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 H, different from artificial annihilative H [4-7]. Artificial H has a positron bound to an antiproton [4-7]; normal H has an electron bound to a proton. The interest in H 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

\[
\begin{align*}
(i) \quad 0 &= e^+ + e^- = e^- + e^+; \quad (ii) \quad e^+ &= -e^-; \quad (iii) \quad 0 &= e^+ - e^-
\end{align*}
\]

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

\[
\alpha_C = \pi/2 \ (90°)
\]

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

\[
\begin{align*}
\text{chirality: left L:} & \ (-x,+y,+z,+t) \quad \text{right R:} \ (+x,+y,+z,+t)
\end{align*}
\]

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

\[
\begin{align*}
P: \quad P(+) &= (-x,-y,-z,+t) \quad \text{and} \quad P(-) &= (+x,+y,+z,+t)
\end{align*}
\]

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
\textbf{C}: PN: \((-x, +t), (e^+; e^-)\); NP, anti-PN: \((+x, +t), (e; e^+)\) \hspace{2cm} (2c)

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

\[ S: S(\downarrow): (-x) \text{ and } S(\uparrow): (+x) \hspace{2cm} (2d) \]

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

\[ |2x| = -x + x = +x - x \hspace{2cm} (2e) \]

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

\[ 0 = +x - x = -x + x \hspace{2cm} (2f) \]

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

\[ 0 = +n - n = -n + n \hspace{2cm} (2g) \]

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

\[ +1 = +n + (1-n) = -n + (1+n) \hspace{2cm} (2h) \]

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

To illustrate this, we \textit{first} consider stick (2e) of length \(|2x|\) with grip \(G\) and pointer \(P\). The \textit{trivial} notation with either \(GP\) or inverted \(PG\), i.e. \textit{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) \textit{applies without restriction}, validating the \textit{laws of physics under translation}. A \textit{second} example is the falling cat [10], which rotates with \textit{zero angular momentum} \(\text{a permutation}\) \textit{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 H. 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 \(\alpha_e\) and
\[ x_{\omega_\epsilon}, \text{describing accurately the potential energy curve (PEC) of } X_2 \text{ at } r_0, \text{can only be rationalized with an ionic asymptote at } r=\infty \text{ or dissociation products } X^+ + X, \text{ 2 charge-conjugated ions instead of 2 neutral atoms } X+X \] [12]. So, the H-convention NP violating \( C \) for H at \( r_0 \) using information related to \( r_H=\infty \) 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 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 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
\[ +m(H) = +m(e^-)+ m(p^+) \text{ or } +m_{\text{int}} = m_e + m_p \quad (3a) \]

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\(_{\text{int}}\), 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
\[ +m(\text{anti-H}) = +m(H) = +m(H) = +m(p^-) + m(e^+) \text{ or } +m_{\text{int}} = m_e + m_p \quad (3b) \]

for anti-NP or PN in (2c), allowed by \( C \), is evident. With (3a) and (3b), Dirac inspired annihilative H has a positron bound to an antiproton. Result (3b) is the basis of [4-7] but the dilemma with natural non-annihilative 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 \( r_H=\infty \), we can use a compression instead [13]. Although (3a) is absolutely correct for the unbound state at \( r_H=\infty \), 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),

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whatever n means for symmetries (2). With (2h), this critical state for H is theoretically in
between its two natural allowed H-states

\[ \text{state NP:} +1 = +n + (1-n) \text{ or } +m_p = +m_r + m_x = +m_r - m_x \]  (3c)

\[ \text{anti-state PN:} +1 = -n + (1+n) \text{ or } +m_p = -m_x + (m_x - m_r) \]  (3d)
since, using (3a), +n = +m_r. 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 \(r_H = n^2 r_0\), which allows us to typify \(r_c\) by
a critical value for principal quantum number \(n_c\) since

\[ r_c = n_c^2 r_0 \]  (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). \textit{Multiplicative} Bohr H theory gives energy levels \(E_{nH}\) and terms \(T_{nH}\)

\[ E_{nH} = -R_H/n^2 \]  (5)

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

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

Conceptually, compression along the Coulomb field axis involves \textit{radial velocities}, a problem
neglected in the past \([14]\). Alternative solutions for Bohr’s theory on \textit{radial kinetic energies} are
possible but were left unnoticed \([8b]\). \textit{Radial velocities along the field axis, where 1D permutations (2) can
take place, must be denoted as rotations with zero angular momentum} \([9]\), \textit{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 \textit{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 \textit{the completeness of wave mechanics} if wave
function \(\psi\) for the state of a quantum system is only defined with multiplicative scaling

\[ \psi' = A \psi = a \psi \]  (7)

Here \(a\) is a number and \(A\) a property of a state, believed to be \textit{completely} described by wave
function \(\psi\). One way to comply with the EPR-thesis is \textit{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

\[ -E_{\text{at}} n^2 = R_{\text{H}}(n) \]  

(8a)

and by checking if \( R_{\text{H}}(n) \) are constant [2], as required by (5) [8b]. An extreme \( R_{\text{H}}(n_c) \) 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 \textit{de Broglie}'s standing wave equation \( 2\pi r = n\lambda \), the basis of wave mechanics \[2,18\]. This is also multiplicative but \textit{unlike} (4), \textit{it is linear in} \( n \) \[8b\], and can be rewritten as

\[ \frac{2r}{\lambda} = \frac{n}{\pi} \]  

(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 \( \pi \). A connection between \( n_c \) and \( \pi \) 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

\[ n_c = \frac{\pi}{2} \]  

(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 \( R_{\text{H}}(n) \) is extreme for \( n=1.5 \) [2]. This is close to (9) but \textit{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 \( 180^\circ \), conform (1b). \textit{This conclusion was never reached with QED} [2], as quantum theories rely on integers, half-integers or Heisenberg-numbers like \( \sqrt{\ell(\ell+1)} \).

\textit{Irrational} number \( \pi \) appears naturally in the \textit{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 \( n=\infty \) to \( n=1 \) being the basis for unique state NP or e^+p^+, this convention cannot be validated as critical \( n=\pi/2 \) (9) must be accounted for with symmetries (2a-d). \textit{At} \( n_c \), (9) conventional left NP (3c) changes into right PN, anti-NP: it opens the door for natural non-annihilative H (3d) [2].

The difference between the above symmetries is that C and S use a symmetrical division, whereas (2a) is a \textit{discrete} division in \textit{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 \textit{discrete not continuous symmetries}, whereas the H spectrum and \( R_{\text{H}}(n) \)-values (8) indicate [2] that the transition point is a quadratic \textit{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 $H$ 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 $H$ 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

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

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

$$H_2 = [H(+1)H(-1)] = HH \quad (11)$$

a valid alternative for $S$-based $H(\uparrow)H(\downarrow)$ 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 $H$ [4-7] with the ultimate prospect of also
verifying CPT-elements like (2). As we anticipated [2], the data reported on artificial $H$ [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 1838.1526675$m_e$ [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 $H$ and non-annihilative $H$ are completely different [24], natural non-annihilative $H$ is much more plausible than annihilative $H$. QED.

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