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BEGGING THE QUESTIONS

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Abstract. In physics we are sometimes confronted with situations that obviously raise some questions. But too often we just don't see the obvious questions. Accepted paradigms just blind us. This paper takes note of several example situations and the questions they obviously raise: **1)** The 'shell' structure of the Periodic Table of the chemical elements is not matched by the 'radial quantum number states' offered by Quantum Mechanics. **2)** Spectral lines are characterized in part by the so-called Rydberg factor, which involves the square of the naked nuclear charge, showing *no* effect of nuclear shielding by inner electron shells. **3)** In some situations, like charges sometimes seem to cluster together, contrary to prevailing theories about electromagnetics. **4)** The so-called 'arrow of time' seems to conflict with the apparent time-reversibility of so many equations in physics. Some candidate explanations for such anomalies are developed within the context of simple Galilean, non-relativistic theory.

Introduction

A scientific anomaly is generally some sort of mismatch between behavior actually observed, as compared to behavior expected on the basis of a currently accepted paradigm concerning physical reality. Anomalies are inherently important for challenging and advancing, or at least altering, our understanding of physical reality. Some important historical examples illustrate this fact:

1) In the world of astronomy, the extreme complexity of the Earth-centered Ptolemaic system in dealing with planets drove Copernicus to think of a Sun-centered system instead. The sun spots observed by Galileo exploded the then-prevalent idea of celestial perfection. That opened the way for Kepler to think of orbits that were ellipses, rather than perfect circles or epicyclical nests of circles. It further opened the way for Newton to think in terms of deviations evolving in time rather than patterns held eternal, and so to come up with his force law. The universal character of Newton's law of gravitation invited all sorts of subsequent generalizations.

2) In the complicated world of electricity and magnetism, Coulomb formulated a law for interaction between charges that was in close analogy to Newton's law of gravitation. Ampère's law for current elements was only slightly more complicated. But the two phenomena, electricity and magnetism, remained separate; an anomaly in the context of Newton's quest for universality. Then Maxwell brought the two phenomena together. His unified theory involved an aether, quaternions, and integral equations. The complexity this theory invited more Newton-like reformulations. Hertz and Heaviside developed reformulations in terms of vectors and differential equations. Einstein expunged the aether aspect of it with his special relativity theory (SRT).

3) In the world of matter and heat, the defining anomaly was blackbody radiation. As described by Maxwell, radiation would consist of waves, and confined within a cavity, the wavelengths would be confined to discrete values fitting between the walls. But the number of wavelengths allowed would nevertheless be countably infinite, and waving them all with democratically equal amplitude would take infinite energy (the so-called ultra-violet catastrophe). The real blackbody spectrum was nothing like that. Short wavelengths, or high frequencies, were clearly disfavored. Planck explained the reality in terms of thermodynamics/statistical-mechanics, associating frequency to energy by a constant *h*. The logic was inverted by Born, using the same constant *h* to define the allowed wavelengths, not for a cavity, but rather for the interior of an atom. Thus we came to quantum mechanics (QM).

Today we still have anomalies left to resolve. The Abstract mentions three of them. All anomalies are worth studying for their possible stimulation of progress. The following paragraphs explain what the three listed anomalies really amount to, and where they may take us if we pay attention.

The Periodic Table

The Periodic Table is a two-dimensional display of information about chemical elements, the elements being arranged in order of increasing nuclear charge, and separated into rows such that members of columns all have similar chemical properties. First conceived by Mendeleev, the Periodic Table predates relevant modern physics, especially QM. By the time QM was invented, the forefront of scientific advance was perceived to lie not in chemistry *per se*, but rather in spectroscopy. Spectroscopy was data-rich, reliably repeatable, and clean. Chemistry was recalcitrant, dirty and wet. As a result, the Periodic Table got retrofitted with the QM atomic states. But the fit is poor, and as yet the poor fit has not been attended to.

Figure 1 shows an abbreviated Periodic Table. The main thing to note is the pattern followed by the lengths of rows. The row lengths are: 2, 8, 8, 18, 18, 32. If the last row went to completion, it would probably also have length 32. The pattern is clearly row length equal to $2n^2$ for $n = 1, 2, 2, 3, 3, 4...$, *etc*.

The atomic states offered by QM follow a different pattern. The quantum states are distinguished first by radial quantum number $n = 1, 2, 3, 4...etc$. Then for each quantum number *n*, there are states for angular momentum quantum number $l = 0,1,...,n$. Then for each quantum number l, there are states for spin quantum number $s = \pm 1/2$. So for given *n*, there are $2n^2$ states. And then the set of all quantum states follows the pattern $2n^2$ for $n = 1,2,3,4...$, *etc*. This comes to 2, 8, 18, 32, 50..., *etc*.

H_1	**Periodic Table of the Elements**	He_2	
Li_3	. . . . . .	Ne_{10}	=2+8
Na_{11}	. . . . . .	Ar_{18}	=10+8
K_{19}	. . . .	Kr_{36}	=18+18
Rb_{37}	. . . .	Xe_{54}	=36+18
Cs_{53}	. . . .	Rn_{86}	=54+32
Fr_{87}	. . . . ???		

Figure 1. Periodic Table. Annotations on the right side call attention to lengths of rows.

The pattern of the Periodic Table is usually interpreted as implying successive atomic 'shells', occupied by electrons numbering 2, 8, 8, 18, 18, 32. One might well think there ought to be some correlation between a 'shell' and a radial quantum number. But clearly, the 'shell' structure of the periodic table of the chemical elements is simply not matched by the 'radial quantum number states' offered by Quantum Mechanics. Attempting to match them up produces a most complicated mess.[1]

One might reasonably expect that as one goes to higher atomic number, the standard quantum states would get filled up in order of energy. But in fact, the filling sequence some-

[1] See, for example, H. Semat, Introduction to Atomic and Nuclear Physics, Chapter 8, Table 8-1 (Rinehart & Co., Inc., New York, 1960).

times jumps around, so the $l=0$ states for some $n+1$ start filling before the $l=2$ or 3 states for n are done filling. This happens for $n = 3, 4, 5, 6$, and probably would continue that way if there were more stable elements. Also, the filling order can be go $l=0$, then $l=2$, then $l=1$, then $l=3$. As for $l>3$, those states never fill at all.

This is a mess. We seem to be in need of additional ideas about the Periodic Table.

Spectroscopy Speaks

In spectroscopy, the spectral lines that occur are characterized in part by the so-called Rydberg factor[2] $R_\infty = \dfrac{2\pi^2 me^4}{ch^3}\dfrac{Z^2}{1+m/M}$, where m is electron mass, M is nuclear mass, and Z is nuclear charge. The important part for the present argument is the involvement of the nuclear charge Z. There are tiny corrections and adjustments to that, but nothing major that would correspond to the effect of the nucleus being shielded by inner electron shells. Spectral lines act as if the nucleus were naked, like a cluster of positive charges, and the electrons too were a spatially separated cluster of negative charges.

This observation from spectroscopy suggests that the conventional view of the Periodic Table, with electron shells, partially filled for most elements and completely filled for noble gasses, could be wrong. Again, we seem to be in need of new ideas about the Periodic Table.

Anomalous Attraction

In Galilean Electrodynamics, we have occasionally had reports and commentary about a most unusual phenomenon: apparent clustering together of electrons.[3,4,5] The phenomenon is widely known; related literature cited in the third of those references is quite extensive, and some of it appears in the most widely circulated physics journals. But the task of explaining electron clustering is far from trivial. The problem is that, on elementary grounds, charges of the same sign are supposed to repel. That is just Coulomb's law. So explaining

[2] See, for example, H. Semat, Introduction to Atomic and Nuclear Physics, Chapter 7, Section 3 (Rinehart & Co., Inc., New York, 1960).

[3] P. Beckmann, "Electron Clusters", Galilean Electrodynamics **1**, 55-58 (1990); see also **1**, 82 (1990).

[4] H. Aspden, 'Electron Clusters' (Correspondence) Galilean Electrodynamics **1**, 81-82 (1990).

[5] M.A. Piestrup, H.E. Puthoff & P.J. Ebert, "Correlated Emissions of Electrons", Galilean Electrodynamics **9**, 43-49 (1998).

the observed facts requires some other effect that could work in opposition to Coulomb repulsion. So we seem to be in need of additional ideas about anomalous attraction.

The Arrow of Time

Since the time of Newton, differential equations have been a standard way of modeling physical interactions. The typical equations involve only second derivatives with respect to time. Solutions for such equations are reversible with respect to time: a solution $\mathbf{r}(t)$ is no more preferred than $\mathbf{r}'(t) = \mathbf{r}(-t)$. This reversibility has seemed at odds with the apparent irreversibility of the macroscopic physical world: scenarios generally seem to evolve toward greater entropy, and not the other way around. On the macroscopic scale, the Universe seems always to expand. One a lesser, more human scale, all materials we know - familiar gasses, liquids, and solids - are described by the equations of statistical mechanics and follow the laws of thermodynamics. Only on the most microscopic scale do things seem potentially reversible: atoms emit and atoms absorb light, and those processes seem to be the same but for time reversal.

There is a mystery here. We do not know where or why reversible time degenerates into irreversible time. The mystery has stimulated much deep thought. A whole area of research related to time was initiated here in Russia by N.A. Kozyrev, and is commemorated in several published and forthcoming issues of GED-East.[6] There is still much research on-going, and though there are many questions pending, the one I cite today is: We seem to remain in need of additional ideas about the arrow of time.

Candidate Ideas

There are plenty of anomalies in the world, but I chose to discuss only the few of them mentioned above, because those particular ones seem to knit together into one candidate coherent story, as recounted below.

Radiation Reaction

Whenever an electromagnetic charge accelerates, or a gravitational mass accelerates, radiation is created. Radiation carries energy away into space, so radiation is an energy loss mechanism for the source. It must put a dragging reaction term into whatever differential equation describes the motion of the source charge or mass. A drag term generally involves

[6] Galilean Electrodynamics and GED-East, joint Special Issues for Spring and Fall of 2000, and beyond.

an odd derivative with respect to time, so it is *not* time reversible. That means we may have been quite wrong to suppose that *any* of the differential equations of physics are in fact time reversible.

However, achieving a mathematical description for radiation reaction is a far from trivial task. The problem lies with so-called runaway solutions to equations implementing Newton's law (see Jackson[7]). The problem with a runaway solution is that it seems to defy the 'arrow of time', and potentially on a scale that is far from microscopic.

The argument goes as follows. We have $\mathbf{F} = m\mathbf{a}$, where **F** is force, m is mass, **a** is acceleration, $\mathbf{a} = d\mathbf{v} / dt$, **v** is velocity, t is time. Such an equation implies a time rate of change of energy along a path, described by power $\mathbf{P} = \mathbf{F} \cdot \mathbf{v}$. In the case of a charge e moving in an electric field **E**, there is a driving force $\mathbf{F} = e\mathbf{E}$, making an energy gain $P_e = e\mathbf{E} \cdot \mathbf{v}$, and there is an energy loss due to radiation power $P_r = 2e^2 a^2 / 3c^3$. The factor $2e^2 / 3c^3$ is often abbreviated $m\tau$, where τ is a characteristic time. The total power is $P = P_e - P_r =$ $e\mathbf{E} \cdot \mathbf{v} - m\tau a^2 = m\mathbf{a} \cdot \mathbf{v}$. Two terms there are conveniently of the form "$\ldots \cdot \mathbf{v}$" from which one can infer at least the important component of force. But $m\tau a^2$ is not in the right form; to change it to that form, one invokes integration by parts:

$$\int a^2 dt = \int \mathbf{a} \cdot d\mathbf{v} = \mathbf{a} \cdot \mathbf{v}\Big|_{\text{limit}\,1}^{\text{limit}\,2} - \int d\mathbf{a} \cdot \mathbf{v} = \int \mathbf{v} \cdot \mathbf{j} dt$$

where **j** is 'jerk', $\mathbf{j} = d\mathbf{a} / dt$. Then one asserts a reason to justify $\mathbf{a} \cdot \mathbf{v}\Big|_{\text{limit}\,1}^{\text{limit}\,2} = 0$. For example, one asserts '**a** is always orthogonal to **v** so $\mathbf{a} \cdot \mathbf{v} = 0$ ', or '$\mathbf{a} \cdot \mathbf{v}$ is constant', or 'the system goes through cycles, so there exists a time interval such that $\mathbf{a} \cdot \mathbf{v}$ is the same at both limits'. The power equation then reads $P = e\mathbf{E} \cdot \mathbf{v} + m\tau\mathbf{j} \cdot \mathbf{v} = m\mathbf{a} \cdot \mathbf{v}$, from which one can guess $\mathbf{F} = e\mathbf{E} + m\tau\mathbf{j} = m\mathbf{a}$. Supposing there is no **E** at all, the force equation implies $\tau d\mathbf{a} / dt = \mathbf{a}$. One solution is perfectly reasonable: $\mathbf{a} = \mathbf{a}_{ok} \equiv 0$. But there is also another solution, and it is questionable: $\mathbf{a} = \mathbf{a}_? = \mathbf{a}_0 \exp(t / \tau)$, where $\mathbf{a}_0$ is the acceleration at $t = 0$, which can be nonzero if $t = 0$ is, for example, when **E** turns off, or the charged particle is kicked. This questionable solution gets bigger and bigger as time goes by; it is the runaway solution.

There is, however, a counter-argument to the above conventional argument about runaway solutions. The counter-argument hinges on the condition $\mathbf{a} \cdot \mathbf{v}\Big|_{\text{limit}\,1}^{\text{limit}\,2} = 0$. If $\mathbf{a} = \mathbf{a}_? = \mathbf{a}_0 \exp(t / \tau)$, then $\mathbf{v} = \mathbf{v}_0 + \int \mathbf{a} dt = \mathbf{v}_0 + \mathbf{a}_0 \tau (e^{t/\tau} - 1)$. For t big enough,

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7 J.D. Jackson, **Classical Electrodynamics**, Second Edition, Chapter 17 (John Wiley & Sons, New York, Chichester, Brisbane, Toronto, Singapore, 1975).

$\mathbf{a}\cdot\mathbf{v}\to a_0^2\tau e^{2t/\tau}$. This is monotonically increasing, and so is inconsistent with $\mathbf{a}\cdot\mathbf{v}\big|_{\text{limit 1}}^{\text{limit 2}}=0$. It is, therefore, impossible to have $\mathbf{a}=\mathbf{a}_?$ except if $\mathbf{a}\neq\mathbf{a}_?$, a contradiction.

A Different Approach

A potentially better approach to examining the two solutions with radiation reaction is to revert to the equation before integration by parts: $e\mathbf{E}\cdot\mathbf{v}-m\tau a^2=m\mathbf{a}\cdot\mathbf{v}$. This is a quadratic equation in the component of **a** along **v**, a_v: $Aa_v^2+Ba_v+C=0$, with $A=m\tau$, $B=mv_a$ (the v_a being the component of **v** along **a**), and $C=-e\mathbf{E}\cdot\mathbf{v}$. The quadratic equation has solutions $a_{v\pm}=\dfrac{-B\pm\sqrt{B^2-4AC}}{2A}$. That is, $a_{v\pm}=\dfrac{-mv_a\pm\sqrt{(mv_a)^2+4m\tau e\mathbf{E}\cdot\mathbf{v}}}{2m\tau}$.

Assuming that **E** is small, power series expansion can be used to evaluate the square root in $a_{v\pm}$. In general

$$(x+y)^n\approx x^n+nx^{n-1}y+\frac{n(n-1)}{2}x^{n-2}y^2+\frac{n(n-1)(n-2)}{2\times 3}x^{n-3}y^3\ldots$$

In particular, with $x=(mv_a)^2$, $y=4m\tau e\mathbf{E}\cdot\mathbf{v}$, and $n=1/2$, one has

$$\sqrt{(mv_a)^2+4m\tau e\mathbf{E}\cdot\mathbf{v}}\approx mv_a+\frac{1}{2}\frac{4m\tau e\mathbf{E}\cdot\mathbf{v}}{mv_a}-\frac{1}{8}\frac{(4m\tau e\mathbf{E}\cdot\mathbf{v})^2}{(mv_a)^3}+\frac{1}{16}\frac{(4m\tau e\mathbf{E}\cdot\mathbf{v})^3}{(mv_a)^5}\ldots$$

So for the first one of the two solutions,

$$a_{v+}\approx\frac{e\mathbf{E}\cdot\mathbf{v}}{mv_a}-\frac{(e\mathbf{E}\cdot\mathbf{v})^2m\tau}{(mv_a)^3}+2\frac{(e\mathbf{E}\cdot\mathbf{v})^3(m\tau)^2}{(mv_a)^5}\ldots$$

The first term here is consistent with the baseline expected $\mathbf{a}=e\mathbf{E}/m$. The second term does fight against **E**, and can be interpreted as some sort of radiation reaction. But it goes away if **E** goes away. The third term is negligible. Altogether, this is a normal, well-behaved solution.

The other one of the two solutions is

$$a_{v-}=-\frac{v_a}{\tau}-\frac{e\mathbf{E}\cdot\mathbf{v}}{mv_a}+\frac{(e\mathbf{E}\cdot\mathbf{v})^2m\tau}{(mv_a)^3}\ldots$$

With no **E**, this solution comes to $a_{v-} = -v_a / \tau$, and supposing **a** and **v** to be parallel, it implies $d\mathbf{v} / dt = -\mathbf{v} / \tau$, or $\mathbf{v} = \mathbf{v}_0 \exp(-t / \tau)$. This solution also is no run-away; if anything, it is instead a *capture* solution. It tends to suppress any relative velocity that may exist between interacting bodies. It thereby holds the bodies at some steady stand-off range.

With no runaway solution at all, there is no conflict with the arrow of time. The second radiation reaction solution is, however, of considerable interest. In suggesting a capture phenomenon, it offers a candidate explanation for phenomena such as electron clustering.

Clustering in Atoms

So suppose that in the atom we haven't got electron shells at all; suppose they have electron clusters instead. At the very least, the pattern of the Periodic Table offers a clue as to what those clusters must look like. To fit the $2n^2$ for $n = 1, 2, 2, 3, 3, 4...$ pattern, the clusters must not be amorphous, they must not be spherical; they must be dumbbell shaped. They are made up from building blocks illustrated in side view by Figure 2 (a) through (d) for $n = 1, 2, 3, 4$. They stack together as illustrated by Figure 2 (e).

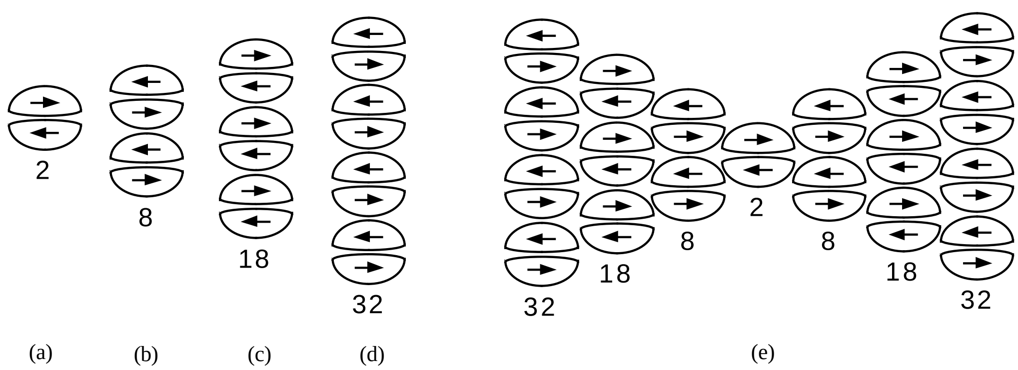

Figure 2. Clusters. Building blocks (a) through (d) correspond to *n*=1,2,3,4. (e) shows dumbbell-shaped stack corresponding to the electron cluster in a heavy atom.

Two-Step Light

In modern quantum electrodynamics, electromagnetic forces are envisioned as being carried by so-called virtual photons. One supposes that virtual photons are somewhat like real ones, at least in regard to propagation directions and times. The conventional model for light, whether as photons or waves, assumes steady, linear propagation across space, characterized by a constant *c*.

At the last Conference in St. Petersburg, I presented a paper arguing for a new model for light propagation.[8] The new model acknowledges two steps: expansion from a source, followed by collapse to an absorber. At no time during the two-step process is the light spatially localized to a progressing particle or wavefront. Each step is characterized by a constant $2c$; note the 2. It means that the center of attraction (*i.e.* opposing particle) is seen in position retarded by distance times $v/2c$. In an atom, the electron cluster sees the nucleus in retarded position, and *vice versa*, the nucleus sees the electron cluster in retarded position.

The conventional idea about the center of attraction is quite different. The pre-Einsteinian model developed at the turn of the century by Liénard and Wiechert[9] includes some factors that essentially expunge the retardation, making the center of attraction almost the present but unknowable position of the source. The validity of this model has been challenged extensively.[10]

Energy Gain

The new model means that the attractive forces in an atom are *not* central. The system has torques on it. The result is a rate of energy gain to the system, which is inconsistent with Newtonian mechanics. But Newtonian mechanics has instantaneous action at a distance, whereas electrodynamics has finite interaction speed. This makes a big difference.[11] One way to understand the situation is to recognize that finite interaction speed implies fields, and fields can be repositories for energy, momentum, angular momentum, *etc*. Conservation of any kind works out only if one includes the fields in the inventory. If one looks only at particles, conservation will fail.

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[8] C. Whitney, "Re-Doing Relativity in Light of New Data", pp. 177-189 in Proceedings of V International Conference on Probems Space Time and Motion, 1998; published 1999.

[9] For a discussion that is English-language and modern, see J.D. Jackson, **Classical Electrodynamics**, Second Edition, Chapter 14 (John Wiley & Sons, New York, Chichester, Brisbane, Toronto, Singapore, 1975).

[10] See, for example, C. Whitney, "A Gedanken Experiment with Relativistic Fields" and references cited there, Galilean Electrodynamics **2**, 28-29 (1991).

[11] See, for example, P. Cornille, "Newton's Third Principle in Post-Newtonian Physics: Part I: Theory, and Part II: Interpretation and Experiment", Galilean Electrodynamics **10** (3) 43-49 (1999) and **11** (4) 69-73 (2000).

Consider the hydrogen atom. Torque is generally $\mathbf{T} = \mathbf{r} \times \mathbf{F}$. For the torque on the electron, you've got $\mathbf{T}_e = \mathbf{r}_e \times \mathbf{F}_e$ where $\mathbf{F}_e$ has magnitude $e^2 / (r_e + r_p)^2$. With two-step light, the direction of $\mathbf{F}_e$ is half-retarded, and hence rotated from the direction $\mathbf{r}_e$, by thesmall angle $\frac{v_p}{2c} = \frac{m_e}{m_p}\frac{v_e}{2c}$. Altogether ,$\mathbf{T}_e$ is normal to the orbit plane and has magnitude $T_e = r_e \frac{e^2}{(r_e + r_p)^2}\frac{m_e}{m_p}\frac{v_e}{2c} = \frac{r_e e^2}{(r_e + r_p)^2}\frac{m_e}{m_p}\frac{v_e}{2c}$.

There is also torque on the proton. Where the light particle, the electron, sees a tiny tangential force, but has a large orbit, the heavy proton, sees a large tangential force, but has a tiny orbit. So the proton ends up seeing the *same* torque as the electron; that is, $\mathbf{T}_p = \mathbf{r}_p \times \mathbf{F}_p = \mathbf{r}_e \times \mathbf{F}_e$. The system overall sees total torque $\mathbf{T} = \mathbf{T}_e + \mathbf{T}_p$ of magnitude $2T_e$. The torque implies energy gain at the rate $P_T = T\Omega$. With $\Omega = \frac{v_e}{r_e}$, $P_T = \frac{e^2}{(r_e + r_p)^2}\frac{m_e v_e^2}{m_p c}$. Using the Virial theorem to substitute $m_e v_e^2 = \frac{e^2}{r_e + r_p}$, one finds $P_T = \frac{e^4}{m_p c (r_e + r_p)^3}$.

Energy Loss

In addition, the fact that $\mathbf{F}_p \neq \mathbf{F}_e$ means the center of mass must execute an orbit too, on top of what the individual particles do. So even as absolute temperature goes to zero, the system inherently retains some version of 'zero-point motion'. The center of mass does not affect the torquing power into the system, but it does contribute to radiation losses. If the center of mass of the hydrogen atom were fixed, the radiation power P_R would be mainly from the electron, and would amount to $P_e = m\tau a_e^2 = \frac{2e^2}{3c^3}\left[\frac{e^2}{m_e (r_e + r_p)^2}\right]^2$. With the center of mass moving too, there is more radiation. The amount can be estimated as follows: we know from the experimental fact of electron anomalous magnetic moment that the orbit frequency 'seen' by participants in a two-body system is only half the orbit frequency 'seen' by an external observer. That suggests radiation should be based on $\Omega' = 2\Omega_e$. That means the effective acceleration is $a' = 2^2 a_e$, and $P_R = 2^4 P_e = \frac{2^5 e^6}{3c^3 m_e^2 (r_e + r_p)^4}$.

Balance

For steady state, the energy loss due to radiation has to balance the energy gain due to torquing; that is, $P_R = P_T$, or $\frac{2^5 e^6}{3c^3 m_e^2 (r_e + r_p)^4} = \frac{e^4}{m_p c (r_e + r_p)^3}$. This equation of balance can be solved for $r_e + r_p$, yielding $r_e + r_p = 32 m_p e^2 / 3 m_e^2 c^2$. This comes to 5.5×10^{-9} cm. One can compare this approximation for $r_e + r_p$ to the accepted value for r_e,, 5.28×10^{-9} cm; close, though not perfect consistency.

Planck's Constant

The more interesting point is that according to conventional quantum mechanics, r_e is supposed to be evaluated by $r_e = h^2 / 4\pi^2 \mu e^2$, where h is Planck's constant, presumed to be a Fundamental Constant of Nature, and $\mu = m_e m_p / (m_e + m_p)$ is the classical reduced mass for the system. The important thing is that, since r_e can be obtained from a different formula, $r_e \approx r_e + r_p = 32 m_p e^2 / 3 m_e^2 c^2$, it is suggested that Planck's constant is not necessarily fundamental.

Excited States

The conventional idea about the so-called 'excited states' of an atom involves a single electron teetering in an upper shell, ready to fall back to a lower shell with an available opening. An atom model featuring electron clusters rather than electron shells requires a very different idea. A clue lies in the known fact that light emission is always a little bit laser-like: photons get emitted not as singletons, but rather in bursts.[12] It suggests that atoms get excited not as singletons, but as groups. For example, suppose 'excitation' of the hydrogen to quantum number *n* involves *n* atoms all working in some coherent way. In particular, suppose the *n* electrons make one cluster, and the *n* protons make another cluster, and the two cluster make a scaled-up super hydrogen atom.

The replacement of single particles with clusters must affect both the torquing and the radiation reaction, and the balance between them. It affects the torquing power because each electron or proton accelerates as if it were driven by a force created by *n* protons or *n* elec-

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[12] J.P. Wesley, **Classical Quantum Theory**, Chapter 7 (Benjamin Wesley, Weiherdammstrasse 24, 78176 Blumberg Germany 1996).

trons, respectively. Starting with $P_T = \dfrac{e^4/2}{m_p c\,(r_e + r_p)^3}$ per-particle, scaling m_p and each factor of e^2 by *n*, ones find the per-particle torque power scales by $n^2 / n = n$, or n^2 for the system. The replacement affects the radiation power because every factor of e and every factor of *m* scales by *n*. Starting from $P_R = \dfrac{64 e^2}{3c^3}\left(\dfrac{e^2}{m_e (r_e + r_p)^2}\right)^2$ for the system overall, one finds the system radiation scales by n^4, or n^3 per particle. The solution radius then scales by $\dfrac{\text{radiationscale}}{\text{torquingscale}} = \dfrac{n^4}{n^2} = \dfrac{n^3}{n} = n^2$. So $r_e + r_p \rightarrow n^2 (r_e + r_p)$.

Summary

In present day science, we really do have some inconsistencies to confront, including (but not limited to) the following: **1)** The Periodic Table of chemical elements demands something different from shells related to radial quantum numbers. **2)** The naked nuclear-charge dependence of spectral lines seems to demand no shells at all. **3)** Nature offers clusters, but they aren't well understood. **4)** The arrow of time demands some explanation.

To resolve these inconsistencies, we really do have explanation opportunities available: **1)** Radiation reaction provides irreversibility. **2)** A new analysis of radiation reaction eliminates an inconsistency in the standard analysis and provides an explanation for clustering. **3)** The Periodic Table suggests a picture for clusters in atoms. **4)** Two-step light propagation implies that an atom has not only energy loss due to radiation, but also energy gain due to torquing. **5)** Balance between energy loss and energy gain predicts the ground state of the hydrogen atom without recourse to Planck's constant. **6)** Excited states can be explained through clustering of multiple atoms.

The explanations involve some heresies. **1)** There are no familiar atomic 'shells'; there are clusters instead. **2)** There is a previously unrecognized process allowed in an atom built with an electron cluster: torquing. **3)** Model results are consistent with results from conventional quantum mechanics, but the model itself is *not* consistent with the Copenhagen interpretation: It is not talking about a single atom; involves multiple atoms at its very heart.

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