FRACTAL PHYSICS THEORY - ELECTRONS, PHOTONS, WAVE-PARTICLES, AND ATOMIC CAPACITORS

LEONARD J. MALINOWSKI

BASF Dispersions and Resins
Monaca, Pennsylvania, USA

Abstract

This third article, in a series of five, applies Fractal Physics Theory to electron. The magnetic dipole moment of a cosmic scale electron is obtained from known properties of ordinary matter. Fractal Physics Theory (FPT) considers electrons to be composed of 10^{52} subquantum scale iron atoms with an excess of 10^{40} subquantum scale electrons. Like all human scale matter, the fractal electron is proposed to exist in solid, liquid, gaseous and plasma phases. This provides insight into the wave-particle duality of quantum particles. FPT considers a photon to be composed of 10^{80} subquantum scale photons. The initial and final states of atomic absorption and atomic emission have long been understood and described by Quantum Mechanics. This article illustrates the process occurring between these initial and final states in spatial and temporal resolution. Hydrogen atom's discrete spectra are reproduced from transitions occurring between atomic spherical capacitors. The capacitor is formed from a vaporized and delocalized electron that has a proton center and outer shell of subquantum scale (sqs) electrons. It temporarily stores the absorbed photon energy in its electric field.

1. Fractal Electron

1.1. Electron composition and bulk properties

The first two articles of the Fractal Physics Theory series provide essential

background information [1, 2]. The electron's mass, electric charge, magnetic dipole moment, and spin are examined from the Fractal Physics perspective. The most energetically stable nuclei such as Iron and Nickel are considered the primary materials comprising the cosmic scale electron. Iron, Nickel, and to a lesser extent Cobalt all have the unique duel distinction of being both stellar thermonuclear endpoints and when cool enough, ferromagnets. The familiar electron properties listed in Table 1 are directly scaled up to obtain the cosmic scale (cs) electron properties. However, the electron's composition, shape, and properties derived there from, are scaled down from the cs-electron. The cosmic scale electron's core composition is idealized to match Earth's isotopic Iron, while its density is idealized to match an Earth core density of $12580 \, \text{kg}/\text{m}^3$.

Table 1. Fractal electron properties

Observables	Object Scale Location	
Measured in the Human Scale	Cosmic	Quantum
Mass (kg)	1.0835913×10^{27}	$9.1093826 \times 10^{-31}$
Charge (C)	$-3.40123056 \times 10^{21}$	$-1.60217653 \times 10^{-19}$
Spin, S_z (Js)	$2.376279513 \times 10^{46}$	$5.272858412 \times 10^{-35}$
Magnetic moment, μ_z (J/T)	$-7.467434623 \times 10^{40}$	$-9.284764116 \times 10^{-24}$
Density (kg/m³)	12580	5.7508047×10^{17}
Volume (m³)	8.6136033×10^{22}	$1.5840188 \times 10^{-48}$
Radius (m)	2.7396731×10^{7}	$7.2314253 \times 10^{-17}$
Surface area (m²)	9.4320777×10^{15}	$6.5713966 \times 10^{-32}$
Electric field at surface (N/C)	4.0726772×10^{16}	2.7536197×10^{23}
Magnetic field at poles (T)	1.2579571×10^{12}	8.5053036×10^{18}
Gravitational field at surface (m/s²)	96.35	3.650×10^{25}
Composition of sphere	1.1685062×10^{52} Iron atoms, coated with superconducting Lead, 2.1228813×10^{40} excess electrons	1.1685062×10^{52} sqs-Iron atoms, coated with superconducting sqs-Lead, 2.1228813×10^{40} excess sqs-electrons

1.2. Electron magnetic dipole moment

1.2.1. Solid rotation

The minimum period T of rotation that an astronomical mass can have at its equator based on balancing the mass's gravitational force with its centrifugal force is

$$T = [\, 3\pi/G\rho \,]^{1/2}, \tag{1}$$

where $G = 6.6742 \times 10^{-11} \text{Nm}^2/\text{kg}^2$, and $\rho = $ object's density.

Using the cosmic scale electron's density $\rho = 12580 \, \text{kg}/\text{m}^3$, yields a minimum equatorial period $T = 3350$ seconds. If the whole cs-electron spins any faster it will be flung apart. With a radius $= 2.74 \times 10^{7} \text{m}$ and a period $T = 3350$ seconds, the maximum equatorial rotation velocity of the cs-electron $= 51.4 \, \text{km}/\text{s}$.

A steady current flowing around a circular loop creates a magnetic dipole moment:

$$\boldsymbol{\mu} = \text{(number of wire turns)(current)(area enclosed by loop)} = 1(\mathbf{i})\,(\pi r^2). \quad (2)$$

If the excess charge of the cs-electron is fixed around the equator, then the maximum magnetic dipole moment form the whole spinning mass is:

$$\boldsymbol{\mu} = (-3.4012306 \times 10^{21}\text{C})\,\pi(2.74 \times 10^7\,\text{m})^2\,/\,3350\,\text{seconds}$$

$$= -2.395 \times 10^{33}\,\text{Joules/Tesla}.$$

This falls well below the value expected from Table 1,

$$[e^-,\,\boldsymbol{\mu}_z\,]_{1,\,0} = -7.467 \times 10^{40}\,\text{J/T}.$$

1.2.2. Equatorial charge current

The iron atom has a magnetic dipole moment of $2.22\mu_B$. The maximum ferromagnetic field of the cs-electron occurs when all its iron atom magnetic moments align.

$$\boldsymbol{\mu} = (\,2.22\mu_B\,/\text{atom}\,)(1.1685062 \times 10^{52}\,\text{atoms}) = 2.4058 \times 10^{29}\,\text{J/T}. \quad (3)$$

If an electric current flows around the equator (perpendicular bisector to magnetic poles) the charges will travel through a homogeneous magnetic field. A magnetic force results directed normal to the surface. If the current flows in the direction indicated in Figure 1, the magnetic force will be directed towards the cs-electron. This configuration is ideal for circular motion, in that the magnetic force does not change the electron's speed and always acts perpendicular to the electron's velocity.

$$\mathbf{F} = q\mathbf{v} \times \mathbf{B}. \quad (4)$$

The magnetic field strength of the ferromagnetic dipole $\boldsymbol{\mu} = 2.4058 \times 10^{29}$ J/T at the cs-electron's surface equator is approximated by:

$$\mathbf{B} = \mu_0\boldsymbol{\mu}\big/(4\pi r^3) = (1 \times 10^{-7}\,\text{Tm/Amp}\,)(2.4058 \times 10^{29}\,\text{J/T}\,)\big/(2.74 \times 10^7\,\text{m})^3$$

$$= 1.17\,\text{Tesla}. \quad (5)$$

Assuming that the size and shape of the cosmic scale electron are fairly accurate,

then only the current can significantly affect the magnetic dipole moment. Let us examine if the excess charge flowing around the cs-electron's equator has a maximum velocity, $\mathbf{v} = 2.998 \times 10^8$ m/s.

The magnetic force on a circulating electron is then:

$$\mathbf{F} = (-1.60217653 \times 10^{-19} \text{C})(2.998 \times 10^8 \text{ m/s})(\sin 90°)(1.17 \text{ T})$$

$$= -5.62 \times 10^{-11} \text{N.} \tag{6}$$

Due to the electron's acceleration it has a centripetal force opposing the magnetic force:

$$\mathbf{F} = m\mathbf{a} = m\mathbf{v}^2 / r = (9.1093826 \times 10^{-31} \text{kg})(2.998 \times 10^8 \text{m})^2 / 2.74 \times 10^7 \text{m}$$

$$= 2.99 \times 10^{-21} \text{N.} \tag{7}$$

The circulating electrons are bound to the cs-electron.

With a current spin velocity of 2.998×10^8 m/s, the period, T, of one orbit:

$$T = 2\pi(2.74 \times 10^7 \text{m})/(2.998 \times 10^8 \text{ m/s}) = 0.574 \text{ seconds.} \tag{8}$$

This would generate a magnetic dipole moment:

$$\boldsymbol{\mu} = (-3.4012306 \times 10^{21} \text{C})(\pi)(2.74 \times 10^7 \text{m})^2 / 0.574 \text{ seconds}$$

$$= -1.40 \times 10^{37} \text{ J/T.} \tag{9}$$

This -1.40×10^{37} J/T is too low to account for the expected cs-electron magnetic dipole moment, -7.47×10^{40} J/T.

1.2.3. Equatorial conduction electrons supplemented current

The only remaining variable is the conducting charge. Iron is a fairly good conductor. Conductors typically have one valence electron per atom that is not confined to a single atom. Conducting metals contain a "sea" or "gas" of mobile electrons that flow about the relatively stationary positive matrix. If the cs-electron is composed of 1.2×10^{52} Iron atoms, then an equal reservoir of charge is available to flow.

Once a current is flowing around the cs-electron's equator, a large magnetic field

is established at the center of the cs-electron. Some Iron valence electrons with 7.9 eV kinetic energy and orbital velocities 1.667×10^6 m/s experience a substantial force that drives conduction electrons towards the surface.

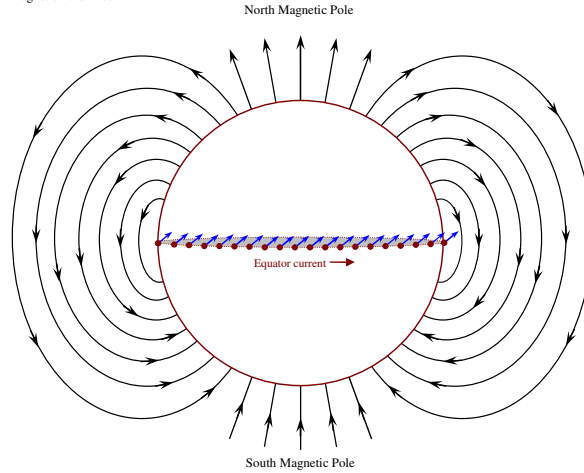**Figure 1.** Fractal electron with magnetic field lines.

A cs-electron is composed of 1.1685062×10^{52} Iron atoms and an excess of 2.1228813×10^{40} electrons has:

$$(1.1685062 \times 10^{52})(26) \big/ 2.1228813 \times 10^{40} = 1.4311286 \times 10^{13} \text{ cs-units}$$

of positive charge, balanced by

$$(1.1685062 \times 10^{52})(26) \big/ 2.1228813 \times 10^{40} = 1.4311286 \times 10^{13}$$

cs-units of negative charge with only the excess 2.1228813×10^{40} = providing 1 cs-unit of negative charge to the cs-electron.

A spin current velocity of 51.4 km/s completes one cosmic scale electron orbit period, P, in 3350 seconds.

The cosmic scale electron magnetic dipole moment is $\boldsymbol{\mu} = \sqrt{3}$ times the $\boldsymbol{\mu}_z$ value listed in Table 1. To determine the amount of charge needed to account for the cs-electron magnetic dipole moment, a period of 3350 seconds is used in equation (10):

$$\boldsymbol{\mu} = \sqrt{3}\left(-7.467434623 \times 10^{40} \text{ J/T} \right) = -1.293397617 \times 10^{41} \text{ J/T}$$

$$= q\pi \left(2.74 \times 10^7 \text{ m} \right)^2 \big/ 3350 \text{ s}. \tag{10}$$

A charge $q = -1.84 \times 10^{29}$ Coulombs must flow around the cs-electron's equator in order to generate the scaled up expected magnetic dipole moment. This amount of charge requires 1.15×10^{48} conduction electrons (from the 1.169×10^{52} Iron atom conduction electrons available) to be flowing on the cs-electron's surface to generate the expected cs-electron magnetic moment.

FPT predicts velocity is scale invariant, therefore the surface current flowing on an electron is in the range 51.4 km/s to $2.998 \times 10^8 \text{ m/s}$, with an effective charge in the range $8.67 \times 10^{-12} \text{C}$ to $1.48 \times 10^{-15} \text{C}$. Although not determined exactly at this writing, FPT clearly allows for a simple, visual, reasonable explanation for the electron's magnetic dipole moment and therefore spin.

1.2.4. Magnetic field at the cs-electron poles

The magnetic field at the cs-electron poles is approximated by:

$$\mathbf{B} = \mu_0 \boldsymbol{\mu} \big/ \left(2\pi z^3 \right) = \left(2 \times 10^{-7} \text{ Tm/A} \right)\left(1.293397617 \times 10^{41} \text{ J/T} \right) \big/ \left(2.7396731 \times 10^7 \text{ m} \right)^3$$

$$= 1.2579571 \times 10^{12} \text{ T}. \tag{11}$$

1.3. Is the cosmic scale electron's surface coated with a superconductor?

Stellar nuclear fusion from Hydrogen stops at the stable Iron 56 isotope. If a small amount of elements leading up to Iron remain in the cosmic scale electron, then some Vanadium would be available (Tables 2.a and 2.b).
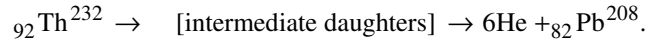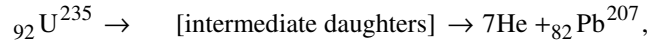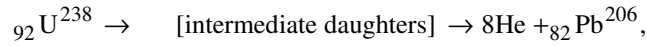
Table 2.a. Cosmic scale electron elemental properties [3]

Element	M_0 (Tesla)	Magnetic dipole/atom	Curie temp. (Kelvin)		Element	T_c (K)	B_c (Tesla)
Iron	2.2020	2.22 μ_B	1043		Vanadium	5.40	0.1408
Cobalt	1.8170	1.72 μ_B	1388		Lead	7.20	0.0803
Nickel	0.6410	0.62 μ_B	627				

Table 2.b. Cosmic scale electron elemental properties [3]

Element	Symbol	Mass (amu)	Melting pt (°C)	Boiling pt (°C)	Molten density (g/cm³)	Solid density (g/cm³) @ 25°C
Vanadium	V_{23}	50.9415	1910	3407	5.5	6.0
Iron	Fe_{26}	55.845	1538	2861	6.98	7.87
Cobalt	Co_{27}	58.9332	1495	2927	7.81	8.86
Nickel	Ni_{28}	58.6934	1455	2913	7.75	8.90
Lead	Pb_{82}	207.2	327.5	1749	10.66	11.3

A cosmic scale electron cooling down to 2700°C will have Vanadium, Iron, Cobalt, and Nickel all in their liquid phase. The least dense molten Vanadium would rise to the top of the molten cs-electron. After cooling to 1800°C, the Vanadium will solidify but the iron, cobalt, and nickel will be liquids. The less dense solid Vanadium will float to the top of the cooling cs-electron. When cooled below 5 K the Vanadium will be superconducting.

The solar system is proposed to be one cosmic scale neutron about midway through the process of cosmic scale beta decay, with the planets forming the seeds of one yet to form cosmic scale electron [2]. Currently the Earth has an abundance of Uranium and Thorium near its surface. If the forming cs-electron is coated with Uranium 238, Uranium 235, and Thorium 232 consider the following:

$$_{92}U^{238} \rightarrow \quad \text{[intermediate daughters]} \rightarrow 8He +_{82}Pb^{206},$$

$$_{92}U^{235} \rightarrow \quad \text{[intermediate daughters]} \rightarrow 7He +_{82}Pb^{207},$$

$$_{92}Th^{232} \rightarrow \quad \text{[intermediate daughters]} \rightarrow 6He +_{82}Pb^{208}.$$

The end result of this radioactive decay is a mass of Lead and Helium. At temperatures between 1800°C and 2800°C, Iron, Cobalt and Nickel are liquids but Lead and Helium are still low density vapors in the atmosphere. Cooling to 1700°C Lead will liquefy on top of the molten metals. If little mixing takes place and rapid cooling to 1400°C, the metals will solidify with liquid Lead still on the surface. At 1000 K the paramagnetic Iron turns ferromagnetic. At a temperature of 7 K Lead is superconducting. Superconductors allow current to flow with zero resistance and no energy loss. Superconductors expel magnetic field lines.

1.4. Electron spin

When a magnetic dipole moment is measured, applying the following formula calculates a spin:

$$\mu_z = (1.001156652)(\text{cs-electron charge})(S_z)/(\text{cs-electron mass}),$$

$$S_z = (1.0835913 \times 10^{27} \text{kg})(7.467434623 \times 10^{40} \text{ J/T})/[(1.001156652)$$

$$\times (3.4012306 \times 10^{21} C)] = 2.3762866 \times 10^{46} \text{Js}, \tag{12}$$

which compares to the value in Table 1.

1.5. Electron phase energies

1.5.1. Cs-electron Coulomb potential energies

The solid state cs-electron has a large central pressure and therefore central temperature >> 0 K, while the surface of the cs-electron has a surface temperature = 2.725 K. Coulombic potential energies of a fractal electron are the energies required to heat, melt, boil and completely ionize its 1.2×10^{52} Iron atoms.

$$Q = mC_p\Delta T + mL_F + mC_p\Delta T + mL_v + \text{I.E.} \tag{13}$$

Q = heat energy,

m = mass of cs-electron, 1.0835913×10^{27} kg $= 1.9403500 \times 10^{28}$ moles,

C_p = molar heat capacity at constant pressure,

ΔT = change in temperature,

L_F = Iron's latent heat of fusion,

L_v = Iron's latent heat of vaporization,

I.E. = Ionization energy.

1.5.2. Cs-electron gravitational potential energy

The gravitational potential energy of a fractal electron is the energy required to delocalize and disperse the gaseous phase atoms.

$$U_g = Gm^2/r = -2.8604311 \times 10^{36} \text{ J} \tag{14}$$

$G = 6.6742 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$, $m =$ mass of cs-electron, 1.0835913×10^{27} kg, $r =$ radius of cs-electron, 2.7396731×10^7 m.

1.5.3. Cs-electron heating and melting the solid phase

The approximation is made, as a maximum limit, that the starting temperature is 3 K for the whole cs-electron. To simplify the cs-electron is considered composed of 100% Iron similar to the isotopic composition in Table 3.

Table 3. Iron isotopic masses [3]

Iron	amu	(%)	amu
54	53.9396105	5.845	3.152770234
56	55.9349375	91.754	51.322542554
57	56.9353940	2.119	1.206460999
58	57.9332756	0.282	0.163371837
			55.845145624

Table 4 lists molar constant pressure heat capacities at progressive temperatures. Table 5 lists energies required to heat a mass of Iron, equal to the cs-electron mass, from 3 K to Iron's normal melting point 1811.15 K [3].

Table 4. Molar heat capacities for Iron at constant pressure [3]

Temperature (K)	200	250	300	350	400	500	600
C_p (J/mol K)	21.59	23.74	25.15	26.28	27.39	29.70	32.05

Table 5. Energy to heat the solid cosmic scale electron

Temperature Range (K)	Δtemp (K)	C_p (J/mol K)	Q Energy[1] (J)
3 - 250	247	21.59	1.034736×10^{32}
250 - 300	50	23.74	2.303195×10^{31}
300 - 350	50	25.15	2.439990×10^{31}
350 - 400	50	26.28	2.549620×10^{31}
400 - 500	100	27.39	5.314619×10^{31}
500 - 600	100	29.70	5.762840×10^{31}
600 - 1811.15	1211.15	32.05	7.531926×10^{32}
		$\Sigma =$	$\mathbf{1.040369 \times 10^{33}}$

[1]$Q = mC_p\Delta T$, $m = 1.940350032 \times 10^{28}$.

The energy required to change the phase of the cs-electron from solid to liquid at 1811.15 K:

$$Q = mL_f = 2.679721 \times 10^{32} \, \text{J}, \tag{15}$$

$L_F =$ Iron's enthalpy of fusion at its melting point

$$= 247.3 \, \text{J/g} = 13810.50451 \, \text{J/mol} \ [3],$$

$m = 1.940350032 \times 10^{28}$ moles of iron.

1.5.4. Cs-electron heating and boiling the liquid phase

Energy to increase a cs-electron's temperature from 1811.15 K to 3134.15 K:

$$Q = mC_p\Delta T = 8.227501 \times 10^{32} \text{J}, \tag{16}$$

$m = 1.940350032 \times 10^{28}$ moles of iron,

$C_p =$ estimate the specific heat capacity of liquid iron as $32.05 \text{ J}/(\text{mol K})$,

$\Delta T = (3134.15 \text{ K} - 1811.15 \text{ K})$,

$\text{Fe}_{\text{b.p.}} = 2861°C + 273.15 = 3134.15 \text{ K}$ [3].

Energy to change the phase of the cs-electron from liquid to gas at 3134.15 K:

$$Q = mL_v = 6.811405 \times 10^{33} \text{J}, \tag{17}$$

$L_v =$ Iron's enthalpy of vaporization $= 351.04 \text{ kJ}/\text{mol}$ [4],

$m = 1.9403500 \times 10^{28}$ moles of iron.

1.5.5. Cs-electron energy to ionize 1.1685062×10^{52} gaseous phase Iron atoms

Table 6 lists the ionization energies required to remove the 26 electrons bonded to an Iron atom.

Table 6. Iron atom ionization energies [3]

e– #	Energy (eV)	e– #	Energy (eV)	e– #	Energy (eV)
1	7.9024	10	262.1	19	1456
2	16.1877	11	290.2	20	1582
3	30.652	12	330.8	21	1689
4	54.8	13	361.0	22	1799
5	75.0	14	392.2	23	1950
6	99.1	15	457	24	2023
7	124.98	16	489.256	25	8828
8	151.06	17	1266	26	9277.69
9	233.6	18	1358		

Σ of 26 I.E. $= 34604.528 \text{ eV}/\text{atom} = 5.5442563 \times 10^{-15} \text{ J}/\text{atom}$.

The energy required to ionize every electron from every iron atom of a cs-electron:

$$\text{I.E.} = (5.5442563 \times 10^{-15} \text{ J}/\text{atom })(1.1685062 \times 10^{52} \text{ Iron atoms})$$

$$= 6.4784979 \times 10^{37} \text{ J}. \tag{18}$$

1.5.6. Fractal electron phase energy summary

The energy scaling fractal, $¥E = 1.189533 \times 10^{57}$, is used to convert self-similar

fractal object energies located in scales separated by $\Delta m = +/- 2$ [1]. Table 7.a lists the 5 Coulombic and 1 Gravitational energy phases discussed in Subsection 1.5, with values listed from electrons located in the cosmic scale and the quantum scale measured relative to the human scale. Table 7.b lists the energy required to ionize all the fractal Iron atoms of a fractal electron in steps; to remove one electron from each of the many Iron atoms, then the second, and so on, until all 26 electrons from every Iron atom is ionized.

Table 7.a. Fractal electron phase energies relative to the human scale

Q	Phase	Electron Scale Location	
		Cosmic	Quantum
1	Heating solid	1.040369×10^{33} J	5.459×10^{-6} eV
2	Melting solid	2.679721×10^{32} J	1.406×10^{-6} eV
3	Heating liquid	8.227501×10^{32} J	4.317×10^{-6} eV
4	Boiling liquid	6.811405×10^{33} J	3.574×10^{-5} eV
5	Work against gravity to disperse gas phase	2.860431×10^{36} J	0.015009 eV
6	Ionizing Fe	6.478498×10^{37} J	0.339928 eV
		6.765435×10^{37} J	0.354984 eV

Table 7.b. Energy to ionize Iron atoms of a fractal electron measured in the human scale

Fe^{+n}	Cs-electron (J)	Qs-electron (eV)	Fe^{+n}	Cs-electron (J)	Qs-electron (eV)
1st	1.4794504×10^{34}	0.0000776	14th	7.3425852×10^{35}	0.0038527
2nd	3.0305856×10^{34}	0.0001590	15th	8.5557405×10^{35}	0.0044892
3rd	5.7385242×10^{34}	0.0003011	16th	9.1596223×10^{35}	0.0048061
4th	1.0259400×10^{35}	0.0005383	17th	2.3701461×10^{35}	0.0124362
5th	1.4041150×10^{35}	0.0007367	18th	2.5423842×10^{36}	0.0133400
6th	1.8553039×10^{35}	0.0009735	19th	2.7258552×10^{36}	0.0143026
7th	2.3398172×10^{35}	0.0012277	20th	2.9617465×10^{36}	0.0155404
8th	2.8280747×10^{35}	0.0014839	21st	3.1620669×10^{36}	0.0165914
9th	4.3733501×10^{35}	0.0022947	22nd	3.3680038×10^{36}	0.0176720
10th	4.9069137×10^{35}	0.0025747	23rd	3.6506989×10^{36}	0.0191553
11th	5.4329888×10^{35}	0.0028507	24th	3.7873661×10^{36}	0.0198724
12th	6.1930831×10^{35}	0.0032495	25th	1.6527369×10^{37}	0.0867195
13th	6.7584733×10^{35}	0.0035462	26th	1.7369258×10^{37}	0.0911369

The energy required to vaporize a solid electron, the sum of the first $4Q$ values in Table 7.a, is 4.693×10^{-5}, a tiny amount compared to the electron's rest mass 510999 eV. Adding additional energy to this quantum scale gaseous phase of the electron will greatly enlarge the volume it occupies in space. The electron and the waveform describing it delocalize in space. The electron has more energy in its waveform phase than it does in its particle form phase. Fractal Physics returns Classical Physics concepts to the quantum realm. Classical equations applied to

subquantum scale atoms, reiterated enormously to account for the time scale difference, are expected to reproduce Quantum Mechanical calculations.

2. Wave-Particle Duality Discussion

2.1. Fractal electron phase changes

An electron obeys classical particle physics in some experiments and classical wave physics in others. The electron is never a particle and a wave simultaneously. This wave-particle duality is complimentary. The de Broglie relation applied to a single particle remains undefined until the particle's velocity is compared to a reference point.

$$\mathbf{p} = h/\lambda. \tag{19}$$

Experiments performed on particles such as electrons measure wavelengths that are indirectly proportional to the electron's momentum. Fractal Physics proposes that the electron is composed of 1×10^{52} subquantum scale atoms. This collection of subquantum scale atoms can exist in lilliputian scale (ls) phases such as ls-solid, ls-liquid, ls-gas, and ls-plasma. The ls-solid and ls-liquid phases are localized in space like "particles" while the ls-gas and ls-plasma phases are delocalized in space like "waves". An object is never a complete solid and complete gas simultaneously. The phases of matter are complimentary. For an object to behave as a wave, it is proposed that the object's mass-energy occupies the wave-space. Let the wavelength of an object be directly proportional to the object's disk diameter.

The wave-particle duality of matter observed at the quantum scale relative to the human scale can be understood as evidence of the existence of subquantum scale atoms that undergo lilliputian scale phase transitions. Consider a 5 kilogram block of ice. Surely in this phase it obeys classical particle physics. Place this block of ice in a ripple tank at room temperature and wait. The 5 kilograms of water will obey classical wave physics.

An electron with linear momentum has translational velocity. Each of the 1×10^{52} sqs-atoms comprising the electron also have the same translational velocity, their sqs-atomic velocities are all aligned. Encounters with external fields of ambient objects can stimulate conversion of some of an electron's translational kinetic energy into increasing the internal kinetic energy of its sqs-atoms. The electron becomes ls-hotter and changes phases. In its ls-gaseous phase the ls-cloud spreads out as a disk.

To remain bound the kinetic energy of small differential masses at the cloud's radius must be less than the escape velocity from the cloud at that radius, the clouds total energy must be negative:

$$T = U_g + E_k < 0. \tag{20}$$

The kinetic energy, $E_k = 0.5\,mv^2$, of a particle in the cloud is related to its temperature by $E_k = 1.5\,kT$. The gravitational potential energy of a whole cloud of mass M with a small differential mass m is $U_g = -GMm/R$. Objects emit electromagnetic radiation from their surface per the Stefan-Boltzmann equation:

$$P = \varepsilon\sigma(\text{SA})T^4, \tag{21}$$

ε = emissivity, between 0 and 1,

$\sigma = 5.670400\times10^{-8}\ \text{W}/(\text{m}^2\text{K}^4)$,

SA = object's surface area,

T = surface temperature,

P = power or energy radiated per unit time.

For a constant mass and size, a 10-fold increase in temperature leads to a 10000-fold increase in energy radiated.

The Virial theorem describes the relationship between the gravitational potential energy and the internal kinetic energy of a massive cloud in space in statistical equilibrium. Half the potential energy from gravitational collapse goes into the kinetic energy of the cloud increasing the cloud's temperature. The opposite is also true. As a cloud expands, half of the gravitational potential energy gained comes from the kinetic energy of the cloud. As a mass expands it cools.

2.2. Fractal wave-particle duality

For a particle of constant mass, the greater its linear momentum the more energy is available to increase the particle's internal energy. The ls-hotter particle changes phases expanding into a growing disk shape, with its surface area radiating sqs-radiation to cool. It is proposed that the higher the initial ls-temperature, the more rapid the ls-cloud cools, which limits the diameter of the delocalizing particle.

In the dual slit experiment, the electron in its waveform must retain a significant

amount of translation kinetic energy if it is to pass through the slits and eventually reach the screen for detection (Figure 2). The delocalized disk shaped electron passes through both slits and interferes with itself. The interference establishes the direction heading for the ls-cooling, collapsing ls-cloud on route to the screen for detection as a particle. An electron with translational velocity $= 1 \times 10^8$ m/s and traveling 35 centimeters from the dual slits to the detection screen, takes 3.5 nanoseconds as measured in the human scale. The lilliputian scale measures this time of flight as 42 million years. There is ample time for the delocalized electron to cool by emitting sqs-radiation and contract before reaching the detector.

2.3. Cosmic scale free electron example

Let a cs-electron have kinetic energy $= 1 \times 10^{37}$ J, and let enough energy transform the cs-electron from cold solid to gas and expand the gas to overcome its gravitational potential. Let enough translational kinetic energy convert to create an initial gaseous sphere the density of Earth's air $= 1.21 \, \text{kg/m}^3$. This initial sphere has a radius $= 5.9795 \times 10^8$ m, about the size of the Sun. If the surface of this sphere is a gas at temperature $T = 3500$ K, using equation (21) with ε arbitrarily set $= 0.5$, it will radiate power $= 1.912 \times 10^{25}$ J/s. This is a very high rate considering the limited source of supply energy. The central temperature of a solid cosmic scale electron should be relatively high, but well below fusion temperatures, while its surface temperature is proposed to be 2.725 K. If the cs-electron increase in disk size is driven mainly by central temperature increases and the rate of energy transfer to the surface area remains relatively slow, the power radiated will be limited.
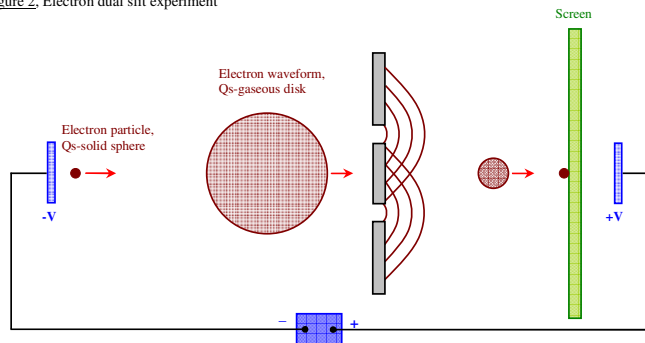

Figure 2, Electron dual slit experiment

Figure 2. Electron dual slit experiment.

Let additional translational kinetic energy transform into internal energy expanding this initial sphere into a delocalized gaseous disk of radius $r = \lambda/2$ and thickness $t = 2 * 6 \times 10^8 \, \text{m} = 1.2 \times 10^9 \, \text{m}$. This cs-electron has translational velocity $74412 \, \text{m/s}$, and linear momentum $\mathbf{p} = 8.0632 \times 10^{31} \, \text{kgm/s}$, and if measured records a cosmic scale de Broglie radius:

$$\text{Cs-electron } \lambda = ([h]_{1,0} = 2.9861209 \times 10^{47} \, \text{Js}) / (8.0632 \times 10^{31} \, \text{kgm/s})$$

$$= 3.7034 \times 10^{15} \, \text{m}.$$

To remain bound the atoms at the disk's edge have to be ultra cool with velocities less than the escape velocity:

$$\text{Escape velocity} = (\, 2GM/R \,)^{1/2} = 8.8 \, \text{m/s}, \tag{22}$$

$$G = 6.6742 \times 10^{-11} \, \text{Nm}^2 / \text{kg}^2,$$

$$M = 1.0835913 \times 10^{27} \, \text{kg},$$

$$R = 1.8517 \times 10^{15} \, \text{m}.$$

3. Fractal Photon

A fractal photon is the result of an enormous collection of subquantum scale photons. These sqs-photons all travel together in the same direction, have the same sqs-frequency, and are in phase. A photon is the result of an enormous amplification of coherent sqs-photons. A photon is a sqs-LASER pulse. Regardless of its frequency, a single photon has angular momentum spin $\mathbf{S} = \hbar = 1.054571682 \times 10^{-34} \, \text{Js}$.

Using the scaling fractal $¥\hbar = 4.506624921 \times 10^{80}$, yields the cosmic scale value $[\hbar]_{1,0} = 4.752559025 \times 10^{46} \, \text{Js}$.

One way to create a cosmic scale photon spin angular moment $= 4.752559025 \times 10^{46} \, \text{Js}$ out of coherent photons is to combine the spin angular moment of $4.506624921 \times 10^{80}$ photons. Therefore it is proposed that a photon is composed of $4.506624921 \times 10^{80}$ subquantum scale photons. The scaling fractal

$¥\hbar = 4.506624921 \times 10^{80}$, appears to be the most self-similar energy fractal, in that pure photon energy is composed of pure sqs-photon energy. Each of the $4.506624921 \times 10^{80}$ sqs-photons composing a single photon all have the same wavelength and frequency as the parent photon. These sqs-photons all have the same energy equal to $1/4.506624921 \times 10^{80}$ of the parent photon's energy. Figure 3 below illustrates the amplification of the electric field of only 10 of the 4.5×10^{80} photons.

The wave propagates with a phase speed $c = \omega/k$. The traveling photon has no rest mass and can be considered pure kinetic energy. The photon's energy can be considered contained within its electric and magnetic fields.

Photon electric field equation: $\mathbf{E}(x, t) = \mathbf{E}_m \sin(kx - \omega t)$ (23)

Photon magnetic field equation: $\mathbf{B}(x, t) = \mathbf{B}_m \sin(kx - \omega t)$ (24)
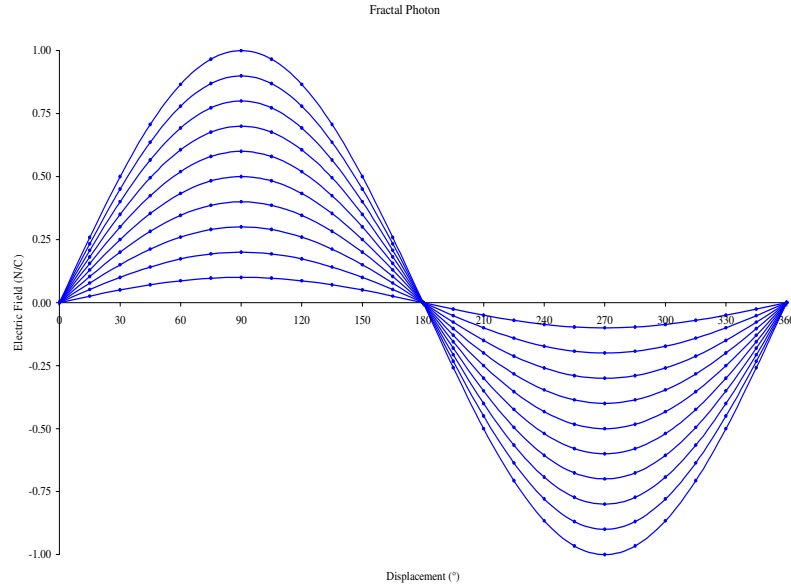

Figure 3. Fractal photon.

4. Hydrogen Atomic Absorption in Spherical Capacitors

4.1. Quantum scale spherical capacitor

Let a ground state electron of a Hydrogen atom, while in its ls-solid phase

(particle state), encounter the external field of a nearby object. Allow this encounter to stimulate the electron to convert a portion of its orbital translational kinetic energy into internal kinetic energy of its sqs-iron atoms. The localized ls-solid electron, utilizing its own energy, transforms into its delocalized wave form. The electron becomes a ls-gaseous cloud of 1×10^{52} sqs-Iron atoms filling a volume contained within an average radius = 0.529 Å surrounding the central proton. This delocalized electron cloud has a density $1.5 \, \text{kg}/\text{m}^3$. The electron's excess charge, composed of 2×10^{40} sqs-electrons, that previously coated the surface of the electron's ls-solid phase orbiting the proton at an average radius = 0.529 Å, now disperses itself along the surface of the delocalized ls-gas, still at the same average radius. The localized sqs-electric charge delocalizes along an equipotential surface without requiring energy. The delocalized electron cloud carries a surface charge density $4.6 \, \text{C}/\text{m}^2$. The Hydrogen atom is now a charged quantum scale spherical capacitor still in its ground state energy.

The Hydrogen atom qs-spherical capacitor can only absorb external energy if this energy equals the energy required to charge the Hydrogen atom into specific qs-spherical capacitor configurations. When a traveling photon is absorbed by an atom, the pure kinetic energy of the photon is converted to pure potential energy of the charged atomic capacitor's electric field. The traveling photon electric field becomes static electric field of the charged capacitor, while the traveling magnetic field, $c\mathbf{B}$ also converts into the static electric field of the charged capacitor.

Figure 4 shows a Hydrogen atom in its first excited state. Energy from outside the ground state Hydrogen atom (the system) enters the system perhaps by way of photon absorption, optical pumping. This qs-spherical capacitor stores the absorbed photon energy (atomic excitation). Eventually the higher energy qs-spherical capacitor configuration, while collapsing back to its ground state qs-capacitor configuration, releases the energy stored in its electric field as 4.5×10^{80} coherent sqs-photons. The sqs-LASER pulse emitted is perceived as a single quantum of radiation, a single photon, to the human scale.

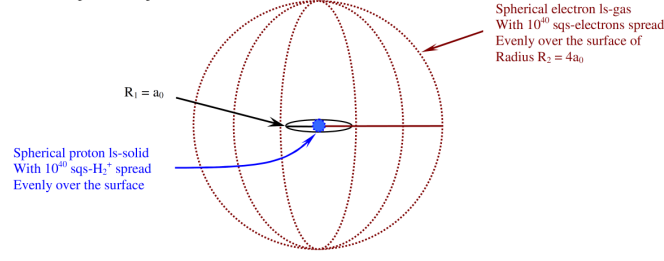Figure 4, Fractal Hydrogen atom, n = 2
Quantum scale spherical capacitor

Spherical electron ls-gas
With 10^{40} sqs-electrons spread
Evenly over the surface of
Radius $R_2 = 4a_0$

$R_1 = a_0$

Spherical proton ls-solid
With 10^{40} sqs-H_2^+ spread
Evenly over the surface

Figure 4. Fractal Hydrogen atom, $n = 2$ Quantum scale spherical capacitor.

4.2. Bohr hydrogen atom theoretical values

In the Bohr Hydrogen atom, the electron's total mechanical energy T is a sum of its potential energy U and kinetic energy K. Bohr Hydrogen atom theoretical values are calculated in Tables 8 and 9 to compare with atomic spherical capacitor values in Subsection 4.4, Tables 10 and 11.

Table 8. Bohr Hydrogen atom theoretical values $(n =$ principle quantum number $)$

n	$r_n = n^2 r_1$ $\text{Å}^{(1)}$	$v_n = v_1/n$ $\text{km/s}^{(2)}$	$T_n = T_1/n^2$ $(eV)^{(3)}$	$U_n = -2T_n$ (eV)	$K_n = -T_n$ (eV)
1	0.52946541	2187.691263	-13.598286	-27.196572	13.598286
2	2.1178616	1093.845632	-3.3995715	-6.7991430	3.3995715
3	4.7651887	729.230421	-1.5109207	-3.0218413	1.5109207
4	8.4714466	546.922816	-0.84989288	-1.6997858	0.84989288
5	13.236635	437.538253	-0.54393144	-1.0878629	0.54393144
6	19.060755	364.615211	-0.37773017	-0.75546033	0.37773017
7	25.943805	312.527323	-0.27751604	-0.55503208	0.27751604
8	33.885786	273.461408	-0.21247322	-0.42494644	0.21247322
9	42.886698	243.076807	-0.16788007	-0.33576015	0.16788007
100	5294.6541	21.876913	-0.0013598286	-0.0027196572	0.0013598286
10000	52946541	0.218769	-0.0000001360	-0.0000002720	0.0000001360

$^{(1)} r_1 = 4\pi\varepsilon_0 \hbar^2 / \mu_e e^2 = 5.2946541 \times 10^{-11} \text{m},$ \hfill (25)

$$\varepsilon_0 = 8.854187817 \times 10^{-12} \, C^2 / (Nm^2), \quad \hbar = 6.6260693 \times 10^{-34} \, Js/2\pi,$$

$$\mu_e = m_p m_e / (m_p + m_e) = 9.104424176 \times 10^{-31} \text{kg},$$

$$m_e = 9.1093826 \times 10^{-31} \text{kg}, \quad m_p = 1.67262171 \times 10^{-27} \text{kg},$$

$$e = 1.60217653 \times 10^{-19} C,$$

$^{(2)} v_1 = c\alpha = 2.187691263 \times 10^6 \text{ m/s}, \quad c = 299792458 \text{ m/s},$

$$\alpha = 7.297352568 \times 10^{-3},$$

$$^{(3)}T_1 = \mu_e e^4 / [2\hbar^2 (4\pi\varepsilon_0)^2] = 2.178685540 \times 10^{-18}\,\text{J} = 13.598286\,\text{eV}. \tag{26}$$

Table 9. Bohr hydrogen atom transition energies (from Table 8, Column 4)

Δn	ΔE (eV)	Δn	ΔE (eV)	Δn	ΔE (eV)
10000 − 1	13.598286	8 − 2	3.1870983	10000 − 4	0.84989274
100 − 1	13.596926	7 − 2	3.1220555	100 − 4	0.84853305
9 − 1	13.430406	6 − 2	3.0218413	7 − 4	0.57237684
8 − 1	13.385813	5 − 2	2.8556401	6 − 4	0.47216271
7 − 1	13.320770	4 − 2	2.5496786	5 − 4	0.30596144
6 − 1	13.220556	3 − 2	1.8886508	10000 − 4	0.54393130
5 − 1	13.054355	10000 − 3	1.5109206	100 − 4	0.54257161
4 − 1	12.748393	100 − 3	1.5095609	7 − 5	0.26641540
3 − 1	12.087365	8 − 3	1.2984475	6 − 5	0.16620127
2 − 1	10.198715	7 − 3	1.2334047		
10000 − 2	3.3995714	6 − 3	1.1331905		
100 − 2	3.3982117	5 − 3	0.96698926		
9 − 2	3.2316914	4 − 3	0.66102782		

4.3. Spherical capacitors

A capacitor is a device that stores energy in an electrostatic field. A capacitor is charged if its plates carry equal and opposite charges $+q$ and $-q$. Large capacitors are used to provide intense laser pulses. Charge is directly proportional to the potential difference between the plates, $q = CV$. The proportionality constant C is the capacitance in units of farads. A charged capacitor has stored in it an electrical potential energy U equal to the work W done by an external agent as the capacitor is charged. This energy can be recovered if the capacitor is allowed to discharge.

The electric field $\mathbf{E}$ is related to the charge on the plates by Gauss' law:

$$\varepsilon_0 \oint \mathbf{E} \cdot d\mathbf{A} = q, \tag{27}$$

$d\mathbf{A}$ = vector element normal to the surface,

$\varepsilon_0 = 8.854187817 \times 10^{-12}\,\text{C}^2/(\text{Nm}^2)$,

q = charge contained within the Gaussian surface, the integral is carried out over that surface.

Figure 5 illustrates a central cross section through a spherical capacitor that consists of two concentric spherical shells of radii a, b. A Gaussian surface of radius r is drawn with surface area $A = 4\pi r^2$. The vectors $\mathbf{E}$ and $d\mathbf{A}$ are parallel, therefore:

$$\varepsilon_0 EA = q = \varepsilon_0 E 4\pi r^2.$$

The electric field due to a uniform spherical charge distribution:

$$\mathbf{E} = q \big/ \left(4\pi\varepsilon_0 r^2\right) = kq \big/ r^2 . \qquad (28)$$

Spherical capacitor capacitance $C = 4\pi\varepsilon_0 ab \big/ (b - a)$. $\qquad (29)$

Potential energy stored in a capacitor $U = 0.5\, q^2 \big/ C$. $\qquad (30)$
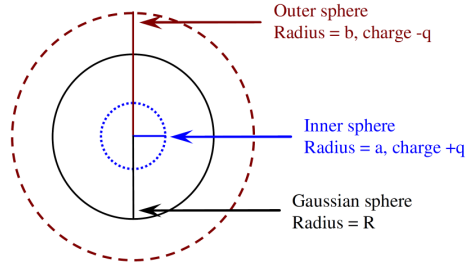

Figure 5. Central cross section through a spherical capacitor.

4.4. Fractal Bohr Hydrogen atom spherical capacitor energies

The Fractal Bohr Hydrogen atom is interested in the total energy stored in spherical capacitors. Values calculated in Tables 10 and 11 are compared with values of Subsection 4.2, Tables 8 and 9. Notice the similarity of transition energies (Table 9 and Table 11), which give rise to the measured atomic spectra, demonstrate that the Fractal Bohr Hydrogen atom compares in this regard to the Bohr Hydrogen atom.

Table 10. Fractal Hydrogen atom qs spherical capacitor energies (corrected for reduced mass)

n	$r_n = n^2 r_1$ (m)[1]	Capacitance, C_n (F)[2]	Energy, U_n (eV)[3]
1	$5.29465410 \times 10^{-11}$	$1.112671071 \times 10^{-25}$	719968.628558
2	$2.11786164 \times 10^{-10}$	$1.112655310 \times 10^{-25}$	719978.827273
3	$4.76518869 \times 10^{-10}$	$1.112652391 \times 10^{-25}$	719980.715924
4	$8.47144656 \times 10^{-10}$	$1.112651369 \times 10^{-25}$	719981.376952
5	$1.32366353 \times 10^{-9}$	$1.112650897 \times 10^{-25}$	719981.682913
6	$1.90607548 \times 10^{-9}$	$1.112650640 \times 10^{-25}$	719981.849114
7	$2.59438051 \times 10^{-9}$	$1.112650485 \times 10^{-25}$	719981.949329
8	$3.38857862 \times 10^{-9}$	$1.112650384 \times 10^{-25}$	719982.014371
9	$4.28866982 \times 10^{-9}$	$1.112650315 \times 10^{-25}$	719982.058965
10	$5.29465410 \times 10^{-9}$	$1.112650266 \times 10^{-25}$	719982.090862
100	$5.29465410 \times 10^{-7}$	$1.112650058 \times 10^{-25}$	719982.225485
10000	$5.29465410 \times 10^{-3}$	$1.112650056 \times 10^{-25}$	719982.226845

[1]From Table 8, Column 2

$$[2]C_n = 4\pi\varepsilon_0 a r_n/(r_n - a), \quad a = \text{proton radius} = 1\times10^{-15}\,\text{m}, \quad r = \text{radius} \tag{31}$$

$$[3]U_n = 0.5q^2/C_n, \quad q = -1.60217653\times10^{-19}\,\text{C}.$$

Table 11. Fractal Hydrogen atom qs-spherical capacitor transition energies (from Table 10, Column 4)

Δn	ΔE (eV)	Δn	ΔE (eV)	Δn	ΔE (eV)
$10000 - 1$	13.598286	$8 - 2$	3.1870983	$10000 - 4$	0.84989272
$100 - 1$	13.596927	$7 - 2$	3.1220555	$100 - 4$	0.84853303
$9 - 1$	13.430406	$6 - 2$	3.0218414	$7 - 4$	0.57237681
$8 - 1$	13.385813	$5 - 2$	2.8556401	$6 - 4$	0.47216268
$7 - 1$	13.320770	$4 - 2$	2.5496787	$5 - 4$	0.30596140
$6 - 1$	13.220556	$3 - 2$	1.8886508	$10000 - 5$	0.54393132
$5 - 1$	13.054355	$10000 - 3$	1.5109206	$100 - 5$	0.54257163
$4 - 1$	12.748393	$100 - 3$	1.5095609	$7 - 5$	0.26641541
$3 - 1$	12.087366	$8 - 3$	1.2984475	$6 - 5$	0.16620128
$2 - 1$	10.198715	$7 - 3$	1.2334047		
$10000 - 2$	3.3995714	$6 - 3$	1.1331906		
$100 - 2$	3.3982117	$5 - 3$	0.96698930		
$9 - 2$	3.2316915	$4 - 3$	0.66102786		

4.5. Derivation of the Balmer formula

The Balmer formula inspired the Bohr model of the Hydrogen atom which eventually led to the development of Quantum Mechanics. The fractal atom spherical capacitor model can also readily derive the generalized Balmer formula:

$$1/\lambda = R(1/n_f^2 - 1/n_i^2), \tag{32}$$

$R = $ Rydberg constant,

$n = 1, 2, 3, ...,$

$n_f = \text{final } n, \quad n_f < n_i,$

$n_i = \text{initial } n.$

The potential energy difference between Hydrogen atom spherical capacitors from equation (29) and equation (30):

$$\Delta U = U_i - U_f = 0.5e^2/C_i - 0.5e^2/C_f = 0.5e^2(1/C_i - 1/C_f)$$

$$= 0.5e^2[(r_i - a)k/ar_i - (r_f - a)k/ar_f] \tag{33}$$

$$= 0.5e^2[(r_i k - ak)/ar_i - (r_f k - ak)/ar_f] = 0.5e^2(r_i k r_f - akr_f - r_i k r_f + akr_i)/ar_i r_f$$

$$= 0.5ke^2(-r_f + r_i)/r_i r_f = 0.5ke^2(-1/r_i + 1/r_f) = 0.5ke^2(-1/n_i^2 r_1 + 1/n_f^2 r_1)$$

$$= (0.5ke^2/r_1)(1/n_f^2 - 1/n_i^2) = (0.5k^2 e^4 \mu_e/\hbar^2)(1/n_f^2 - 1/n_i^2)$$

$$= (4\pi^2 e^4 \mu_e/32\pi^2 \varepsilon_0^2 h^2)(1/n_f^2 - 1/n_i^2)$$

$$= hc/\lambda = (e^4 \mu_e/8\varepsilon_0^2 h^2)(1/n_f^2 - 1/n_i^2),$$

$$k = 1/(4\pi\varepsilon_0),$$

$$r_i = n_i^2 r_1 \text{ and } r_f = n_f^2 r_1,$$

$$r_1 = \hbar^2/k\mu_e e^2,$$

$1/\lambda = (e^4 \mu_e/8c\varepsilon_0^2 h^3)(1/n_f^2 - 1/n_i^2) = R(1/n_f^2 - 1/n_i^2)$, the generalized Balmer

formula. $\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad$ (34)

5. Cosmic Scale Hydrogen Atom cs-photon Absorption

5.1. Cs-Hydrogen atom spherical capacitor

The cs-Hydrogen atom with its cs-electron in its localized solid-state has cosmic scale electric field (**E**) lines starting from the cs-proton and ending on the cs-electron (Figure 6). Fractal Physics attributes the cs-proton's positive charge to an excess of 2.1228813×10^{40} protons distributed over its surface, while the cs-electron's negative charge is attributed to an excess of 2.1228813×10^{40} electrons on its surface. One should visualize 2.1228813×10^{40} electric field lines connecting each excess proton-electron pair. Therefore one cosmic scale **E** line is considered composed of a tight bundle of 2.1228813×10^{40} quantum scale **E** lines. Perhaps the cs-Hydrogen atom must have its cs-electron in its delocalized state, the ground state configuration of a spherical capacitor, as a prerequisite for cs-photon absorption. In the ground state spherical capacitor configuration the cs-electron is a low density Iron gas contained within the cs-Hydrogen atom's volume (Figure 7). The surface area of this volume contains the 2.1228813×10^{40} excess electrons evenly distributed with a surface area electron density:

$$\sigma = 2.1228813 \times 10^{40} e^- s/[4\pi(2.0059147 \times 10^{13} \text{m})^2]$$

$$= 4.1984687 \times 10^{12} e^- s/\text{m}^2. \qquad\qquad\qquad\qquad (35)$$
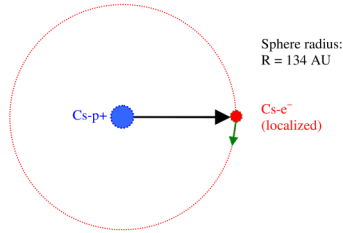
Figure 6. Cosmic scale H-atom with cs-e– in its solid state. Single **E** field line depicted terminating on the cs-e–. One orbital period takes 1.83 years. Not to scale.

The cs-Hydrogen atom is now a ground state spherical capacitor with 2.1228813×10^{40} **E** lines starting on the cs-proton and terminating on the 2.1228813×10^{40} excess surface electrons also with a density 4.2×10^{12} **E** lines$/\mathrm{m}^2$. Each of the 2.1228813×10^{40} protons providing the cs-proton's positive charge are composed of an excess of 2.1228813×10^{40} sqs-protons, while each of the 2.1228813×10^{40} electrons providing the cs-electron's negative charge are composed of an excess of 2.1228813×10^{40} sqs-electrons. Consequently, each of the 2.1228813×10^{40} cosmic scale **E** lines of the cs-atomic capacitor is considered composed of 2.1228813×10^{40} quantum scale **E** lines. Therefore any cosmic scale atomic energy level is considered in Fractal Physics as a capacitor with 4.5066250×10^{80} quantum scale **E** lines. Then, due to fractal self-similarity, every qs-atomic energy level is considered a qs-capacitor with 4.5066250×10^{80} sqs-**E** lines.
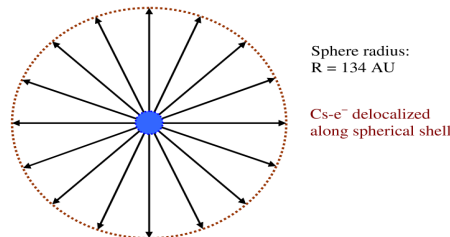

Figure 7. Cosmic scale H-atom with cs-e– in its delocalized gaseous state. A 2-D slice of the ground state spherical capacitor with some **E** field lines depicted. Not to scale.

It is instructive to contrast the greatly accelerated time frame of the Hydrogen atom with the time frame of the cosmic scale Hydrogen atom, both viewed from the

human scale. The velocities of both the ground state electron of the Hydrogen atom and the ground state cs-electron of the cs-Hydrogen atom equal 2.188×10^6 m/s.

The mass reduced Bohr radius of the Hydrogen atom is 5.295×10^{-11}m, while the cs-mass reduced Bohr radius of the cs-Hydrogen atom is 134 AU. Consider the Earth-Sun distance is 1 AU. The cs-electron of the ground state cs-Hydrogen atom will complete one orbit in 1.83 years, while the electron of the ground state Hydrogen atom completes one orbit in 1.52×10^{-16} seconds or 6.5761×10^{15} cycles per second. Using the reduced Bohr radius, the ground state Hydrogen atom has a surface area $= 3.5228 \times 10^{-20}$ m^2. Using the electron radius in Table 1, the electron's cross section $= 1.6428 \times 10^{-32}$ m^2. Dividing these two areas show that 2.14 trillion electrons (without charge) placed on the sphere of the Hydrogen atom will completely occupy the shell's space. To the human scale the electron in the Hydrogen atom appears to occupy all possible atomic shell positions in 3×10^{-3}s!

Some properties of the ground state and first excited state of the spherical capacitor cosmic scale Hydrogen atom are listed in Table 12.

Table 12. Cosmic scale H-atom $(n = 1)$ and $(n = 2)$ spherical capacitor properties

Observables	Ground state $(n = 1)$	First excited state $(n = 2)$
Radius (m)	2.0059147×10^{13}	8.0236586×10^{13}
Surface area (m^2)	5.0563227×10^{27}	8.0901164×10^{28}
Volume (m^3)	3.3808507×10^{40}	2.1637444×10^{42}
[1]Capacitance (F)	0.042154276	0.042153679
[2]Energy (J)	$1.372146603 \times 10^{44}$	$1.372166036 \times 10^{44}$

[1]$C_n = 4\pi\varepsilon_0 a r_n/(r_n - a)$, $a =$ cs-proton radius $= 3.788566 \times 10^8$ m, $r =$ radius,

$$(36)$$

[2]$U_n = 0.5 q^2/C_n$, $q = -3.40123056 \times 10^{21}$ C.

5.2. Cosmic scale photon

The energy difference between the two capacitor states in Table 12:

$$\Delta\text{Energy} = E_2 - E_1 = 1.9433 \times 10^{39}\,\text{J}. \qquad (37)$$

A cosmic scale photon with energy $= 1.9433 \times 10^{39}$ J has a frequency:

$$[f]_{1,0} = E/[h]_{1,0} = 6.507774 \times 10^{-9}\,\text{Hz}, \qquad (38)$$

$E = 1.9433 \times 10^{39} \, \text{J},$

$[h]_{l,0} = h * \yen h = 2.986121 \times 10^{47} \, \text{Js} \ [1],$

$h = \text{Planck's constant} = 6.6260693 \times 10^{-34} \, \text{Js},$

$\yen h = \text{Planck's constant scaling fractal} = 4.506625 \times 10^{80}.$

A cosmic scale photon with frequency $= 6.507774 \times 10^{-9} \, \text{Hz}$ has a wavelength:

$$[\lambda]_{l,0} = c/[f]_{l,0} = 4.606682 \times 10^{16} \, \text{m} = 4.869 \, \text{ly}, \tag{39}$$

$$c = 299792458 \, \text{m/s}.$$

6. Conclusion

This third article of the series continues to demonstrate the range of Fractal Physics Theory. The properties of the electron are determined from a composition of 1×10^{52} subquantum scale atoms and an excess of 2×10^{40} sqs-electrons. The photon is proposed to be a laser pulse of 4.5×10^{80} subquantum scale photons. The wave-particle duality can be understood as lilliputian scale phase changes and ls-heat radiated by composite sqs-atoms. The spectrum of the Hydrogen atom and the Balmer formula can be reproduced by a qs-spherical capacitor model.

References

[1]   L. J. Malinowski, Fractal Physics Theory - Foundation, Fundamental J. Modern Physics 1(2) (2011), 133-168.

[2]   L. J. Malinowski, Fractal Physics Theory - Cosmic Scale Nuclear Explosion Cosmology, Fundamental J. Modern Physics 1(2) (2011), 169-195.

[3]   D. R. Lide, editor, Handbook of Chemistry and Physics, CRC Press, Boca Raton, FL, 2006.

[4]   T. K. Varga and C. Bello, editors, Periodic Table of the Elements, © 1994 Papertech Marketing Group, Inc., 163 Buttermill Ave., Unit 12, Concord, Ontario, Canada L4K 3X8.