Quantum Dynamic Relativity

Rethinking Bohr, Heisenberg and Neutron Spin uncovers
a relationship between Quantum Mechanics and Relativity

by William Gray

Bohr's Correspondence and Heisenberg's Uncertainty

Relativity and Quantum Mechanics become Classical when, as Einstein showed, velocities are low and there are no independent observers and, as Bohr showed with his Correspondence Principle, the energy differences between quantized levels vanish.

In 1913 Niels Bohr amazed the scientific world with a theory of quantum mechanics that explained atomic spectra. He proposed that in hydrogen an electron orbits a proton by Coulomb attraction in specific quantum energy states and an excited electron jumps to a lower energy state by giving up a photon with a frequency given by $hf = E_e - E_1$, where h is Planck's Constant. This meant its frequency is independent of orbital motion, contrary to Classical theory where its frequency must equal the orbital revolution rate.

He also reasoned that an orbital electron's quantum energy is constant so it may be analyzed with classical mechanics as long as its classical angular momentum is an integral multiple of quantum angular momentum, or $m_e vr = n\ h/2\cdot pi$. Under these conditions the electron has a kinetic orbital and a potential coulomb attraction energy, or $E = KE + PE = \frac{1}{2}mv^2 - k_e e^2/r$, and these energies result in equal coulomb and centripetal forces that maintain the orbit.

With equal coulomb and centripetal forces, $k_e e^2/r^2 = m_e v^2/r$, the kinetic energy is $KE = \frac{1}{2}mv^2 = \frac{1}{2}k_e e^2/r$ and substitutes into the $E = \frac{1}{2}mv^2 - k_e e^2/r$ energy relation so $E = \frac{1}{2}k_e{}^2/r - ke e^2 = -\frac{1}{2}k_e e^2/r$. This negative value means that the electron is bound to the proton in an energy well where the electron's kinetic energy is exactly half of the potential energy so it only requires $\frac{1}{2}k_e e^2/r$ to ionize it from the proton and make the total energy equal to zero.

Since the electron's classical and quantum angular momentums are equal, $m_e vr = n\, h/2\cdot pi$, its velocity is $v = n\, h/2\cdot pi\cdot m_e r$ which Bohr substituted into his **KE** $= \frac{1}{2}mv^2 = \frac{1}{2}k_e e^2/r$ relation to derive a quantized orbital radii expression, $r_n = n^2h^2/4\cdot pi^2 m_e k_e e^2$, which is Bohr's $a_o = 0.529177249 \times 10^{-10}$ m lowest energy state radius if $n = 1$ and $r_n = n^2 a_o$. With known radii, and energy in terms of r_n, the allowed quantum energies are $E_n = \frac{1}{2}k_e e^2/r_n = (1/n^2)\ \frac{1}{2}k_e e^2/a_o$, which simplifies to $E_n = -13.6/n^2$ eV (actually $13.605698/n^2$ eV).

The $E_n = -13.6/n^2$ energy levels constitute energy wells that specify the electron's ionization energy. The $n = 1$ ground state energy is 13.6 eV, which is hydrogen's actual ionization energy so Bohr had achieved a major success with his model. For $n = 2$ the ionization energy is 3.4 eV, and so forth, up to $n = \infty$ where it completely ionizes and behaves classically. But Bohr's crowning achievement was that his model predicted hydrogen's spectra.

Balmer and others had developed **an** empirical relation for the wavelength of emitted light, $1/\lambda = R_H(1/n_1{}^2 - 1/n_e{}^2)$, where R_H is Rydberg's 1.0973731534×10^7 m^{-1} experimentally derived constant. And since Bohr had postulated that an electron emits a photon when jumping between energy levels he calculated that $f = (E_e - E_1)/h = k_e e^2/2a_o h(1/n_1{}^2 - 1/n_e{}^2)$, which matches the empirical relation since $1/\lambda = f/c$, and when he calculated $k_e e^2/2a_o hc = 1.097373227 \times 10^7$ m^{-1} he was within 6.743×10^{-6} % of Rydberg's constant.

Bohr had successfully explained the ionization energy and the observed spectral lines. When improved spectroscopy revealed that these lines were actually closely spaced line pairs which could be further split into 3 closely spaced lines if the atoms were placed in strong magnetic fields, De Broglie, Schroedinger, Dirac, Pauli and Heisenberg then used this new information and Bohr's model to develop modern quantum theory based on the electron's wave nature with a principle quantum number n, an orbital quantum number l, an orbital magnetic number m_l, and a spin magnetic quantum number m_s.

This version of quantum theory is accepted as correct because it not only explains the observed spectra of all elements, it also explains the observed bonding angles between atoms in molecules in terms of Schroedinger's electron orbital wave functions. However there is one aspect of modern quantum theory that matches Bohr's model exactly, the allowed energy states of the principle quantum number n are still $E_n = -\frac{1}{2}k_e e^2/a_0 n^2$ and it was from this relation that Bohr developed his Correspondence Principle.

Simply stated, quantum mechanics and classical physics agree when the energy differences between quantized levels vanish, which occurs for hydrogen if n = 10,000 since the electron's energy well in this state is only $E = 13.6/10^8 = 1.36 \times 10^{-7}$ eV and only 2.72×10^{-11} eV or 0.02% different from its adjacent energy state. The significance of this is that the differences between energy wells and their depths are converging to zero so the continuous energy relations of classical physics apply to the proton and electron.

Einstein showed by Relativity that nature's laws are the same in all inertial reference frames and no preferred reference frame exists so observers cannot tell if they or the reference object is moving. Normally hydrogen is analyzed from an independent vantage relative to the proton since it is heavier than the electron. But from the electron's vantage the proton appears to orbit it just as the sun appears to orbit earth. Because a proton is $m_p/m_e = 1836$ times heavier than an electron it appears to be a very high energy state particle with respect to the electron, which means that it's behavior will be classical by Bohr's Correspondence Principle.

This means that an electron's quantum behavior to independent observers becomes classical behavior from the electron's vantage. The concept is further substantiated by Heisenberg's Uncertainty, which states that it is fundamentally impossible to simultaneously measure a particle's position and momentum with infinite accuracy. This is mathematically stated as $dx \cdot dp \geq \frac{1}{2}h/2 \cdot pi$, which means the position and momentum uncertainties are greater than or equal to ½ the photon wavelength used to measure it, since a photon transfers momentum and distance less than ½ a wavelength can't be measured.

However Heisenberg's Uncertainty is a statement of logic that is accepted because no line of reasoning has been able dispute it, but it has corollaries. First, it only applies to measurements by observers and only exists because of the actual characteristics of particles and photons. So it really occurs by a particle-photon Certainty relation which Yukawa and Feynman relied upon to predict pion existence and develop particle interaction Feynman Diagrams. Second, measurement accuracy increases as an observer moves closer to an object. And third, momentum accuracy increases as the mass to velocity ratio of a particle's momentum increases.

So standing on a hydrogen atom's proton yields large position and momentum measurement uncertainties, but moving to the electron makes its position known and the proton's distance uncertainty is reduced by the ratio of its larger size to the photon, minimizing the photon's quantum effect. The proton's mass is also 1836 times less affected by the photon's momentum. And combined both effects reduce the quantum nature by the ratio of proton to electron radii times their mass ratio, or about 40,000 times.

So as with Bohr's Correspondence Principle, quantum mechanics and classical physics agree if Heisenberg's Uncertainty converges by changing vantage to the smallest particle since quantum effects are masked by closer proximity to the smaller particle and greater size and mass to velocity ratio of the larger particle's momentum. This is why planets and stars behave by classical and relativistic relations while atoms have quantum statistical relations, and if we change our vantage to the electron's everything we reference to has greater size and mass so continuous classical physics applies.

And there is an important consequence of quantum to classical convergence. Planck's $h = 6.626075 \times 10^{-34}$ Joule-seconds Constant was originally shown to correlate light's wavelength and energy by $E = hc/\lambda = hf$ in hot body emission experiments. It was then shown by photoelectric experiments that electron ionization only occurs if light's energy equals the orbital ionization energy or $E_i = hf$. And finally Einstein showed with his $hf = E_i + \frac{1}{2} mv^2$ photoelectric relation that if light's energy exceeds the ionization energy its excess energy equals the electron's kinetic energy. So it takes a threshold frequency of light to ionize an electron and any extra energy in higher frequency light becomes electron kinetic energy, which means that light is discrete bundles or quanta of energy.

From this Planck's Constant was concluded to be a fundamental structural energy unit in matter, as in an orbital oscillation or $E = hf$ photon energy. For constant energy, position and momentum are specified by Heisenberg's $x \cdot p = \frac{1}{2}h/2 \cdot pi$ Certainty relation and if energy changes, as in an $E_e - E_1 = hf$ orbital jump, his $dx \cdot dp = \frac{1}{2}h/2 \cdot pi$ Uncertainty applies because position and momentum cannot be measured. So Bohr postulated correctly that for a constant $E = KE + PE$ orbital energy, the coulomb and centripetal forces balance and $m_e vr = nh/2 \cdot pi$ because distance and momentum vary continuously but with a constant radius velocity product over an orbital period so $x \cdot p/T = \frac{1}{2}h/2 \cdot pi \cdot T$, where $\frac{1}{2}x \cdot p/T = \frac{1}{2}mv^2$, and energy is constant.

It is an average energy with momentum and distance components of h that continuously vary in magnitude and direction. They can not be precisely measured but $mv^2 = \frac{1}{2}h/2 \cdot pi \cdot T$ so the $\frac{1}{2}mv^2$ KE = $\frac{1}{2}$PE and it is a stable energy well as Bohr analyzed with energies that are classically continuous from the electron's vantage. So h is not just a quantum structural energy unit. Under these conditions $h = 6.626075 \times 10^{-34}$ Newton-meter-seconds with behaviors that are distinctly opposite to the quantum Joule-seconds behaviors. This makes it a superposition state with one set of behaviors from the independent observer's vantage and a diametrically opposing set of behaviors from the perspective of an electron inside the atom.

This gives Planck's Constant a unique relativistic lens or rectifier effect that only allows observers a glimpse of what is occurring in particle interactions. Like a gravitational lens effect deflecting starlight around the sun, star's gravitational fields shifting atomic spectra to lower frequencies, or frequency shift caused by stars moving away or towards observers, the cause of the effects may only be surmised from an observer's vantage but continuous classical-relativistic principles do explain them.

For constant orbital energies classical principles yield the correct principle quantum number energies based on h whether $n = 1$ ground or higher state energies. And orbital energy jumps explain $hf = E_e - E_1$ frequency emissions in terms of h. But no classical interpretations of distance or momentum explains the instantaneous quantum jump or its statistical outcomes from our vantage. So the electron behavior is classically explained within constant energy orbitals but not in between them. However each case, the initial orbital, intermediate jump and final orbital, is defined by h.

Since the components of h are classical for constant energies it may be postulated that behavior during the energy jump is also classical, just as classical impulse explains short high intensity energy transfers. Since electron behavior is defined within the constraints of h, and classical during constant energy conditions, then without evidence to the contrary it may be surmised that the behavior is also classical during energy level jumps, especially if light speed photon energy transfer constitutes a short impulse energy equivalent to a high energy state, and classical by Bohr's Correspondence, with time dilated classical momentum and distance behaviors that appear instantaneous to a relatively lower energy density observer through a relativistic lens of Planck's Constant.

And with these interpretations of Bohr's Correspondence, Heisenberg's Uncertainty and Planck's Constant it is possible to explain neutrons and their spin, nuclear binding, quantum behavior in atoms, proton charge, magnetism and spin, and neutrinos.

Neutron Spin

Protons, electrons and neutrons are matter's building blocks. And although well studied with precisely measured characteristics, their spin and magnetic values have yet to be explained in terms of quantum $\frac{1}{2}$-integer multiples of Planck's Constant. Even more mysterious is that neutrons possess magnetism without a charge.

The concept of spin originates from the gyroscopic behavior of spinning masses that orients them along their axis of rotation. Because the resultant of spin is along its spin axis tops stand up and they are referred to as having a spin of 1. The strength or moment of a spin resultant is given by a simple L = mvr relation, where L is the angular moment created by a mass m rotating with a velocity v at a radial distance r from its center axis. (Fig. 1)

Particles however have angular moments quantized in terms of Planck's Constant h and can only have $L = (s(s+1))^{\frac{1}{2}}\ h/2\cdot pi$ values, so if $s = \frac{1}{2}$ and $(\frac{1}{2}(\frac{1}{2}+1))^{\frac{1}{2}} = (3/4)^{\frac{1}{2}} = 3^{\frac{1}{2}}/2$ then $L = 3^{\frac{1}{2}}\ \frac{1}{2}h/2\cdot pi$. This means the moment has a resultant of $3^{\frac{1}{2}}\ \frac{1}{2}h/2\cdot pi$ that precesses about its center axis (Fig. 2) when the particle is in an external magnetic field. Since the component in the direction of the field is $\frac{1}{2}h/2\cdot pi$ the precession angle is $\cos^{-1}\ (\frac{1}{2}h/2\cdot pi)\ /\ (3^{\frac{1}{2}}\ \frac{1}{2}h/2\cdot pi)$ $= \cos^{-1}\ 3^{-\frac{1}{2}} = 54.735610^{o}$ from the center axis. (Fig. 3)

In electrons the magnetic moment relates to its charge e and mass m_e by Bohr's $u_B = e/m_e\ \frac{1}{2}h/2\cdot pi$ magneton relation, which means the component in an external magnetic field's direction is $\frac{1}{2}h/2\cdot pi$ times the electron's charge-to-mass ratio. Using the same line of reasoning scientists expected the proton's and neutron's magnetons to be explained by substituting the proton's mass m_p into the Bohr relation to yield a $u_n = e/m_p\ \frac{1}{2}h/2\cdot pi$ nuclear magneton but their actual measured values are 2.7928 u_n and -1.9135 u_n, respectively, and no line of reasoning to date has explained these variations.

However the proton's 2.7928 variation can be simply explained

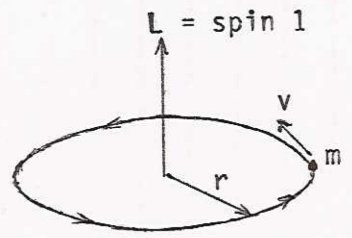

Fig. 1

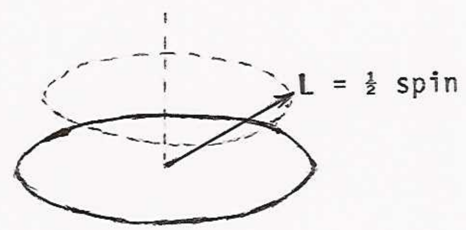

Fig. 2

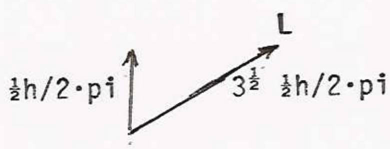

Fig. 3

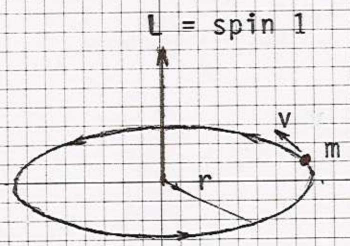

Fig. 1

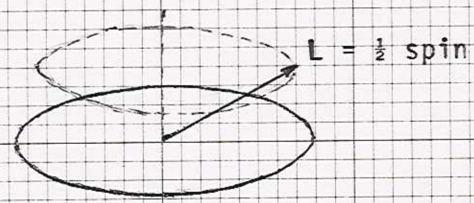

Fig. 2

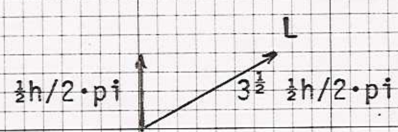

Fig. 3

by examining Bohr's $u_B = e/m_e \frac{1}{2}h/2\cdot pi$ relation. The fundamental angular momentum unit is $h/2\cdot pi$ and for particles its value in an external magnetic field's direction is ½ of that. Conceptually a magneton is generated by an orbiting charge e and attenuated by a mass m_e in the field, and if mass attenuates a field then a lower density would be expected to mitigate that attenuation.

An electron's radius is 0.05 fm (1 fermi = 1×10^{-15} m) and a proton's radius is 1.0355 fm so the proton has a $(r_p/r_e)^3 = 20.71^3 = 8882.6$ times greater volume. But their mass ratio is m_p/m_e = 1836.153 so the proton has a 8882.6/1836.136 = 4.8376 times lower density. Because density is 3-dimensional and a magnetic field is 1-dimensional the effect of its lower density is to increase the nuclear magneton by $4.8376 / 3^{\frac{1}{2}} = 2.7930$, within 0.007% of 2.7928.

While lower density explains the proton's 2.7928 u_n magneton a neutron is chargeless and a -1.9135 negative magneton means that its field direction is opposite to the angular moment as if it was generated by a (-) orbital charge. The only comparable structure in nature is that of a hydrogen atom, neutral since a (-) orbital electron and (+) proton nucleus cancel charges, and the orbital electron generates a magneton in a direction opposite its angular moment. The fact that a neutron decays into a proton, electron, electron anti-neutrino and 0.78233 MeV energy also substantiates that a neutron may be a special case of a hydrogen atom.

Bohr analyzed that hydrogen is a proton and orbital electron with an $a_o = n^2(h/2\cdot pi)^2 / k_e m_e e^2 = 0.529177249 \times 10^{-10}$ m radius and an $E_o = -k_e e^2 / 2a_o = -13.605698$ eV n = 1 quantum ground state energy. This -13.6 eV energy is a radial charge energy that bonds the proton and electron in a 2-dimensional planar orbit but actual orbitals form 3-dimensional spheres since planar orbitals precess to maintain equal dimensional energies. If a neutron is hydrogen with a (+) 0.78233 MeV energy then its orbital would be unstable and decay like neutrons do, its energy would divide into 3 equal 260777 eV components and it would have an $r_o = a_o\ (E_o / 260777 \text{ eV})$

= 2.760913 fm radius. Since 0.78233 MeV amounts to a (0.78233 MeV + m_e) / m_e = 2.53098 electron mass increase it relativistically contracts this orbital radius to $r_n = r_o$ / 2.53098 = 1.09085 fm

Because the electron radius is only $r_n - r_p$ = 0.05535 fm from the proton it may be represented by Bohr's magneton relation with a proton mass, density and (-) moment generated by a (-) particle. However the 2.53098 relativistic contraction constitutes a density or mass increase in the magneton 2-dimensional orbital generation plane but not the 3rd dimension so the 4.8376 lower proton density is attenuated to yield -4.8376 / 2.53098 u_n = -1.9113 u_n. This is less than the neutron's measured -1.9135 u_n value because the neutron's magneton measurement was made using a deuterium nucleus which is 2.224356 MeV less massive than the 1877.838 MeV mass of a proton and neutron. Since this represents a 0.1185% mass loss the measured magneton will be 0.1185% greater and -1.9135 (1.001185) = -1.91356, or within 0.0034% of the measured value.

In the neutron with a relativistically contracted orbital the proton mass center contracts toward the orbital electron surface that observers see. In essence, the proton with a spin 1 angular moment moves toward observers $(r_o - r_n) / r_o$ = 60.4895%, which is the cosine of a 52.7787° spin moment, within 1.957° or 3.6% of the 54.7356° ½-spin moment. However the proton is also accelerated by the electron's charge through contracted space with a 2.53098 time dilation, causing its acceleration to persist after the electron has continued along its orbital path to the proton's far side.

The electron and proton have an average $r_n - r_p$ = 0.05535 fm gap between their radii so the proton has a peak $2^{\frac{1}{2}}$ x 0.05535 fm = 0.078277 fm motion away from the electron's $r_o - r_n$ = 1.670 fm far side contraction. However this 0.078277 fm gyration is reduced by the 2.53098 m_e / 1836.153 m_e = 0.0013784 relativistic electron to proton mass ratio times the 1.0355 fm proton radius, or 0.0013784 x 1.0355 fm = 0.00142735 fm So the 0.078277 fm - 0.00142735 fm = 0.07685 fm gyration is 180° out of phase with the electron and the spin 1 displacement is $(r_o - r_n - 0.07685 \text{ fm}) / r_o = 57.706\%$, the cosine of 54.756^o and within 0.037% of the 54.7356^o ½-spin value.

Angular momentum must conserve and when a neutron decays from its 3-dimensional relativistically contracted spherical orbital to a proton, electron and 0.78233 MeV, the proton and electron form a ground state hydrogen with the electron in a 2-dimensional planar Bohr orbital $E = -13.6 \text{ eV} / n^2$ energy state. This means that a dimensional momentum has been lost which is equivalent to a 3rd dimension in Bohr's analysis. His 13.6 eV radial and associated kinetic energies are components of a $(13.6^2 + 13.6^2)^{\frac{1}{2}} = 19.24$ eV 2-dimensional resultant. And a lost dimension of this energy in a 3-dimensional volumetric form would be $19.24^{1/3} = 2.67959$ eV times the 2.53098 relativistic contraction, which results in the 6.78 eV ½-spin electron anti-neutrino that occurs on neutron decay

So a simple classical-relativistic analysis, permitted by the Bohr Correspondence Principle since the electron is 0.78233 MeV, accounts for the neutron's mass, radius, neutral charge, magneton, ½-spin and decay products. Protons can be similarly explained but are more complex and require further conceptual development before being examined. And, as will be shown, resonance between the time dilation and spatial contraction that results in the ½-spin of the neutron can also explain the observed quantum integer increments in orbital energy and oscillation frequency based on Planck's Constant. But first nuclear binding and the associated nuclear magnetons need to be examined to further develop the concepts.

Nuclear Force

Light is an electromagnetic structure with inertial momentum, particles have charge, magnetism and inertial mass, and all forms of matter from atoms to Black Holes seem to exist and interact by inertial and electromagnetic forces, with the exception of nuclei. So the Universe's structure exists by inertia and electromagnetism but somehow 99% of its mass is captured into tiny proton-neutron clusters that are bound by a unique force.

How, in such a vast recursive structural pattern of matter, can a unique force only manifest in one element of the pattern unless it somehow relates to the forces that cause the pattern? And, if the inertial can alter the electromagnetic, bending it and changing its energy as stars do to light, then is it not possible for inertia to concentrate its strength into a unique form?

When examining a Potential Energy versus Separation plot for nuclear binding (Fig. 4) it can be seen that within 2.7 fm energy must be added according to a curve similar to Bohr's $U = -k_e e^2 / r$ Potential Energy versus Radius plot for hydrogen (Fig. 5) until the neutron and proton are about 1 fm apart. Then energy releases as they form a fixed 0.4 fm bond that requires an equal energy to separate them back to the 1 fm transition point.

Prior to 2.76 fm a proton would see a neutron as neutral but, using the orbital electron neutron model, at 2.76 fm a proton and neutron's proton would exhibit an $F = k_e e^2 / r^2$ coulomb repulsion. The electron sees itself as $r_o = 2.76$ fm from the neutron's center (Fig. 6a) but the reactant proton sees it $r_n = 1.091$ fm from the center because of its 2.53 spatial contraction (Fig. 6b). So when the proton, with an $r_p = 1.03$ fm radius, is 2.76 fm from a neutron its center is $(2.76 + r_p) = 3.79$ fm from the electron and $(2.76 + r_n + r_p) = 4.88$ fm from the neutron center (Fig. 6c), with an $E_a = k_e e^2/3.79$ fm $= 0.38$ MeV attraction energy for the electron and $E_r = k_e e^2/4.88$ fm $= 0.30$ MeV repulsion toward the neutron's proton.

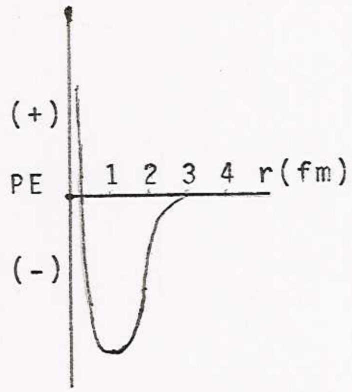

Fig. 4

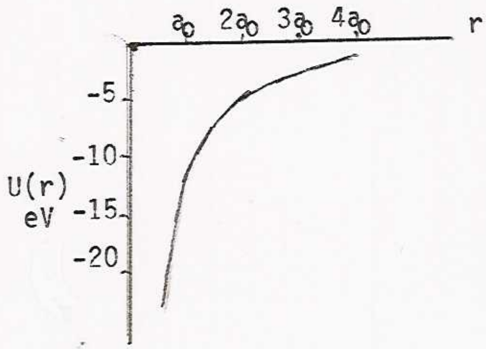

Fig. 5

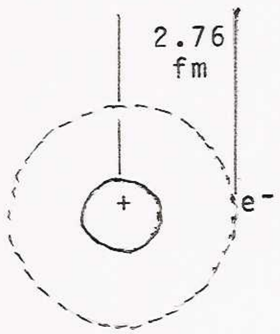

Fig. 6a

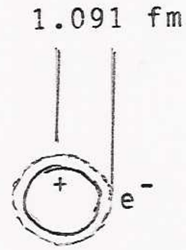

Fig. 6b

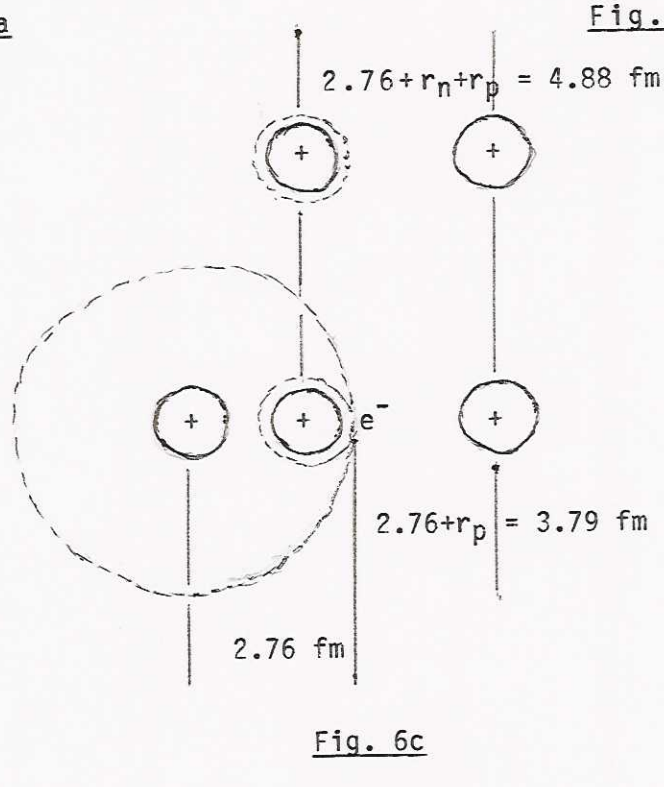

Fig. 6c

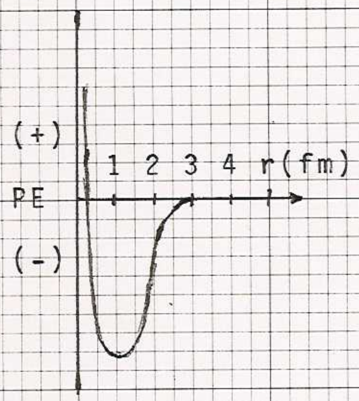

Fig. 4

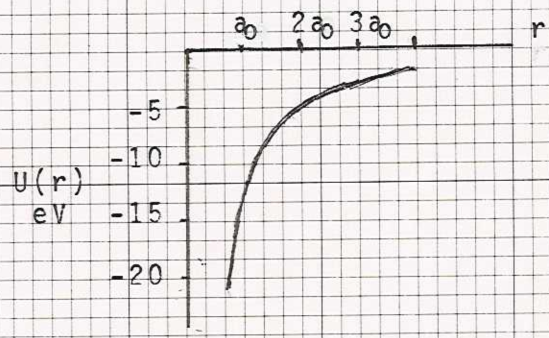

Fig. 5

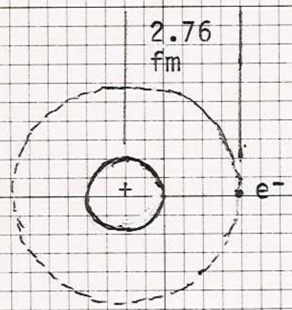

Fig. 6a

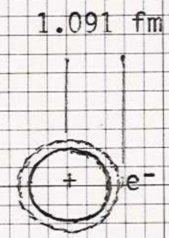

Fig. 6b

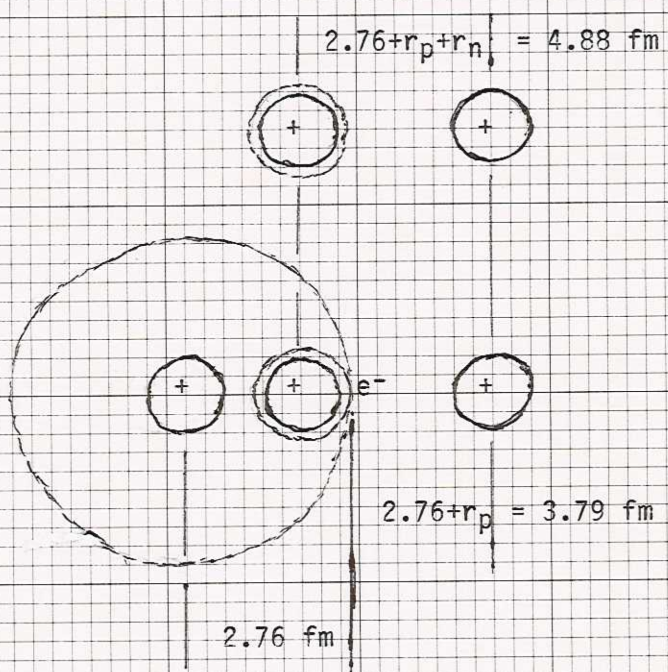

Fig. 6c

The reactant proton should feel a 0.08 MeV attraction at 2.76 fm but actually has no net force because the less massive electron absorbs the energy which alters its spherical neutron orbital to increase its duration between the protons, so 2.76 fm becomes the initial interaction point. The increased presence of the electron between the protons also attenuates their repulsion to modify the shape of potential energy curve between 2.76 fm and 1 fm.

As the reactant proton approaches 1 fm from the neutron its center is $(1 + r_n + r_p) = 3.12$ fm from the neutron's center and the repulsion energy between it and the neutron's proton should be $E_r = k_e e^2 / 3.12$ fm = 0.46 MeV. However because a 1 fm separation between the proton and neutron is less than the proton's radius of 1.03 fm something very significant occurs.

In 1961 Stanford's Hofstadter and Cornell researchers showed that a proton's charge is less than $\frac{1}{2}e^+$ 0.3 fm from its center and increases to a e^+ surface charge, which means that if protons are within a radial distance of each other the energy calculation must be to their surfaces, not centers. For a 1 fm gap the $E_r = k_e e^2/r$ repulsion energy is 1.44 MeV which the 0.78233 MeV orbital neutron electron also absorbs to give it a total E_e = (0.78233 MeV + 1.44 MeV) = 2.2223 MeV, and within 0.075% of deuterium's 2.224 MeV B.E.

Because of the electron's lower mass, the absorbed attraction energy accelerates it from its neutron state toward the reactant proton with an excess (1.44 - 0.78233) = 0.658 MeV, since 0.78233 MeV counters the original neutron's 0.78233 MeV, and it will form a neutron state with the reactant proton. A neutron state may not exceed 0.78233 MeV because contracting a 2.76098 fm radius orbital to less than 1.091 fm would impact the proton's 1.0355 fm radial surface, which is not contracted by the electron's 0.138% mass.

The opposing 0.78233 MeV energies have two effects, forming a neutron state with the reactant proton and causing a relativistic 2.531 contraction of the 1 fm to the observed 0.4 fm nuclear bond.

In this configuration the electron has a local perspective of 1 fm from a proton surface and 2.76 fm from a proton center (Fig. 7a), and observers see a proton and neutron gap of 0.4 fm (Fig. 7b). Because the electron already has an orbital angular momentum, the added 0.658 MeV forms a resonance orbital with the protons that carries it 1 fm from one proton where it absorbs 1.44 MeV to form a neutron orbital state that brings it to 1 fm from the other.

In order for a resonance orbital to occur between the protons the 0.658 MeV energy component orthogonal to their connecting axis must have a comparable energy occurring along the connecting axis, like the orthogonal kinetic and potential energies in a pendulum. In other words, the 0.658 MeV resonance energy must synchronize to the 0.78233 MeV neutron energy. Since the radial component of a 0.78233 MeV 3-dimensional orbital is 0.78233 MeV/3 = 0.260777 MeV, and it occurs in space contracted by 2.531 from 1 fm to 0.4 fm for independent observers, it becomes 2.531 x 0.260777 MeV = 0.660 MeV which is within 0.3% of the 0.658 MeV for a 1 fm interaction.

And if 0.660 MeV is used in the model as the resonance energy it results in a (0.78233 MeV + 0.660 MeV) = 1.442 MeV interaction energy which, added to the pre-exising 0.78233 MeV neutron energy, yields deuterium's 2.224 MeV B.E. at $r = k_e e^2/1.44$ MeV = 0.998 fm. So a 0.660 MeV resonance energy and a 0.78233 MeV neutron orbital energy do synchronize at a 0.998 fm interaction distance, a 1.44 MeV attraction energy results that in conjunction with the 0.78233 MeV neutron state energy yields deuterium's 2.224 MeV B.E. and a 0.78233 MeV component of the 1.44 MeV energy contracts the 0.998 fm separation by 2.531 to the observed 0.4 fm bond.

Actual binding occurs by proton mass loss from electrostatic repulsion in a relativistic acceleration field. An electron will gain mass by acceleration in an electric field and will lose mass by deceleration in an opposing field. Similarly, in the deuterium proton-electron-proton model the protons are held in equilibrium by their repulsion and the electron's attraction, with equal 1.44

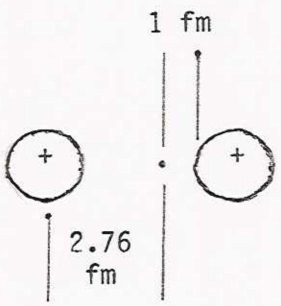

Fig. 7a

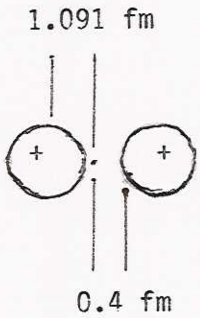

Fig. 7b

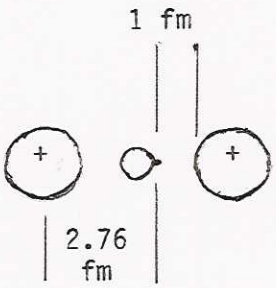

Fig. 8a

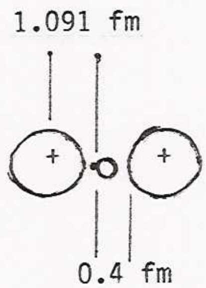

Fig. 8b

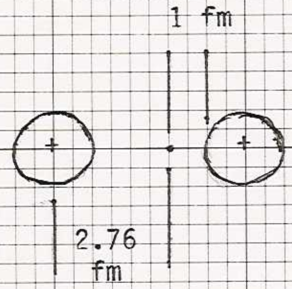

Fig. 7a

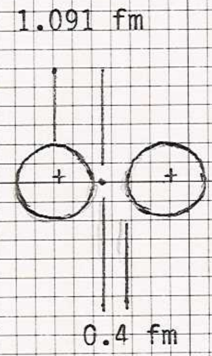

Fig. 7b

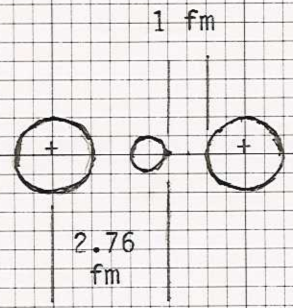

Fig. 8a

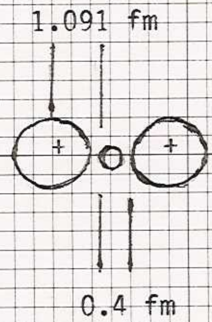

Fig.8b

MeV 1 fm energies, but the added 0.78233 MeV electron axial energy causes a relativistic contraction or acceleration field, which the protons' charge repulsion opposes, and if acceleration increases mass then such a deceleration will result in a mass loss.

From its perspective the electron resonates between 1 fm from the surface and 2.76 fm from the center of each proton (Fig. 8a), but the protons see 2.531 spatial contractions of each distance by the opposing 0.78233 MeV electron energies so it resonates between a 1.091 fm neutron state radius to a 0.4 fm surface distance, from $r_n - r_p$ = 0.0555 fm to 0.4 fm from their surfaces, so they only see themselves as 0.4 fm from each other (Fig. 8b). When the electron is on the proton-proton axis they each see a e^- charge less than a radial distance away so there is a -2e charge gradient from each proton's surface to the electron which neutralizes the 2e gradient between them. However, during each orbital ½-cycle the e^- charge is adjacent to the protons, not between them, so they repel in an acceleration field that persists because of its dilated time, and which gives them a deceleration mass loss.

Since this occurs in ½-cycles the mass loss or Binding Energy is an $E = k_e e^2/r = Fd$ average energy, or ½ the contracted distance times the force change between 0.4 fm and 1 fm, so B.E. = ½ (0.598 fm) ($F_{0.4} - F_{0.998}$) = 0.299 fm (1440.5 - 231.6 = 1208.9 N) = 3.615 x 10^{-13} J = 2.256 MeV, within 1.5% of 2.224 MeV. Alternatively, relativistic contraction magnifies the 1.442 MeV attraction energy so when the 1 fm interaction distance contracts by 2.531 the 1.442 MeV energy becomes a relative 1.442 MeV x 2.531 = 3.6497 MeV and a 3.6497 MeV - 1.442 MeV = 2.206 MeV increase in attraction energy.

This requires an equal proton repulsion so the deceleration mass loss is also 2.206 MeV, within 0.7% of 2.224 MeV. The error is attributed to distance resolution and probable distortions by 1-dimensional forces along the protons' axis to the 2-dimensional resonance orbital, since the axial electron charge attraction only occurs along the axis and which would oblate a circular orbital.

Nuclear Binding therefore occurs when a reactant proton with at least 1.442 MeV of kinetic energy in the direction of a neutron reaches a 0.998 fm interaction point so the neutron's electron can absorb 1.442 MeV in coulomb energy from it. This energy adds to its existing 0.78233 MeV to yield 2.224 MeV with two 0.78233 MeV energies to maintain a neutron state and relativistically contract the 0.998 fm separation by 2.531 to a 0.4 fm bond. The 1.442 MeV also has a 0.660 MeV component, related by the 2.531 contraction to the 0.78233 MeV / 3 = 0.260777 MeV neutron state radial energy, to maintain a resonance of the neutron state between the protons.

The 2.224 MeV B.E. results from proton mass loss by coulomb repulsion in the electron's acceleration field that contracts them from 1.442 MeV at 1 fm to 3.666 MeV at 0.4 fm. Since the electron maintains a resonance orbital, and orbital momentums are equal and opposite and cancel in the dilated time of the acceleration field, the electron's 1.442 MeV absorbed from the proton constitutes an orbital energy without mass increase or negative energy well that binds the protons by a relativistically enhanced coulomb force, or a Nuclear Force that causes a 2.224 MeV mass loss by the protons' coulomb deceleration in the relativistic acceleration field.

Deuterium's 2.7928 u_n proton and -1.9135 u_n neutron magnetons would be expected to align and produce a 0.8797 u_n resultant but its actual value is 0.8574 u_n. This discrepancy results from the electron's resonance orbital magneton effect that acts to increase the (-) neutron component and decrease the (+) proton component.

The electron's 2.761 fm neutron state radius contracts by its 2.531 mass increase to the observed r_n = 1.091 fm radius and when it changes neutron states it will be 0.998 fm contracted to 0.4 fm from the proton's surface so its resonance orbital radius is 2.761 fm - r_p - 0.998 fm = 0.7275 fm / 2 = 0.3637 fm that its absorbed 1.442 MeV contracts by $m_e/(m_e + 1.442)$ = 0.26165 to a 0.09516 fm peak radius with a $0.09517/2^{\frac{1}{2}}$ = 0.0673 fm average. The resonance orbital occurs within the 2.761 fm neutron radius so it reduces it to a 2.761 - 0.0673 = 2.6937 fm radius which contracts by 2.531 to 1.0643 fm. This compounded 1.0643 / 1.091 = 0.9755 relativistic contraction attenuates the magnetons to (2.7928 - 1.9135) x 0.9755 = 0.8578, which is within 0.05% of deuterium's 0.8574 magneton.

Shared-electron resonance bonding was first presented in 1939 by Linus Pauling in "The Nature of the Chemical Bond" and explains benzene type compounds by showing that delocalized electrons form energetically favorable bonds between atoms. If these principles apply to bonding at atomic distances then there is also reason to believe that they apply at nuclear distances, with the distinction that a high energy electron invokes Relativity which magnifies the forces and their persistence, allowing one electron to maintain an equilibrium with 2 protons. This makes the bonding more ionic and predictable, like Na^+ and Cl^- ions in salt, than covalent quantum statistical bonding between atoms of similar electronegativities.

Technically a reactant proton and neutron state electron are a Bronsted-Lowry proton-donor acid and a proton-acceptor base. By this definition a nuclear resonance bond is a reversible internal acid-base reaction that inter-converts isomers (p-n = n-p) by the movement of an electron and a hydrogen atom (in a neutron state). In chemistry this is a tautomeric structure, or tautomerism, which makes nuclear and molecular bonding parallel functions.

Deuterium's resonant orbital electron bond is a 1-dimensional bond between two nucleons and applies with equal accuracy to the 2- and 3-dimensional nucleon structures of tritium helium-3 and helium-4. A general B.E. = $3^{1/d}$ $(p \times 2.2147)^n$ geometric relation exists, where 2.2147 MeV is deuterium's 1-dimensional B.E. reduced by 0.42% to account for orbital resonance distortion from multiple dimensions, d is the structural dimension (2 for H-3 and He-3 and 3 for He-4), and p and n are the number of protons and neutrons. Calculated Binding Energies for H-3, He-3 and He-4 are 8.495 MeV, 7.672 MeV and 28.296 MeV respectively, within 0.6% of the actual 8.482 MeV, 7.718 MeV and 28.297 MeV values.

In Tritium and Helium-3 the electrons follow planar tri-lobed clover-leaf orbitals (Fig. 9a) with neutron state radii from each proton center and ½-cycle resonance orbital transition regions to change neutron states. With a 2.761 fm neutron radius, a 0.998 fm separation and 1.0355 fm proton radius, the transition region has a (2.761 - 0.998 - 1.0355) = 0.7275 fm cross-section diameter that occurs within each neutron state radius and a 0.36375 fm resonance orbital radius. So the electron passes within 1 fm from a proton, absorbs 1.442 MeV to undergo transition to a neutron state with it as in deuterium, and then repeats the process with each proton.

Because a 3rd proton is present the electron absorbs an added coulomb energy as it transitions the resonance orbital's ½-cycle. The distance from the 3rd proton's center to the electron cannot be computed as it undergoes a resonance orbital transition because it is in a quantum relativistic state change from a neutron state with the 1st proton to a neutron state with the 2nd. However the 3rd proton's energy component may be found as it enters transition by calculating the resultant of the distance to the center-line of the other two protons and the resonance orbital's ½-cycle radius.

The center-line's distance is cos 30^o ($r_n + r_p$ + 0.998 fm) = cos 30^o (4.7945) = 4.1522 fm and the resonance orbital radius is 0.36375 fm so the resultant is $(4.1522^2 + 0.36375^2)^{\frac{1}{2}}$ = 4.1681 fm There are three forces acting on the electron at this point. From the reactant proton at 0.998 fm the force is $F_r = k_e e^2/0.998\ fm^2$ = 231.63 N. From its neutron state proton at 2.761 fm the force is $F_n = k_e e^2/2.761\ fm^2$ = 30.264 N. And from the 3rd proton at 4.1681 fm the force is $F_3 = k_e e^2/4.1681\ fm^2$ = 13.28 N. Since the neutron and reactant proton forces oppose their sum is F_s = 231.63 - 30.26 = 201.37 N and the resultant of all three forces is $(F_s{}^2 + F_3{}^2)^{\frac{1}{2}}$ = $(201.37^2 + 13.28^2)^{\frac{1}{2}}$ = 201.807, which represents a 201.807 / 201.37 = 1.00217 increase in the 2.224 MeV electron energy to 2.2288 MeV. And substituting this exact 1-dimensional binding energy into the general relation yields a B.E. = $3^{\frac{1}{2}}$ $(2 \times 2.2288)^1$ = 7.7208 MeV, which is within 0.0032% of He-3's actual 7.718346 MeV energy.

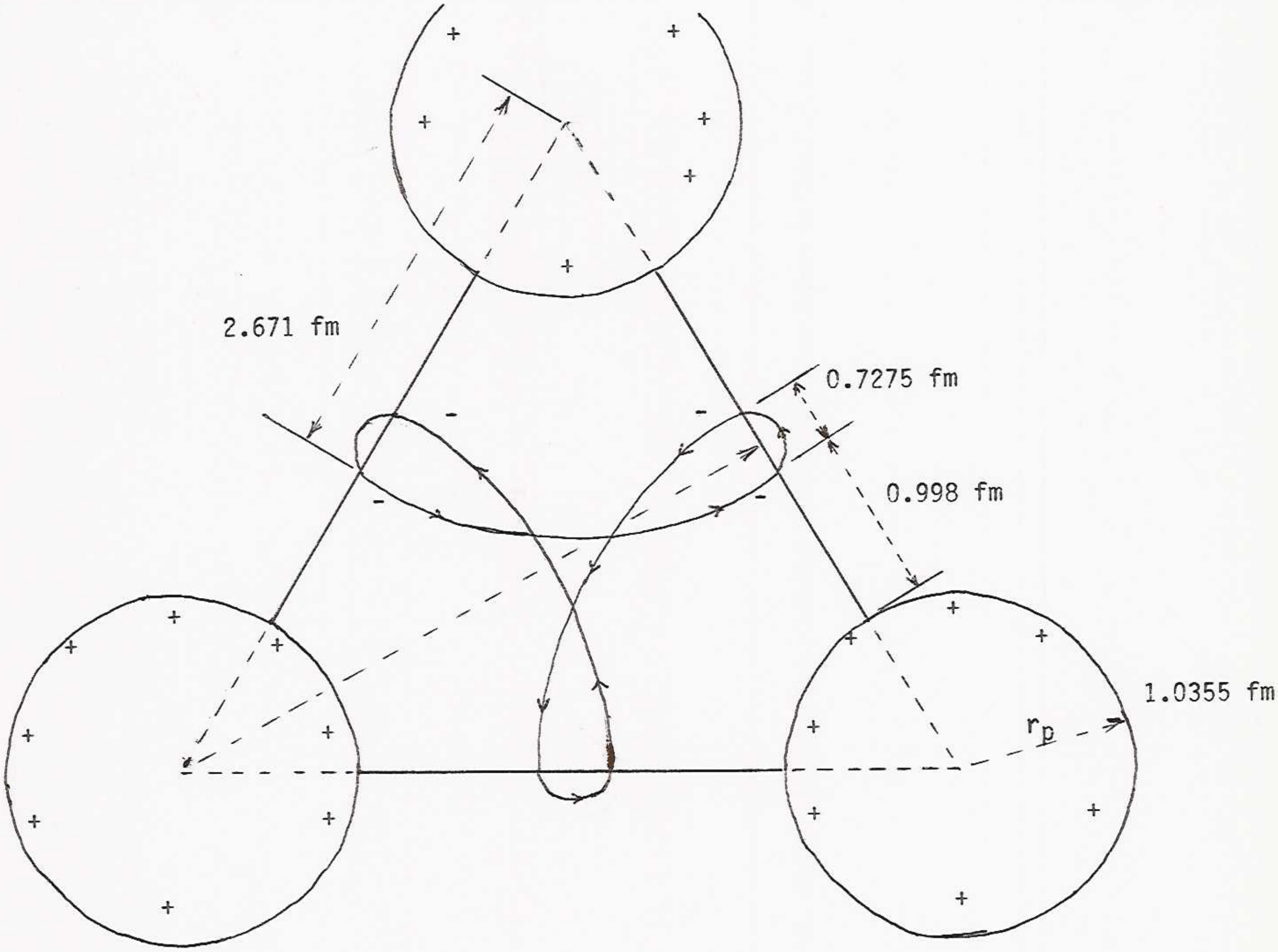

Fig. 9a - Tritium and Helium Orbital

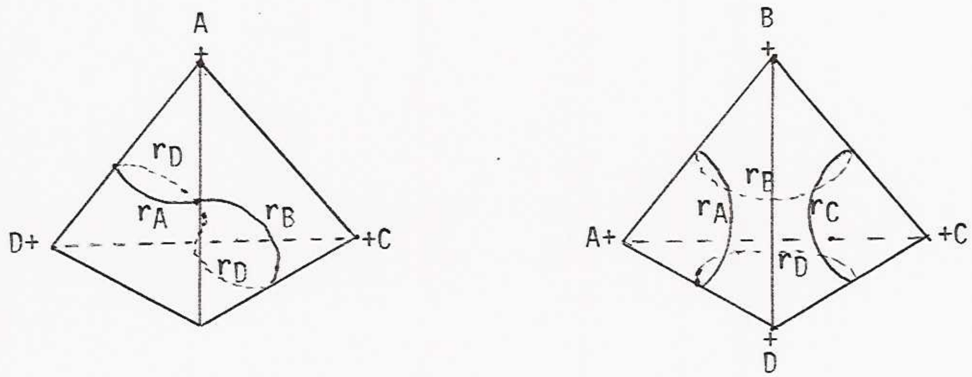

Fig. 9b - Helium-4 Orbital

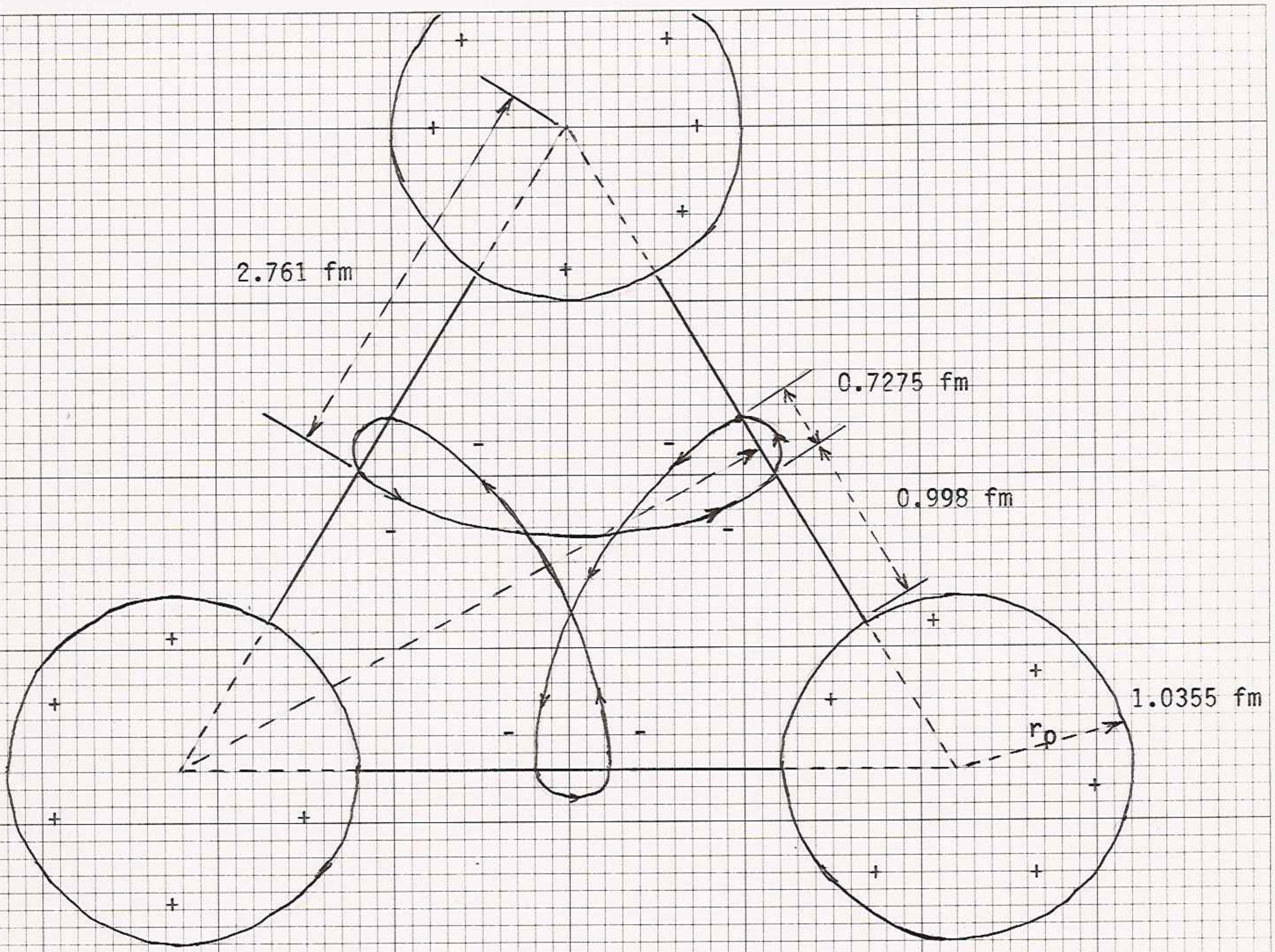

Fig. 9a - Tritium and Helium-3 Orbital

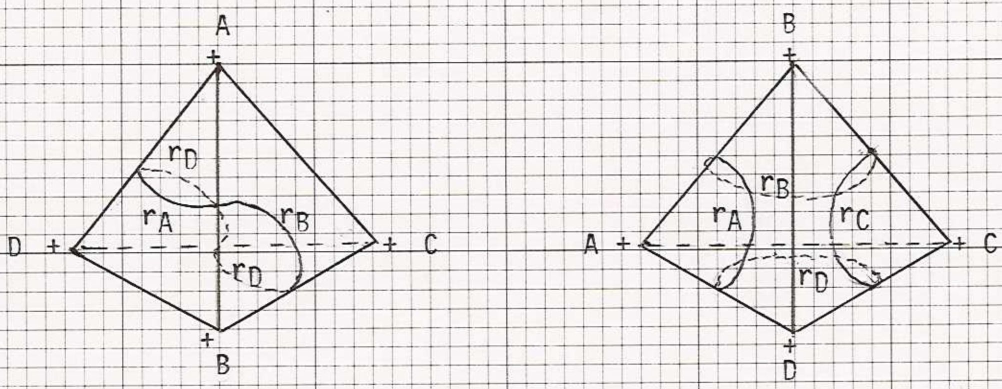

Fig. 9b - Helium-4 Orbital

Helium-3's 7.718346 MeV B.E. is a composite of the electron's 0.78233 MeV neutron state energy and 6.936016 MeV in relativistic energy that contracts the 0.7275 fm resonance orbital by m_e / (m_e + 6.936) = 0.06862 to a 0.04992 fm peak and $0.04992/2^{\frac{1}{2}}$ = 0.0353 fm average, reducing the neutron's 2.761 fm / 2.531 = 1.091 fm radius to 1.091 - 0.0353 = 1.0557 fm From the electron's vantage this is a relative $(1.091 / 1.0557)^3$ = 1.1037 proton volume increase, density decrease and neutron magneton increase. The 6.936016 MeV electron mass increase is also a relative proton mass decrease and m_p / (m_p - 6.936016) = 1.00745 increase to the neutron magneton. Since He-3's two proton magnetons will cancel, the factors combine to a (1.1037 x 1.00745) (-1.9135) = -2.12766 u_n neutron magneton, which is within 0.0075% of He-3's actual -2.1275 u_n magneton.

Tritium's two neutron orbital electrons also follow the He-3 clover-leaf orbital with He-3's 7.718346 MeV B.E. + 0.78233 MeV = 8.500676 MeV to accommodate the additional neutron energy state. This value is within 0.22% of tritium's actual 8.482047 MeV value and detailed calculations only reduced this error to 0.15%. The fact that the actual B.E. is less than the calculated 8.500676 MeV is attributed to energy loss by charge repulsion between electrons in the same planar orbital and also to the fact that the structure dimensions limit a planar orbital's B.E. and He-3's 7.718 MeV B.E. already contracts the neutron electron orbital radius to 1.0557 fm from 1.091 fm, within 0.02 fm of the proton's 1.0355 fm radius.

With two 0.78233 MeV neutron state energies each electron has ½ of 8.482047 MeV - 2 (0.78233 MeV) = 0.69174 MeV or 3.4587 MeV to contract its 0.7275 fm resonance orbital by m_e / (m_e + 3.4587) = 0.1287 / $2^{\frac{1}{2}}$ = 0.0910 to yield 0.0662 fm. Since the orbitals are lobed two electron will always affect a neutron orbital radius by contracting both its end 0.7275 fm transition region lobes so the effect on its radius is 2.761 fm - 2 (0.0662 fm) = 2.6286 fm which contracts by its 2.531 neutron state energy to 1.03856 fm. This 2.761 fm / 1.03856 fm = 2.6585 compound relativistic contraction causes a 2.531 / 2.6585 = 0.95205 magneton attenuation.

And since contraction has an associated time dilation it will attenuate both (2.7928 - 1.9135) = 0.8793 deuterium-type magnetons to 0.8793 x 0.95205 = 0.83714 so tritium's cumulative magneton for a proton and two neutrons is $(2.7928^2 + 2 \times 0.83714^2)^{\frac{1}{2}}$ = 3.03337. However since the 8.482047 MeV mass loss to the protons represents a relative m_p / (m_p - 8.482047) / m_p = 1.0091225 mass increase to each electron, and subsequent 1 / 1.0091225 = 0.99096 relativistic attenuation from each electron, the tritium magneton is 3.03337 x $(0.99096)^2$ = 2.978775, within 0.0009% of tritium's 2.9788 value.

In helium-3 the two proton magnetons align and cancel so only a relativistically enhanced neutron magneton remains but tritium only has a strong single proton magneton to align weaker neutron magnetons into deuterium-type magnetons. Tritium's two orbital electrons also only occupy 3.5 MeV negative binding energy wells while helium-3's electron has a 7 MeV energy well giving it more stability than radioactive tritium. And from this it follows that helium-4's proton and neutron pairs align and cancel to yield the zero magneton it has and its two electrons divide its 28.297 MeV B.E. to form two 14 MeV energy wells that form a stable structure.

Helium-4's four nucleons form a tetrahedron with tri-nucleon faces identical to tritium and helium-3 (Fig. 9b) but instead of a clover-leaf orbital the electrons traverse a neutron state radial path across each face around a nucleon and then on to an adjacent face to repeat the process. However the energy calculations are very lengthy and presented on pages 49, 49a and 50 of Radioactive Decay (@ mqnf.com) and result in a B.E. = $3^{1/3}(2 \times 2.22)^2$ = 28.432 MeV binding energy, within 0.48% of He-4's 28.297 MeV value.

From this it was shown how H-2, H-3, He-3 and He-4 constitute primary components of higher nuclear structures. Lithium-6 and 7, carbon-12 and 14 and nitrogen-14 magneton and B.E. values were derived by showing that H-3 and He-3 act like enhanced protons and neutrons, with their respective 2.9788 and -2.1275 magnetons, that form overlayed npn and pnp deuterium-type structures with opposing

H-3 and He-3 faces. When the compounded 0.975 contraction from the resonance orbital energy effect on the 2.761 fm to 1.091 fm neutron state contraction is factored into the H-3 and He-3 B.E.'s it yields Li-6's actual 1.975 (8.482047 + 7.718356) = 31.9958 MeV B.E. And by factoring the H-3 and He-3 magnetons, a 0.975 (2.9788 - 2.1275) = 0.8300 magneton results that reduces to 0.8226, within 0.1% of Li-6's 0.8220 value, if the $(6m_p - BE)/6m_p = 0.99432$ mass loss and $(1 - 6(m_e/m_p)) = 0.99107$ sub-resonances are factored in.

Lithium-7 was shown to be a deuterium-type bond of a neutron from an He-4 tetrahedron and an enhanced H-3 proton (Radioactive Decay, pp. 63-4) with a calculated 39.2345 MeV B.E., within 0.03% of Li-7's actual 39.24547 MeV value. Its magneton was calculated to be 3.1928, within 2% of Li-7's 3.2563 value, and when the spins of the He-3:n:H-3 form of its He-4:H-3 structure were incorporated the He-3, n and H-3 ½-spins combine to a 3/2-spin and relativistic orbital momentums cancel so only electron-proton mass and neutron-proton radii ratios affect the 3.2563 magneton's 3/2 spin to yield a $(3/2)^{\frac{1}{2}} \times (m_e + m_p)/m_p \times r_n/r_p = 1.2911 \times 3.2563 = 4.2042$ value, within 0.0075% of the measured 4.2039 value, and explains the 4.90 Shell Model calculation discrepancy from the actual 4.20 value.

Carbon-12 was shown to be an H-3 center with He-3's bonded to its neutrons and an H-3 bonded to its proton, similar to Hoyle's suggested 3 He-4 structure but with added 2.224 $(0.975)^2$ MeV bonds to the H-3's neutrons and an added 2.224 $(1 / 0.975)^2$ MeV bond to its proton, adding 6.56789 MeV to the 85.60344 MeV energy of the two He-3 and two H-3 structures for a total 92.17133 MeV B.E., and within 0.01% of C-12's actual 92.161734 MeV value. C-14 and N-14 were also shown to be a C-12 structure with an added neutron pair or an added deuterium, respectively.

An early on proton-electron nuclear model was proposed and rejected because Nitrogen-14's 7 protons and 7 neutrons would have 21 ½-spin protons and electrons that sum to a ½-spin number which could not be reconciled with its actual spin 1 value. However, as was shown in Neutron Spin, a neutron's ½-spin results from a 2.531 relativistic contraction of an electron's spin 1 orbital about its proton center. This means a relativistic ½-spin effect is always associated with each electron so N-14's 14 protons and 7 electrons have 28 ½-spins and its spin 1 results from the 0 spin of its C-12 component and the spin 1 of its deuterium component.

These different cases of nuclear behavior, from the neutron to 1-dimensional deuterium, 2-d tritium and helium-3, 3d helium-4 and compound higher nuclear structures, along with an explanation for N-14's spin 1 and Li-7's 4.2 magneton, strongly indicate that nuclear binding and its associated spin and magneton values result from classical electromagnetic forces compounded by relativistic spatial contraction and time dilation. Bohr's Correspondence and Heisenberg's Uncertainty Principles permit such treatment from the perspective of a high energy electron in the vicinity of high mass low velocity momentum protons. **However** a description of nuclear force may not be considered complete without a treatment of pions.

The quantum theory of force fields proposes that a field at a distance from its source is carried by a quantum force messenger. In 1935 Yukawa suggested that such messengers were involved in 1.4 fm nucleon interactions, where a messenger is emitted by a nucleon at near light speed and is destroyed near another nucleon, giving rise to an attraction force, and if no other nucleon is nearby the the messenger turns back and disappears. Since messenger emission violates mass-energy conservation, since a proton does not equal a proton + messenger, this reaction may only occurs for a duration less than the time given by Heisenberg's Uncertainty Principle.

Yukawa reasoned that if dE·dt = h/2·pi and dt = 1.4 fm / c = 0.47 x 10^{-23} s then dE = h/2·pi·dt = 140 MeV. In 1945 139.6 MeV pions were discovered, they do interact with nucleons and Yukawa's theory that they carry nuclear force was confirmed. As it turns out he was correct about their existence and involvement but it is not necessary to violate conservation of mass-energy if Relativity and Heisenberg's $dx \cdot dp = \frac{1}{2}h/2 \cdot pi$ relation are used. A pion cannot exceed light speed so its maximum momentum is $m_{pi}c$ and if $x \cdot m_{pi}c = \frac{1}{2}h/2 \cdot pi$ then $m_{pi}c = \frac{1}{2}h/2 \cdot pi \cdot x$ so its energy is $m_{pi}c^2 = \frac{1}{2}hc/2 \cdot pi \cdot x$ and correlates to a $x = \frac{1}{2}hc/2 \cdot pi \cdot 139.6$ MeV = 0.70676 fm distance.

This 139.6 MeV 0.7 fm nucleon interaction distance correlates to the average distance between nucleons as they transition from 1 fm into a 0.4 fm nuclear bond by the electron's 2.531 contraction and also with the contraction of the resonance orbital's 0.7275 fm transition region that transforms a reactant proton into a neutron proton. So as an electron passes within 1 fm of a reactant proton and contracts the 1 fm space to 0.4 fm it also undergoes resonance orbital contraction into a neutron state with that proton.

As a 2.761 fm neutron orbital contracts to 1.091 fm the space between the proton and electron becomes 1.091 fm - r_p = 0.0555 fm so 2.761 fm - r_p = 1.7255 fm is contracted by 31.09 to 0.0555 fm and its 0.7275 fm resonance region contracts by 31.09 to 0.0234 fm for a net 0.7275 fm - 0.0234 fm = 0.7041 fm contraction. Now this actually constitutes an electron motion 99.6236% of the 0.70646 fm pion distance toward a proton as it moves from 1 fm into a 0.4 fm bond with a neutron while the electron transforms it to a neutron and the former neutron's proton ends up bonded 0.4 fm from it.

The electron is in the resonance orbital energy well with an instantaneous energy of 139 MeV, or 99.6236% of a 139.6 MeV pion. As was shown for deuterium, the 0.7275 fm resonance orbital radial energy is 0.660 MeV, or 2.531 times the 0.78233 MeV / 3 = 0.260777 MeV neutron state radial energy, so its actual orbital energy is 3 x 0.660 MeV = 1.98 MeV. But a 99.6236% contraction correlates to a 1 / (1 - 0.996236) = 265.6748 m_e = 135.76 MeV mass increase and when its 1.98 MeV orbital energy, 0.78233 MeV neutron state energy and 0.511 MeV rest mass are added its energy is exactly 139 MeV so conservation of mass-energy is not violated. Only a 0.70676 fm - 0.7041 fm = 0.00266 fm kinetic impact compression is required to achieve a 139.6 MeV pion energy state and destabilize the orbital.

However if this were all that was involved it would simply be a 139.6 MeV beta particle. A pion is a unique meson in that it is spin 0 and it decays within 26 ns to a ½-spin muon and ½-spin muon anti-neutrino. Because the pion is in a contracted relativistic resonance orbital it contains a contracted ½-spin angular momentum that cancels the ½-spin it ends up with as a muon, so it is spin 0 on release as a pion. This ½-spin relativistic angular momentum is what is released as a muon anti-neutrino on decay.

So the pion is, as Yukawa predicted, responsible for nuclear force but it is the instantaneous energy and relativistic angular momentum state of a binding electron as it transitions through a resonance orbital to form a neutron state with a reactant proton. A tau particle, with a Yukawa interaction distance of 0.0553 fm originates from the electron in its (2.761 fm / 2.531 = 1.091 fm) - r_p = 0.0555 fm neutron state with a proton. Its 1784 MeV energy is exactly 12.78 times the pion's 139.6 MeV energy which is also the ratio between the 1-dimensional 2.2 47 MeV bonding energy and He-4's $3^{1/3}$ $(2 \times 2.2147)^2$ = 28.3 MeV binding energy and the 12.78 factor is the $3^{1/3}$ $(p)^n$ = $3^{1/3}$ 2^2 = 5.769 geometric structural effect times the 2.2147 MeV 1-d bond energy.

The tau, kaon, pion, muon and their associated neutrinos are more fully treated on pages 4-25 of Electron, Neutrinos and Mesons (@ mqnf.com). A more complete treatment of all aspects of nuclear force would require substantial elaboration on these concepts but the examples presented here show that binding energy, magneton and spin values, and the pion as the nuclear force messenger, parallel electromagnetic behaviors at classical levels except the energies involved at nuclear distances invoke relativistic effects which magnify the strength of the forces.