Comment on **Proof that the Hydrogen-Antihydrogen Molecule is Unstable**

by D. K. Gridnev and C. Greiner, Phys Rev Lett **94** 223402 (2005)

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Abstract. *The claim by Gridnev and Greiner that molecule H$\underline{H}$ is unstable cannot be a proof as it is based on a wrong conjecture. This is illustrated with 4 examples, including observed natural hydrogen-antihydrogen oscillations never detected previously.*

The conjecture that *with pure Coulomb forces no bound state of hydrogen-antihydrogen exists* [1] is not absolutely true [2-3], since *pure Coulomb forces* give stable H$\underline{H}$ [4-5]. Linking H$\underline{H}$-stability with (*Jacobi*) mass [1] is ambiguous, as particle mass is related with charge-separation. We give 4 *pure Coulomb effects* favoring natural $\underline{H}$ and H$\underline{H}$ [4,5], which invalidates [1].

(i) *Atom hydrogen-antihydrogen difference*. With relatively accurate Bohr theory, energies of left- and right-handed atoms are *degenerate* since *pure Coulomb forces* are identical for e_1e_2 (H) and e_2e_1 ($\underline{H}$). For Bohr, a distinction is *purely conventional*, meaning that Bohr theory is *achiral*. It is then normal to interpret small errors of *achiral* Bohr theory as *signatures for chiral behavior*, a very simple but overlooked solution. Yet in sophisticated bound state QED, *errors of achiral Bohr theory are explained with a quartic, which is very suspicious* as a quartic for a neutral 2-fermion system points to its *chiral behavior* [4]. *This observed quartic proves that stable $\underline{H}$-states exist* [4], contradicting the basis of [1].

(ii) *Hydrogen-antihydrogen interaction. Pure Coulomb effects* on 4-fermion system stability must be assessed unambiguously before validating [1]. The HH non-relativistic 10 term Hamiltonian $\mathbf{H}_+= \mathbf{H}_0+\Delta\mathbf{H}$ has atomic threshold $\mathbf{H}_0$ and perturbation $+\Delta\mathbf{H}$, consisting of *4 pure Coulomb terms*. Then, H$\underline{H}$ *charge-conjugated* Hamiltonian $\mathbf{H}_-= \mathbf{H}_0-\Delta\mathbf{H}$ would suggest *without proof* that *charge-anti-symmetrical* H$\underline{H}$-states are repulsive, in line with [1], iff *charge-symmetrical* HH-states give *stable* H_2. *Mutually exclusive* $\mathbf{H}_\pm=\mathbf{H}_0\pm\Delta\mathbf{H}$ contradict the Heitler-London convention that stable H_2 is *charge-symmetrical* HH, since it can be *proved* theoretically and experimentally [5a] that stable H_2 is *charge-anti-symmetrical* H$\underline{H}$. Errors with H and H_2 symmetries contradict proof [1], *as both $\underline{H}$ and H$\underline{H}$ exist in nature and are stable* [4-5]. These arguments suffice to flaw [1] but *pure Coulomb effects for H$\underline{H}$* have even more direct implications [5b].

(iii) *Hydrogen-antihydrogen oscillations* [6]. The energy difference δ between states HH and H$\underline{H}$ in (ii) is

$$\delta= \mathbf{H}_0-\Delta\mathbf{H}-(\mathbf{H}_0 +\Delta\mathbf{H})=-2\Delta\mathbf{H} \qquad (1)$$

a *pure Coulomb effect*, involving $\underline{H}$. To make sense, H-$\underline{H}$ oscillations hν must obey *pure Coulomb quantum gap* δ, iff hν=δ. Scaling gap δ gives

$$\delta'=\delta/(e^2/r_0)=-2r_0(-1/r_{bA}-1/r_{aB}+1/r_{ab}+1/r_{AB}) \qquad (2).$$

With $r_{AB}=R$, $r_{aA}=r_{bB}=r_0=0{,}5291$ Å and with the 2 leptons rotating in phase in planes, perpendicular to R, *the pure Coulomb dipole-dipole effect* gives

$$\delta'=\delta/(e^2/r_0)=-4(0{,}5291/R)[1-(1+(0{,}5291/R)^2)^{-1/2}] \qquad (3)$$

a genuine ab initio theoretical result for pure Coulomb long-range effects, with the prospect of detecting H-$\underline{H}$-oscillations.

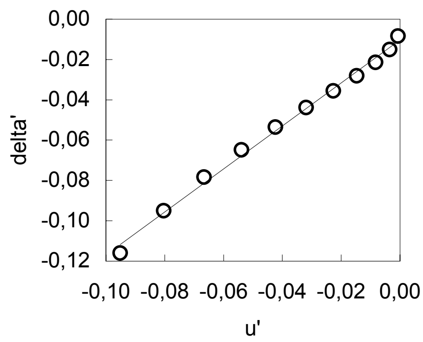

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Fig. 1 δ' vs u'

The H_2 potential energy curve [7] gives *observed long-range behavior,* with energies $u' =(U_\infty-U_R)/(e^2/r_0)$ for 11 outer turning points below the threshold. The linear plot of δ' versus u' in Fig. 1

$$\delta'=1{,}0667u'-0{,}0103 \text{ (fit } R^2=0{,}9945) \qquad (4)$$

is an ab initio proof that H-$\underline{H}$ oscillations occur in nature [5b]. *Pure Coulomb effect* (3) *for stable H$\underline{H}$*, completely neglected in [1], even solves the mystery with H-$\underline{H}$ oscillations (and B-L symmetry breaking) [6]. *With unstable $\underline{H}$*, H-$\underline{H}$ oscillation times are 10^{20} s in the SM [6] (as in [1]). *With stable $\underline{H}$* (as in [4,5]), these are 10^{-15} s, *a common sense but large discrepancy of* 10^{35}!

(iv) *Matter-antimatter asymmetry* [9]. *The pure Coulomb results* (ii-iii) *probing stable H$\underline{H}$ but unjustly disregarded in* [1], can even solve this cosmological problem [9]. The quartic in (i) proves that matter H is different from antimatter $\underline{H}$ [4]. But with (ii)-(iii) it is evident that amounts of matter H and antimatter $\underline{H}$ in *stable* H$\underline{H}$ (H_2) *must be equal for classical stochiometric reasons. Hydrogen being the most abundant species in the Universe, this long-standing difficult problem is simply removed* [5].

We falsify claim [1], inspired by [10-11], *since Coulomb effects (i-iv) prove that 2- and 4-fermion systems $\underline{H}$ and H$\underline{H}$ are natural and stable* [4,5], *instead of unstable* [1].

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