out first of all if, in nature, the H-convention NP is indeed absolutely valid* [1-3].

Applying NP to H mass +m(H) and 2 sub-particle masses instead of to two charges, we get

$$+m(H) = +m(e^-)+ m(p^+) \text{ or } +m_H = m_e + m_p \qquad (3a)$$

Here, the attribution of charges to electron and proton is even irrelevant in accordance with **C**. Since +m(p)=+m(H)–m(e), (3a) gives 2 positive *complementary* [8] *masses* $+m_e$ and $+m_p$ for $+m_H$, associated with state NP allowed by convention. With the discovery of annihilative positron $m(e^+)$ and antiproton $m(p^-)$, *predicted theoretically by Dirac*, the extrapolation towards

$$+m(\text{antiH})=+m(\underline{H})=+m(H)=+m(\underline{p}^-)+m(\underline{e}^+) \text{ or } +m_{\underline{H}} =m_{\underline{e}} +m_{\underline{p}} \qquad (3b)$$

for anti-NP or PN in (2c), allowed by **C**, is evident. With (3a) and (3b), Dirac inspired *annihilative* $\underline{H}$ has a positron bound to an antiproton. Result (3b) is the basis of [4-7] but the dilemma with natural non-annihilative $\underline{H}$ allowed by **C** must be solved.

A solution depends on the existence of a critical r_C for natural H to be related with criterion (1b). Since the H-convention is based on an *expansion* of H to r_H=+∞, we can use a *compression* instead [13]. Although (3a) is absolutely correct for the unbound state at r_H=∞, a compression may provide evidence for a switch at a critical size r_C between $0<r_C<\infty$. Compressing conventional state NP, forces negative electron and positive proton to get closer, eventually to get in contact but at critical r_C a transient state for H will have to be discussed with symmetries (2a-d). In terms of (1a-b), this may be a state where the mirror plane is crossed (the axial configuration with the cosine law). An *unperturbed* transient H-state at r_C can be characterized by +1=+1 for n=0 in (2h), whatever n means for symmetries (2). With (2h), this critical state for H is theoretically in between its two natural allowed H-states

state NP:$+1=+n+(1-n)$ or $+m_H=+m_e+m_P=+m_e+(m_H-m_e)$ (3c)

anti-state PN:$+1=-n+(1+n)$ or $+m_H=-m_e+(m_H+m_e)$ (3d)

since, using (3a), $+n=+m_e$. Natural state PN (3d), a non-annihilative anti-NP state, is clearly at variance with Dirac-based annihilative H (3b). Upon compression beyond r_C, a non-annihilative state with a different symmetry like PN, i.e. anti-NP in (3d), takes over. Accurate measurements of size r_H are now required [13]. Three tools are available.

(a) The first is a relatively accurate Bohr theory for H-size $r_H=n^2r_0$, which allows us to typify r_C by a critical value for principal quantum number n_C since

$$r_C = n_C^2 r_0 \qquad (4)$$

If found, n_C is a link for a transition between states NP (3c) and PN (3d) when n_C is related with (1b). *Multiplicative* Bohr H theory gives energy levels E_{nH} and terms T_{nH}

$$E_{nH} = -R_H/n^2 \qquad (5)$$

$$T_{nH} = R_H(1-1/n^2) \qquad (6)$$

Here (6) is a limit to observe lines n≤2 for H as it covers only 25% of the range 1≤n≤∞ we need. To assess n<2, *extrapolations are required, possibly generating the trompe l'oeil above.*

Conceptually, compression along the Coulomb field axis involves *radial velocities*, a problem neglected in the past [14]. Alternative solutions for Bohr's theory on *radial kinetic energies* are possible but were left unnoticed [8b]. *Radial velocities along the field axis, where 1D permutations (2) can take place, must be denoted as rotations with zero angular momentum* [9]*, for which (1b) applies. But since n --by definition-- relates to non-zero angular momentum values, this is a problem. Fortunately, n is also a measure for H-size as in (4), which solves (part of) this problem* [8b].

Results (4)-(5) show that Bohr H theory is mainly *multiplicative* [8b]. Additivity was introduced by Sommerfeld and led to secondary quantum numbers [8b]. His theory was superseded by Dirac's, but their expressions for levels and fine structure are identical and led to bound state QED [15]. Anyhow, multiplicative Bohr H theory (4)-(6) must be validated *before* trying to detect n_C (4).

(b) Multiplicative scaling is important for wave mechanics (replacing Bohr theory) as proved by Einstein, Podolsky and Rosen [16]. They questioned *the completeness of wave mechanics* if wave function ψ for the state of a quantum system is only defined with multiplicative scaling

$$\psi' = A\psi = a\psi \qquad (7)$$

Here a is a number and A a property of a state, believed to be *completely* described by wave function ψ. One way to comply with the EPR-thesis is *complementarity* [8], exactly the argument used by Bohr [17] in defense of wave mechanics. Bohr's multiplicative result (5) can be tested with running Rydbergs

$$-E_{nH}n^2 = R_H(n) \quad \text{(8a)}$$

and by checking if $R_H(n)$ are constant [2], as required by (5) [8b]. An extreme $R_H(n_C)$ must be interpreted as a critical n_C (4). Pending its relation with (1b), a permutation of type (2a-c) can have taken place in H.

(c) The third tool is *de Broglie*'s standing wave equation $2\pi r=n\lambda$, the basis of wave mechanics [2,18]. This is also multiplicative but *unlike (4), it is linear in n* [8b], and can be rewritten as

$$2r/\lambda = n/\pi \quad \text{(8b)}$$

showing that the condition for resonance is a match of the 1D diameter of a 2 unit charge system with a certain critical wavelength [18]. This ratio is between integer n and irrational number π. A connection between n_C and π must be of interest for (1b), rotations with zero angular momentum.

Tools (a)-(c) led us to look at running Rydbergs (8a) for the H Lyman series [2]. Critical n_C (4) is

$$n_C = \pi/2 \text{ (or } 90°) \quad \text{(9)}$$

[2], completely in line with generic quantitative expectation (1b) for any 1D permutation. Result (9) can only be obtained [2] with the work of Lamb and Retherford [19]. In QED [15] to order $1/n^4$, the contribution of the Sommerfeld-Dirac term $\alpha^4(1/n-(3/4)/n^2)/n^2$ [16] to $R_H(n)$ is extreme for n=1.5 [2]. This is close to (9) but *different* due to the Lamb-shifts [2]. The QED-explanation for Lamb-shifts is complicated [16], whereas (9) suggests the key is a permutation, a rotation of 180°, conform (1b). *This conclusion was never reached with QED* [2], as quantum theories rely on integers, half-integers or Heisenberg-numbers like $\sqrt{[\ell(\ell+1)]}$. *Irrational* number π appears naturally in the *de Broglie* equation (8b) and experimentally in H through (9). It is a critical value (1b) for the size of natural H [18] and with **C**, the conventional assignment of charges in H may be put in doubt. An extrapolation from n=∞ to n=1 being the basis for unique state NP or e^-p^+, this convention cannot be validated as critical n=π/2 (9) must be accounted for with symmetries (2a-d). *At n_C, (9) conventional left NP (3c) changes into right PN, anti-NP: it opens the door for natural non-annihilative $\underline{H}$ (3d)* [2].

The difference between the above symmetries is that **C** and **S** use a symmetrical division, whereas (2a) is a *discrete* division in *continuously varying* left and right complementary parts, leaving their relative magnitude unspecified [8,9]. Parity switch (2b) permutes the 2 complementary parts, created by divisions (2a) or (2c), whether symmetrical or not. Due to (1b), we correlate switch (9) with parity. **C** and **S** are *discrete not continuous symmetries*, whereas the H spectrum and $R_H(n)$-values (8) indicate [2] that the transition point is a quadratic *continuous* function of a parameter, critical at (9). We interpret this phase-transition in terms of left and right parts (2a), adhering to the fact that chirality is at the same time a *discrete and continuous symmetry* [8,9]. The critical point is reached when the parts are equal in magnitude (*the point of maximum symmetry or achirality* [9]). Whether the left-right character of the parts is due to **C**- or **S**-symmetries is even irrelevant. Since there is no discussion about spin in H, **C** could not even compete with **S**, as long as only one charge distribution for H is allowed *by convention*. The already available H line spectrum [2] proves that both states NP and PN for Coulomb systems, allowed by **C**, *can exist in nature*. Result (9) [2,18,20a-d] can disprove the convention made on the charges in natural H: *non-annihilating natural* $\underline{H}$ *can no longer be neglected*. Even if one cannot to accept that ***C*** *has been violated by convention*, its role for getting at a left-right distinction for H can be taken over **S**, exactly the historical development. *Anyhow, the artificial annihilative* $\underline{H}$ *approach* [4-7] *is always challenged*.

Result (9) can be obtained from first principles through (8c) and (3a) [18]. Angle (9) not only probes a permutation within natural H, it also confirms the EPR-thesis and equally disproves multiplicative scaling (7) in wave mechanics. A convention overruling **C** by allowing only NP is proven wrong with the detection of switch (9) between H-states (3c) and (3d) *allowed by the additive law of addition* [8a]. Result (9) is further confirmed by the Mexican hat or double well potential hidden in the H spectrum [3,18,20a-d]. This proves that left-right or chiral H-symmetries (2a) are real [2]. With respect to EPR, natural species H should be described, not with (7), but with an additive wave function for two mutually exclusive states like

$$\psi_H \sim \psi_{PN} + \psi_{NP} = \psi(e^+e^-) + \psi(e^-e^+) \qquad (10)$$

The mutually exclusive character requires that the states NP and PN, if allowed in nature, will have to be *scaled differently* when multiplicative scaling is applied to global system H [8] (see below). With (10), there is no reason to introduce annihilative properties for any of the 2 complementary charged sub-particles in natural H. The reality of the two states NP and PN in (10) has been overtaken in the past with **S** (2d) to accommodate for discrepancies of the Bohr model and led to the Sommerfeld-Dirac equations, still the basis of bound state QED [15].

Reminding (2c), (2d) and (10), molecule H_2 can be interpreted, *without annihilation* [1,20e-f], as

$$H_2 = [H(+1)H(-1)] = H\underline{H} \qquad (11)$$

a valid alternative for **S**-based H(↑)H(↓) in covalent bonding theory [11]. A confirmation of (11) is in [1] as well as in the behavior of spectroscopic constants [12]. The molecular Hamiltonian for (11) contains an algebraic switch [1,20e-f], due to intra-atomic charge inversion in one of the bonding partners. This algebra does not appear in the spin-related Heitler-London theory [11], a significant and fundamental difference [1, 20e-f].

The too restrictive convention on natural charge inverted neutral atoms led to a premature justification for experiments on artificial annihilative $\underline{H}$ [4-7] with the ultimate prospect of also verifying CPT-elements like (2). As we anticipated [2], the data reported on artificial H̲ [4-7] can be explained classically by available theories for a positron-antiproton plasma [22].

Natural non-annihilating H-states NP (3c) and PN (3d), confirmed by (9), were and are still *overlooked in bound state QED* [2]. An *annihilative* permutation of +n and –n around the absolute origin 0 like in (2e) is compensated by a *non-annihilative* permutation around local origin +1, i.e. from +(1-n) to +(1+n). Even when annihilative equation (2e) holds exactly, equations (3a) and (3b) prove that structure +1 itself survives with annihilative condition n-n=0. Structure +1 must not be annihilated [8], whatever the value of n in (2h) or whenever applying divisions like (2a-d). Furthermore, (3a) and (3b) show how PN and NP states separate (are *mutually exclusive*) as mass m_e is scaled in two different ways, confirming the EPR-thesis [16]. The measure for m_H being m_e, the baryon in Bohr H-state NP is indeed a proton with mass 1836.1526675 m_e, or part +(1-n) in (3c) [2]. For natural charge-inverted non-annihilative state PN, baryon mass is 1838.1526675m_e [2], or part +(1+n) in (3d). This must always result in a *scaling anomaly* for m_e of 0.0011 [2,8] close to the observed value [23].

Since energies for annihilative H̲ and non-annihilative H̲ are completely different [24], *natural non-annihilative H̲ is much more plausible than annihilative H̲*. QED.

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