ESTIMATE OF THE POLARIZED ORBITAL MAGNETIC MOMENT OF THE ISOELECTRONIUM IN THE HYDROGEN MOLECULE

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1. THE NEW HADRONIC CHEMISTRY

In preceding articles [1,2] R. M. Santilli and D. D. Shillady have introduced a new covering of quantum chemistry called *hadronic chemistry* which introduces a new strong force due to the deep mutual overlapping of the wavepackets of the valence electrons when in singlet coupling at mutual distances of the order of 1 fm or less. These effects are absent in quantum mechanics and chemistry. The construction of the new isochemistry was permitted by the preceding achievement of the hadronic generalization of quantum mechanics [3,4].

Like hadronic mechanics, hadronic chemistry too has three branches called *iso-, geno- and hyper-chemistry* which are based on new corresponding mathematics called *iso-, geno-, and hypermathematics* constructed for deeper studies of reversible molecular structures, irreversible chemical reactions and multi-valued irreversible biological systems, respectively. In this paper we study molecular structures and, therefore, we shall solely consider isochemistry.

One of the most important applications of these developments in chemistry has been the construction of a basically novel *isochemical model of the hydrogen and other molecules* which is essentially based on the assumption that two valence electrons from two different atoms bond themselves into a singlet quasi-particle state at distances of the order of 1 fm called *isoelectronium*, which orbits around the two nuclei according to the typical *oo*-shaped orbit of planets in binary systems, with the two branches having opposite rotational directions.

The most important characteristics of the Santilli-Shillady isoelectronium are: charge $-2e$, mass $2m_e$ spin 0, magnetic moment 0, and effective radius $6.8432329 \times 10^{-11} cm = 0.015424288\ bohrs$.

The above new model has permitted the apparent resolution of at least some of the insufficiencies of the current model of molecular bonds (see [1,2,5]). The new approach explains the nature of valence bond in molecules, gives numerical representations of binding energies, electric and magnetic moments which are accurate to the seventh digit, and permits accurate thermochemical calculations. Also, it has been proved that computer calculations in isochemistry can converge at least 1,000 times faster than the conventional ones. Due to the opposite directional motion of the isoelectronia in the two *oo*-branches of their orbits, the new isochemical model of molecular structures prevents a net magnetic polarity with a well defined non-null magnetic moments, in agreement with experimental evidence.

2. THE NOTION OF MAGNECULES

A significant application of the new isochemical model of molecular bonds has been the recent theoretical prediction by R. M. Santilli [5] and experimental verification by various independent laboratories on the existence of a *new chemical species*, he called *magnecules* to distinguish them from the ordinary "molecules", where the first term refers to clusters of molecules and atoms under a new bond solely of magnetic type, while the latter refer to clusters of atoms solely under valence bond.

In Ref. [5], Santilli has conjectured that the magnecules originate from the magnetic moments of the *polarized orbits* of the isoelectronia, and cannot be due to other forces, such as the magnetic moments of nuclei (because they are too week and at too large inter-atomic distances) or to electric polarizability because they are also too weak and would not explain the stability of the magnecules).

Note that the intrinsic magnetic moments of the valence electrons do not contribute to the bond here considered because, when bound into the isoelectronium, the valence electrons acquire an identically null total magnetic moment due to their singlet state.

The main point in Santilli's prediction of the magnecules [5] is the following. Orbital magnetic moment of the isoelectronium results to be much bigger than those of nuclei (by reminding again that the intrinsic electron magnetic moment cannot be considered for the isochemical model).

In particular, Santilli [5] has presented the preliminary estimate that the magnetic moment of one *o*-branch of the polarized orbit of the isoelectronium in the hydrogen molecule is 1,316 times bigger than the intrinsic magnetic moment of the hydrogen nucleus (proton)

$$\mu_{isoelectronium}/\mu_{proton} = 1,316. \qquad (1)$$

The above value is important because, in view of its high character, the existence of magnecules is merely consequential. Moreover, the large literature existing in quantum mechanics and chemistry treats nuclear and electron magnetic moments in great details, but does not appear to treat the magnetic moment of the *polarized orbits* of valence electrons (because these orbits generally have a spherical distribution thus without any well defined magnetic orbit). Because of these occurrences, Santilli [5] has solicited an independent verification of value (1).

3. MAGNETIC MOMENT OF THE ISOELECTRONIUM

Without any intent in entering into the merits of hadronic mechanics and chemistry and their applications, the scope of this note is to provide an independent verification of the important numerical value (1) and to initiate its more accurate calculation. In fact, due to the magnitude of ratio (1), our verification can provide evident credibility to the existence of Santilli's magnecules, and their applications currently under way at various industries (see, e.g., Web site [6]). Our calculations are also preliminary and in need of various refinements due to complex orbital effects and other aspects. The latter more refined calculations are under study and they will be presented in a subsequent paper.

As indicated earlier, the total intrinsic magnetic moment of the two valence electrons $\vec{\mu}_S$ is zero in the singlet state of the isoelectronium. For this reason the only non-vanishing magnetic moment of the isoelectronium arises from its orbital motion as a particle of charge $-2e$.

In this section we estimate the orbital magnetic moment $\vec{\mu}_L$ for such system. We compare numerically two entities, the isoelectronium magnetic moment $\mu_L = |\vec{\mu}_L|$ and the nuclear magnetic moment μ_N for the case of the hydrogen atom.In this case, the latter is evidently the magnetic moment of the proton.

We estimate numerically the orbital magnetic moment caused by a particle of charge $-2e$, spin zero and zero intrinsic magnetic moment moving in the state with non-vanishing momentum in the H^--like atom.

Let us consider the model of two particles system with charges $q = -2e$ and $Q = +e$ and masses $2m$ (m is mass of electron) and M (mass of proton), respectively. If the system is bounded into an atom, i.e. full energy E of system is negative, $E < 0$, then each particle moves on closed paths (in this first study assumed to be a circle for simplicity with corrections studied in future papers).

The magnetic moment μ of charged particle is, by definition,

$$\frac{1}{2c}q[\vec{r},\vec{v}], \tag{2}$$

where $\mu = \vec{v}$ is 3-velocity of the particle $(q, 2m)$, square parentheses $[,]$ denotes vector product, and c is velocity of light in vacuum. Then, for the case of the isoelectronium, we have

$$\mu_L = \frac{q}{4mc}|[\vec{r},\vec{p}]|. \tag{3}$$

Here, $\vec{p}$ is momentum of the particle $(-2e, 2m)$. It can be easily shown that the velocity $\vec{v}$ is equal to velocity of the electron, $v_e = p_e/m$ in the hydrogen atom, but its momentum p is twice that of the electron p_e. We assume that $r = r_B$, where the radius of first Bohr's orbit, $r_B = 0.529 \cdot 10^{-8}$ cm. Elementary calculations give the value

$$\mu_L = 1.854 \cdot 10^{-20} erg/Gauss. \tag{4}$$

.

Let us note that if orbital momentum $L = |[\vec{r},\vec{p}]| = 2\hbar$, then for the magnetic moment μ_L of the particle (-2e, 2m) we obtain, again, the value $1.854 \cdot 10^{-20}$ erg/Gauss. Then the value μ_L is expressed in terms of Bohr's magneton, $\mu_B = e\hbar/(2mc)$, where $\hbar = 1.055 \cdot 10^{-27}$ erg·s is the Dirac action constant. We obtain in this way again value (4), i.e.,

$$\mu_L = 2\mu_B = 2 \cdot 0.927 \cdot 10^{-20} = 1.854 \cdot 10^{-20}\text{erg/Gauss}. \tag{5}$$

Now we compare μ_L to the intrinsic magnetic moment μ_N of the roton for which we have $\mu_N = 2.793 \cdot 5.05 \cdot 10^{-24} \approx 1.41 \cdot 10^{-23}$ erg/Gauss. The ratio μ_L/μ_N is then equal to $\mu_L/\mu_N = 1314.8 \approx 1315$. More accurately, we can obtain this value via the expression

$$\mu_L/\mu_N = \frac{2 \cdot e\hbar/(2mc)}{(5.5855/2)e\hbar/(2Mc)} = \frac{4}{g}\left(\frac{M}{m}\right), \tag{6}$$

where g=5.5855 is well known g-factor of the proton and $M/m = 1836$. Then, we have

$$\mu_L/\mu_N = 1836 \cdot 4/5.5855 = 1,314.8 \tag{7}$$

which is very close to value (1) obntained by Santilli, Ref. [5], Eq. (2.9), p. 803.

If we take into account magnetic moment of the proton, μ_N^{orbit}, arising from its orbital motion around the center of mass for the (electron + proton) system, we obtain the ratio μ_L/μ_N^{orbit} as squared ratio of mass of proton to mass of electron, namely,

$$\frac{\mu_L}{\mu_N^{orbit}} = \left(\frac{M}{m}\right)^2. \tag{8}$$

Taking into account that M/m=1836 we get

$$\mu_N^{orbit}/\mu_N = 4(m/M)/g = 0.716(m/M) \approx 3.9 \cdot 10^{-4} \ll 1 \tag{9}$$

. Hence, the resulting total magnetic moment of proton is $\mu_N + \mu_N^{orbit} \approx \mu_N \approx 1.4 \cdot 10^{-23}$ erg/Gauss. We obtain in this case the value

$$\mu_L/\mu_N \approx 1,315 \tag{10}$$

which is also very close to value (1).

Our study therefore confirms that the magnetic moment of the polarized orbits of a particle with charge $-2e$, spin zero and magnetic moment zero in the ground state of the hydrogen atom is

$$\mu_L = 1.854 \cdot 10^{-20} erg/Gauss, \tag{11}$$

which results to be 1,315 times *bigger* than the intrinsic magnetic moment of the proton, $\mu_N \approx 1.41 \cdot 10^{-23}$ erg/Gauss.

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