Matter in the form of toroidal electromagnetic vortices

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ABSTRACT

The creation of charged elementary particles from neutral photons is explained as a conversion process of electromagnetic (*EM*) energy from linear to circular motion at the speed of light into two localized, toroidal shaped vortices of trapped *EM* energy that resist change of motion, perceptible as particles with inertia and hence mass.

The photon can be represented as a superposition of left and right circular polarized transverse electric fields of opposite polarity originating from a common zero potential axis, the optical axis of the photon. If these components are separated by interaction with a strong field (nucleon) they would curl up into two electromagnetic vortices (*EMV*) due to longitudinal magnetic field components forming toroids. These vortices are perceptible as opposite charged elementary particles $\boldsymbol{e}^{\pm}$.

These spinning toroids generate extended oscillating fields that interact with stationary field oscillations. The velocity-dependent frequency differences cause beat signals equivalent to matter waves, leading to interference. The extended fields entangled with every particle explain wave particle duality issues. Spin and magnetic moment are the natural outcome of these gyrating particles. As the energy and hence mass of the electron increases with acceleration so does its size shrink proportional to its reduced wavelength.

The artificial weak and strong nuclear forces can be easily explained as different manifestations of the intermediate *EM* forces. The unstable neutron consists of a proton surrounded by a contracted and captured electron. The associated radial *EM* forces represent the weak nuclear force. The deuteron consists of two axially separated protons held together by a centrally captured electron. The axial *EM* forces represent the strong nuclear force, providing stability for “neutrons” only within nucleons.

The same principles were applied to determine the geometries of force-balanced nuclei. The alpha-particle emerges as a very compact symmetric cuboid that provides a unique building block to assemble the isotopic chart. Exotic neutron-4 appears viable which may explain dark matter. The recognition that all heavy particles, including the protons, are related to electrons via muons and pions explains the identity of all charges to within 10^{-36}. Greater deviations would overpower gravitation.

Gravitation can be traced to *EM* vacuum fluctuations generated by standing *EM* waves between interacting particles. On that basis, gravity can be correlated via microscopic quantities to the age of the universe of 13.5 billion years.

All forces and particles and potentially dark matter and dark energy are different manifestations of *EM* energy.

Keywords: photon, pair-creation, electron, waves, electromagnetic vortices, matter, elementary particles, neutron, deuteron, gravitation.

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1. INTRODUCTION

Quantum theories require ever-increasing mathematical complexities to simulate the perceived strange behavior of quantum physics. The abstract mathematical formulations moved away from reality into the unimaginable hyperspace with 26 dimensions for some string theories. Virtual (nonexistent) particles abound in infinite quantities, time is reversed for antiparticles, wave or particle behavior is indeterminable, the wavefunction collapses, spooky actions at a distance exist, infinite results have to be evaded by artificial "re-normalizations" and so on.

Quantum-mechanics and general relativity are not compatible. Quantum theories elevated as mathematical reality without comprehension of fundamental physics appear conspicuously like the archaic Ptolemaic astronomy where complex mathematical epicycles were invented to explain the motion of planets from an earth bound perspective.

The standard model does not provide satisfactory answers to many observations. The creation and annihilation of matter from and into photons is a well-established fact. But where do the masses, charges and magnetic moments of the created particles come from when the photons have no mass, no charge and no magnetic moment? Or how do the masses, charges and magnetic moments of the particles disappear when matter is annihilated into photons?

How can a neutral particle without any charge like the neutron have a magnetic moment? How can the conversion of neutrons into protons and electrons or the reverse process of electron capture be explained? How can the magnetic moment of an infinitely small electron be so much larger than for a proton or neutron? How can a point-electron have such a large angular momentum and at the same time its infinite electrostatic field energy is ignored? How can the sea of negative energy electrons exhibit no charge and no mass?

How can the double slit interference with single particles be understood? Is there an explanation of the spooky actions at a distance that imply infinite speed in conflict with relativity? How can the strong nuclear force that holds the nucleus together be reconciled with the weak nuclear force observed in beta-decay? How are these nuclear forces related to the intermediate strong electromagnetic forces holding the electrons within the atom together? What are the sizes and shapes of an electron, proton, neutron, nucleus, photon and so on?

Instead of escaping into a strange hyperspace, an effort is made here to provide answers to these mysteries on a more realistic basis. The assumptions or postulates required for this effort are certainly less mind boggling than the propositions of quantum theories with infinite virtual particles and waves, etc. In general, the theory with the fewest and most sensible assumptions is usually considered superior and that is the attempt here. But it needs an open mind and a willingness to detach from previously taught and accepted dogma.

The following generalized presentation is a condensed version of the detailed original article www.energiewirbel.com . The asterisk * in this text indicates more details in that document.

2. WAVE AND PARTICLE CHARACTERISTICS OF PHOTONS AND ELECTRONS

The particle behavior of energetic electromagnetic waves and the wave behavior of fast moving particles indicate a close relationship of waves and particles. The undisputed fact that energy can be converted from the photon γ moving at the speed of light c into two relatively slow moving ($v_i << c$) particles of equal rest mass m_o but opposite charge provides the experimental verification of such a close relationship. The energy balance $E = h\nu = c\sqrt{(2m_0c)^2 + \Sigma(m_iv_i)^2}$ implies that waves and particles are just different manifestations of the same physical reality, electromagnetic energy. These facts suggest a conversion process where the fleeting energy of the photon is condensed into two localized vortices of trapped electromagnetic energy or Energiewirbel.

Electromagnetic waves can be described by a superposition of left and right circular polarized transverse electric fields of opposite polarity. The opposite electric field vectors can be envisioned as originating from a common zero potential axis, the optical axis of the photon. This would lead to opposite electrical potentials at the surfaces of the Energiewirbel, perceptible as ± charges.

The magnetic field is determined from the electric field according to Maxwell's equations in the form of transverse electromagnetic (*TEM*) waves. The photon is considered a wave packet with a length determined by the coherence length and a core radius depending on the shape of the wave packet's envelope. An extended electromagnetic field surrounds the core of the photon, which is manifested by diffraction and interference effects.

Pair creation requires a collision partner such as a nucleus or electron to transfer excess momentum p since $m\,\Sigma\, v_i = E\, v/c^2 = p_\gamma\, v/c < p_\gamma$. This means that the photon must interact with a strong field to be converted into two particles with opposite charge. The collision is envisioned to split the two electric vectors $E^{\pm}$ of the *TEM* wave apart and separate them in space (somewhat like the unzipping of the DNA helix), creating two *TE* waves with longitudinal magnetic fields. Such a separation would naturally create two oppositely charged wave packets with E^{+} and E^{-} from the neutral photon. In addition, it is contemplated that these split wave packets are unstable due to the impact and longitudinal magnetic field that force these wave packets into two rotating toroids. In other words, the linear motion of the electromagnetic photon field along z = ct is converted into circular motion $R_o\varphi(t) = ct$ of two fast spinning toroids with opposite charge, recognizable as electron and positron.

Figure 1 illustrates pair creation where the translational energy of the photon is converted into rotational energy of two toroidal Energiewirbel or electromagnetic vortices (*EMV)*, recognizable as charged particles that resist change of motion, perceptible as inertia and hence mass.

The linear energy flow represented by the Poynting vector for the photon can now be found in the circular motion of the two energy vortices that represent the created particles of opposite charge. These toroidal-shaped Energiewirbel (*EMV*) represent fast pulsating electromagnetic entities that generate external oscillating field components and thus provide a natural explanation for the wave particle duality of matter. While the torus itself has particle character, the extended field provides the guiding field that leads to interference effects of single particles ascribed as matter waves of moving particles. There is no wave or particle duality problem but instead, all particles are surrounded by extended fields that guide them.

In a double slit experiment the particle core of the photon, electron, etc. passes through one slit while the guide field passes through the other slit, influencing the particles trajectory as expected by wave considerations. The boundary conditions of wave and particle characteristics determine the detailed descriptions of the oscillating toroidal particles in the form of Energiewirbel.

3. ENERGIEWIRBEL AS VORTICES OF TRAPPED ELECTROMAGNETIC ENERGY

The radii of the toroids can be determined from the angular and magnetic moments.
The magnetic moment for the electron is $\mu_e = (1+a)\,\mu_B = (1+a)\, e\, h\, /4\pi m_e \approx 9.28\text{ A pm}^2$ (1)
where a is a small correction related to the fine structure constant $\boldsymbol{\alpha}$ by $a \approx \boldsymbol{\alpha}/2\pi \approx 0.00116$.

Since the energy flow of the photon at the speed of light changes only from a linear to a circular motion, the associated current of an elementary charge for a thin ring is $I = e\,c\,/\,2\,\pi\,R_o$ (2)
The corresponding magnetic moment is $\mu = \pi \int R^2\, dI \approx \pi\, R_o^{\,2}\, I = 0.5\, e\, c\, R_o$ (3)
and hence $R_o \approx h\,/\,2\pi\, m_e c = \boldsymbol{h}\,/\,m_e c = \boldsymbol{\alpha}\, a_o = \lambda_{Ce}\,/\,2\pi = \boldsymbol{\lambda}_{Ce} = 386\text{ fm}$. (4)

This radius of the electron at rest is equal to the Compton radius of the electron $\boldsymbol{\lambda}_{Ce}$ and the Bohr radius $a_o \approx 0.53$ Å multiplied by the fine structure constant $\boldsymbol{\alpha} = e_o^{\,2}\,/\,\boldsymbol{h}\, c \approx 1/137$. The corresponding circumference $2\pi R_o$ is equal to twice the wavelength λ_γ of the photon that created the pair. This implies that the photon with a length of many wavelengths has been compressed during the helicoidal collision to an integral number of two wavelengths to prevent internal interference effects. This final constriction to two instead of one wavelength may be due to symmetry requirements of balancing forces by opposing maxima and minima in the radial field components.

This size of the electron appears huge at first glance in comparison to point electrons assumed in quantum theories. However, we know very well that the mass of the electron increases rapidly as it is accelerated to relativistic speeds. In other words, a fast moving electron is different from an electron at rest, or more distinctively, electrons are not all the same but differ dramatically depending on their kinetic energy. This is also true for the size of the electron, which shrinks as it is accelerated proportional to its reduced wavelength.

The velocities for bound electrons in atoms are not sufficient to cause significant changes in mass and size, but for relativistic electrons with energies of about 1 GeV the corresponding size shrinks to subnuclear dimensions of $R_{1GeV} \approx 0.2$ fm. Hence, scattering experiments with relativistic electrons can probe nuclear shapes while slow electrons are sufficiently small to probe at atomic scales with electron microscopes.

The observed reductions in interaction cross-sections with increasing energies provide additional evidence for the reduction in particle size and its field distribution with kinetic energy.

The initial reaction to relatively large electrons is not justified after closer examination since it is only caused by relating it to the invention of point electrons in quantum theories. Point electrons can not exist because they would have infinite field energies. Cancellations of infinities by renormalizations are just mathematical evasion techniques. The measured magnetic moment of the electron with a classical radius of $R_c = e_o^2/m_e c^2 = 2.82$ fm would require an elementary charge to move at a relativity defying $1/\alpha = 137$ times the speed of light.

The uncertainty in locating a "point particle" in space to the extent of $\boldsymbol{h}$/mc may as well be interpreted as actual extension or size of a particle. The non-locality of the source in QED can be identified with the radius R_o of the Energiewirbel. This Energiewirbel *(EMV)* concept brings the spin and magnetic moment back to the real world from the realm of multidimensionality and renormalization that were artificially invented to allow evaluations of point-like particles.

These dynamic Energiewirbel can also explain the increase in mass as a conversion process of kinetic energy in a more natural way than an actual change of a massive particle in the mental form of a miniature solid sphere. It appears also natural that the total momentum m c is the resultant of the momentum p = m v and the orthogonal "rest" momentum $m_o c$ as expressed by $m^2 c^2 = m_o^2 c^2 + p^2$ or in more familiar form $E^2 = m^2 c^4 = m_o^2 c^4 + p^2 c^2$. (5)

This can be envisioned for an Energiewirbel that moves along the direction of its axis while its rest energy is circulating in the perpendicular plane. Dirac's equation leads to eigenvalues for velocity components of $v_\perp = \pm c$ for particles. Schrödinger's explanation for this fact was that electrons carry out fast irregular motions (Zitterbewegungen) that are responsible for the spin. The Energiewirbel with internal motions at the speed of light provide a more logical explanation than these obscure fluctuations.

The minor radius of the torus r_o can be determined from the angular momentum of the electron $p_\omega = \Theta\, \omega = \boldsymbol{h}/2$, the correction term *a* and the energy balance. The ratio of the minor to major radius of the torus is $\Delta = r_o / R_o = 0.214$ according to equ.9 as explained later. The momentum of inertia $\Theta = \int R^2 dm$ for a ring of uniform density is $\Theta_z = m\, R_o^2\, (1 + 0.75\, \Delta^2)$ around the axis of the torus and $\Theta_\perp = 0.5\, m\, R_o^2\, (1 + 1.25\, \Delta^2)$ for a perpendicular axis corresponding to a spin flip situation. For thin rings, the momentum of inertia for spin flips is one half of the axial value, which explains the half-integer spin values and the observed magneto-mechanical anomaly.

The magnetic moment for a torus with $r_o > 0$ is increased by $1 + b\, \Delta^2$ over the value of equ.3. With the charge concentrated on the surface of the torus the value of *b* would be 0.5.
For a constant field-strength inside the torus, the effective radial charge density dq/dr = e/r leads to a reduced value of *b* = 1/6. This correction term reduces the major radius of equ.4 to
$R_e = (1 + a)\, \boldsymbol{h} / m_e\, c\, (1 + b\, \Delta^2) \approx 384$ fm for $b = 1/6$. (6)

4. ENERGY AND RADIAL FORCE BALANCE

There are several electromagnetic energy contributions. The internal and external electric field energies amount to about 0.7 and 2.2 keV *, respectively. The external magnetic field energy due to the elementary current amounts to ≈ 1 keV *.

These three energy contributions of about 4 keV amount to less than 1% of the rest energy of 511 keV for the electron. External oscillating electromagnetic field energies are also expected to be small. This means that most of the energy must be rotational energy and longitudinal magnetic field energy within the torus.

The rotational energy of the torus is

$E_\Theta = 0.5\, \Theta_z\, \omega^2 = 0.5\, \boldsymbol{h}\, c\, (1+0.75\, \Delta^2) / (1+1.25\, \Delta^2)\, R_e \approx 252$ keV for $\Theta_\perp \omega = \boldsymbol{h}/2$. (7)

Since photons experience gravitational forces and transfer momentum $p_\gamma = h\nu/c$, electromagnetic energy is considered equivalent to mass with respect to inertia and centrifugal forces.

The centrifugal force is $F_{\uparrow\Theta} = + E_\Theta / R_e \approx + 656$ eV/fm. (8)

To determine the longitudinal magnetic field that holds the torus together, other radial forces have to be evaluated. The external electric and magnetic fields add an outward force of about + 10 eV/fm. This means the longitudinal magnetic field has to exert a dominating contractive force that balances all these outward forces, leading to $F_{\downarrow Mi} \approx -666$ eV/fm. The corresponding magnetic energy is $E_{Mi} = -F_{\downarrow Mi} R_e \approx 255$ keV. These energy contributions combine to a total energy of 511 keV, equal to the rest energy of the electron.

It is apparent from this evaluation that the "mass" of the electron can be completely attributed to circulating electromagnetic energy. Mass is the embodiment of trapped electromagnetic energy in the form of Energiewirbel that resist change of motion within a vacuum impedance of 377 Ω.

In addition, the spin and magnetic moment has a very natural origin. There is nothing anomalous about the magnetic moment because of the correction factor *a*. This term is easily explained by the finite size of the Energiewirbel. In contrast, the complex assumptions and calculations of Quantum Electro Dynamics (QED) took over 20 years of computer work to match the presumed anomalous *a* correction. If there is anything anomalous, it is always the theory but never nature.

The radius ratio Δ can be determined from this energy balance by equating the sum of the electromagnetic energy contributions $\Delta E \approx 4$ keV with the reduction in rotational energy $\Delta E_\Theta \approx 0.5\, m_e c^2 (0.5 - b)\, \Delta^2$, which leads to

$\Delta = r_o/R_o = \sqrt{2pa} = 0.214$ *. (9)

5. MUONS, TAUS AND NEUTRINOS (LEPTONS)

The muons $\boldsymbol{\mu}^\pm$ and taus $\boldsymbol{\tau}^\pm$ have rest energies of 105.66 MeV and 1777 MeV with lifetimes of 2.2 μs and 0.3 ps, respectively while all neutrinos $\boldsymbol{\nu}$ are neutral, essentially massless and "stable". All leptons are fermions with spin s = ½ that do not experience strong interactions. The neutrinos $\boldsymbol{\nu}$ exhibit only left-handedness, also called negative helicity, while the antineutrinos $\boldsymbol{\nu}'$ exhibit only right-handedness or positive helicity.

These charged lepton pairs $\boldsymbol{l}^\pm$ can also be created by single photon conversions $\gamma \rightarrow \boldsymbol{l}^- + \boldsymbol{l}^+$ forming Energiewirbel of different energies, sizes and lifetimes.

Single muons are observed as decay products of more energetic particles. Charged pions $\boldsymbol{\pi}^\pm$ with rest energy of 139.6 MeV and a lifetime of 26 ns decay predominantly into muons and muon-neutrinos $\boldsymbol{\nu}_\mu$ according to

$\boldsymbol{\pi}^+ \rightarrow \boldsymbol{\mu}^+ + \boldsymbol{\nu}_\mu + 34$ MeV and $\boldsymbol{\pi}^- \rightarrow \boldsymbol{\mu}^- + \boldsymbol{\nu}_\mu' + 34$ MeV, emitting monoenergetic 29.8 MeV neutrinos.

All muons decay then into electrons, μ-neutrinos $\boldsymbol{\nu}_\mu$ and e-neutrinos $\boldsymbol{\nu}_e$ by $\boldsymbol{\mu}^- \rightarrow \boldsymbol{e}^- + \boldsymbol{\nu}_\mu + \boldsymbol{\nu}_e'$ and

$\boldsymbol{\mu}^+ \rightarrow \boldsymbol{e}^+ + \boldsymbol{\nu}_\mu' + \boldsymbol{\nu}_e$ in about 2.2 μs *.

The tau has many channels decaying into pions, muons, electrons, etc. with associated τ-neutrinos ν_τ and τ-antineutrinos ν_τ'. There are no direct decay channels of muons or taus into photons. The various decay channels are displayed in the energy diagram of fig. 2.

These characteristics of the muons and taus with short lifetimes have the appearance of excited metastable states or resonances of the electron instead of elementary particles. In other words, the electrons and positrons could be considered the lowest energy or groundstate for the muon and tau leptons.

The short lifetime of these leptons is equivalent to the short lifetimes observed for atomic excitations. For atomic transitions the electron cascades down to its lowest energy configuration emitting single s = 1 photons, while the heavy leptons emit two s = ½ neutrinos to reach their lowest energy configuration by expansion toward stable electrons as shown in fig.3.

The neutrinos moving at the speed of light appear to consist of induced *EM*-entities similar to the split photons with spin of one-half, but without zero potential axis. The neutrality and low absorption cross-sections of the neutrinos indicate their field-lines are closed loops with predominantly longitudinal electric fields akin to *TM* waves. Such compact field configurations would have very small effective electric field radii and so exhibit minimal interactions with observed cross-sections in the range of 10^{-12} fm^2/GeV.

Electromagnetic fields appear in three configurations. *TEM* photons consist of equal amounts of electric and magnetic field energy, while the "*TE*" electrons interact primarily with their extended electric fields and the "*TM*" neutrinos seem to be dominated by magnetic field energy.

Detailed evaluations are provided in the original article with correlations to the $\mathbf{W}^{\pm}$ vector bosons.

6. PIONS AND RESONANT STATES

The neutral pion $^{\circ}\pi$ and the charged pions $^{\pm}\pi$ are the lightest bosons, mesons and hadrons with rest energies of 135 and 139.6 MeV respectively. The pions have an assigned spin of s = 0 and no magnetic moment. The charged pions decay in 26 ns predominantly into muons $^{\pm}\mu$ and muon-neutrinos ν_μ according to $\mu \rightarrow {}^{+}\pi^{+} + \nu_\mu$ and $\pi^{-} \rightarrow \mu^{-} + \nu_\mu$'. From these considerations, the charged pions are considered in this analysis to consist of muons rotating around a radial axis, forming essentially spherical shells.

The pions have a unique position among elementary particles because they are observed in the decays of all hadrons, all hadronic resonances and the τ lepton as shown in Table I. Even the very heavy $W^{\pm}$ and Z° bosons decay indirectly into pions via other short-lived hadrons. This unique characteristic suggests that all hadronic states can be considered multiple pion states with various lifetimes and decay channels.

While the assignment of some of the pion numbers n_π* is uncertain due to insufficient data, the plot of rest energies versus pion numbers in fig. 4 exhibits strong correlations that can be approximated by

$$E_n \approx n\cdot_{\pi} m\cdot_{\pi} c^2 + (n - {}_{\pi}1\cdot)\ 91\ \text{MeV} \approx 231\ \text{MeV}\cdot n_\pi \qquad (10)$$

which amounts to a coupling energy of $E_c \approx 91$ MeV. About 62% of the baryons and 32% of the mesons out of the evaluated 60 hadrons fall within ± 5 % of this general trend with an average deviation of ± 3%.

This indicates that the hadrons can be best characterized by pion numbers analogous to nuclei that are characterized by proton and neutron numbers. While the nuclei have many stable members among unstable isotopes, the hadrons have only one stable member, the proton, and only 10 members with lifetimes exceeding 0.1 ns.

The four-pion proton of elementary particles is comparable to the four-nucleon ^{4}He nucleus (α-particle) of nuclei with unique characteristics and stability.

As the nuclei are combinations of nucleons, so can all the hadrons be considered combinations of pions. All hadrons with the exception of the proton represent a cascading short-lived hierarchy of pion states which decay into muons and finally into stable electrons, neutrinos and photons - a great simplification over the present complex standard model.

This close relationship between the hadrons and electron via the pions and muons provides a natural explanation that the charges of all elementary particles are identical in spite of the large differences in energies and dimensions. In contrast, the quark theory requires fractional charges for the quarks of one-third and two-thirds of the electron's charge precise to $<<10^{-36}$ without any relationship between these "particles". Larger deviations would overpower gravitation. Neither fractional charges nor individual quarks have ever been observed.

7. PROTONS

The proton $\boldsymbol{p}^+$ and antiproton $\boldsymbol{p}^-$ are the only stable baryons with spin s = ½, a rest energy of 938.3 MeV and a magnetic moment of $\mu_p = 2.793\ \mu_N$. The nuclear magneton is defined by $\mu_N = e\,\boldsymbol{h} / 2\,m_p \approx 5.05$ kA fm^2. The electric and magnetic formfactors of the proton obtained from scattering experiments reveal that protons are not simple spherical symmetric objects but composite particles. The proton has electric and magnetic polarizabilities of 1.2 and 0.2 10^{-3} fm^2 respectively, which suggests a rearrangement of the proton's constituents in response to electric and magnetic fields.

The annihilation of a proton with an antiproton into photons is very rare. Instead, in most cases many pions are created*, which in turn decay into muons, neutrinos and photons. The interactions of photons with protons lead also to pion productions by the reactions $\boldsymbol{\gamma} + \boldsymbol{p}^+ \rightarrow \boldsymbol{p}^+ + {}^-\boldsymbol{\pi} + {}^+\boldsymbol{\pi}$ or $\rightarrow \boldsymbol{n} + \boldsymbol{\pi}^+$ or $\rightarrow \boldsymbol{n} + \boldsymbol{\pi} + {}^-\boldsymbol{\pi} + {}^+\boldsymbol{\pi}^+$. In addition, numerous excited nucleon resonance $\boldsymbol{\pi N}$ states exist for about 5 10^{-24} s, decaying primarily into a nucleon and pions.

These processes are very different from those involving electrons. The almost three times larger magnetic moment indicates that the protons are composite particles, which can be represented a single- and a triple-elementary current version.

The single-current version (s-proton) consists of a relatively large, charged toroid and a neutral massive core. The radius of the charged toroid is given by equ.6 for $a_p = 1.793$ and replacing m_e with m_p which results in $R_p = 0.583$ fm. The effective radius R_c of the central toroids are in the range of 0.30 to 0.34 fm *.

The dominating forces of the s-proton are determined by the 0.583 fm Energiewirbel because the neutral core does not interact with other particles unless they are in close proximity. Since the neutral core can be ignored for initial evaluations of nuclei structures, the detailed core configuration is not important. Such details can be investigated after sensible structures of nuclei have been obtained with this single-current version.

The triple-current version (t-proton) consists of three Energiewirbel with the same radii and same energies in coaxial contact. For the proton $\boldsymbol{p}^+$, the two outer toroids carry a positive charge while the central toroid carries a negative charge and spins in the opposite direction. Thus, the net charge is equal to one elementary charge while the total magnetic moment amounts to three elementary current loops.

This configuration would be stable because all the magnetic forces and the net electric forces are attractive. The radius R_3 of this configuration would be one-third of the single-current version or $R_3 \approx 0.194$ fm *.

To examine the structures of nuclei, it is again sufficient to model this t-proton as a single charged Energiewirbel of 0.194 fm radius but with three times greater magnetic field. Only in cases of close proximity are the effects of the t-proton structure important. The large s-proton and the compact t-proton provide a sensible choice for initial evaluations.

8. NEUTRON

The neutron $\boldsymbol{n}$ has a rest energy of 939.6 MeV, which is 1.293 MeV greater than for the proton. The neutron has an assigned spin of s = ½ and an unexpected magnetic moment of $\mu_n = -1.913\ \mu_N$. The neutron is stable as long as it is bound within stable nuclei. Free neutrons decay in 15 min. into a proton, electron and electron-antineutrino $\boldsymbol{v}_e$' releasing 782 keV of energy, described as negative beta (β^-) decay $\boldsymbol{n} \rightarrow \boldsymbol{p}^+ + \boldsymbol{e}^- + \boldsymbol{v}_e' + 782$ keV. The reverse process of electron capture by a proton to form a neutron requires an energy of 782 keV according to
$\boldsymbol{p}^+ + \boldsymbol{e}^- + 782\text{ keV} \rightarrow \boldsymbol{n} + \boldsymbol{v}_e$.

The positive beta (β^+) transformation process of proton rich nuclei requires energies of over 1.8 MeV to create a neutron and a positron from a proton via $\boldsymbol{e}^{\pm}$ pair production according to $\boldsymbol{p}^+ + 1.8\text{ MeV} \rightarrow \boldsymbol{n} + \boldsymbol{e}^+ + \boldsymbol{v}_e$ or
$\boldsymbol{p}^+ + \boldsymbol{v}_e' + 1.8\text{ MeV} \rightarrow \boldsymbol{n} + \boldsymbol{e}^+$. All these transformations indicate a very close relationship of the neutron to the proton and electron. In addition, the electric formfactor of the neutron $G_E{}^n$ is not zero, indicating that the neutron is a composite.

The neutron was initially considered to be a composite of a proton and an electron. However, this combination ordinarily would not lead to a spin s = ½ particle and so Heisenberg concluded erroneously in 1932 that the neutron must be a separate elementary particle. This conclusion was based on the assumption that the spin (angular momentum) of the particles is invariant. In contrast, the electron in the form of an Energiewirbel can shrink in size by radial contraction. The associated angular momentum also decreases and becomes small for a captured electron in comparison to the massive proton. This feature can provide a spin of s = ½ for the neutron even though it is a composite consisting of a proton and a contracted electron (*en*).

The capture of an electron by a proton can also explain the unexpected magnetic moment of the neutron. Since the neutron has no charge, no magnetic moment was expected on theoretical grounds, but in 1934, O. Stern proved the theoreticians wrong in spite of their ridicule.

The mystery can be resolved by combining the positive $\mu_p = +2.793\ \mu_N$ of the proton with a negative $\mu_{en} = \mu_n - \mu_p = -4.706\ \mu_N$ of a radially contracted electron in the form of coaxial Energiewirbel with parallel spins as illustrated in fig.5. The radius of the captured *n*-electron is then $R_{en} = -2\ \mu_{en} / e\ c\ (1+\Delta^2/6) = 0.982$ fm. (11)

The corresponding external *EM* energies are $E_{en} = E_{Een} + E_{Men} = (844 + 378 = 1222)$ keV.
An electron captured by an s-proton experiences an electric radial contractive force of –2.08 MeV/fm and a magnetic expansion force of 0.72 MeV/fm that results in a net contractive force of –1.36 MeV/fm.

The energy associated with this contraction process from a free electron with $R_e = 384$ fm to $R_{en} = 0.982$ fm amounts to $E_{ER} + E_{MR} = E_{FR} = (-1629 + 275 = -1354)$ keV.
External *EM* energies for the 0.583 fm s-proton are $E_p = (1424 + 636 = 2060)$ keV
and for the neutron $E_n = (639 + 504 = 1143)$ keV.
The difference $\Delta E_n = E_{FR} + E_p + E_{en} - E_n = (0 + 785 = 785)$ keV
is within 0.4% of the experimental negative binding energy of $-E_{Bn} = 782$ keV for the neutron.

The same evaluation for the 0.194 fm t-proton leads to an energy difference of $\Delta E_{n3} = 664$ keV, which indicates that the s-proton provides a much better representation of the proton than the t-proton. Therefore, the proton is considered synonymous with the s-proton or single-current version. The following evaluations are primarily based on s-protons and the results for t-protons are only given for comparison to assess sensitivity to large changes in geometry.

The results for the neutron suggest that the binding energy is purely of magnetic nature. Work exerted on magnetic fields lead to a reduction in the magnetic field energy according to $E_{FM} = \int F_M\, dz = \int \Delta -0.5\mu_o H^2\, dV = \Delta -E_M$, which explains the sign reversal of $\Delta E_M = -E_{Bn}$. In contrast, work done on electric fields increase the electric field energy by $E_{FE} = +\Delta E_E$, which explains the cancellation of the electric energy contributions to $\Delta E_{en} = 0$.

The radial electromagnetic forces can provide a logical explanation for beta decay without inventing magical weak nuclear forces.

A three dimensional illustration of the s-neutron is shown in fig. 5 along with its electric and magnetic energy distributions. The representation of the s-neutron as a 0.583 fm s-proton surrounded by a 0.982 fm *n*-electron agrees with the general conclusions drawn from the electric formfactor for the neutron, which indicates a positive short-range core surrounded by a negative cloud at larger distances

The instability of the free neutron is probably due to an axial containment energy of (1629–510 = 1139) keV that is only 357 keV above the excess binding energy of 782 keV. This suggests internal oscillations with kinetic energies close to 357 keV may exist in the form of zero-point energy. The stability of the neutron bound in stable nuclei is due to much greater containment energies of the captured electron as discussed next.

9. DEUTERON

The deuteron ***d*** is the stable nucleus of deuterium D = ^{2}H. It consists of a neutron and a proton with a binding energy of $E_{Bd} = (m_p + m_n - m_d)\,c^2 = 2225$ keV which is released as γ-radiation during ***d*** formation. The deuteron has a magnetic moment of $\mu_d = 0.8574\ \mu_N$ and an assigned nuclear spin of $I = 1$ corresponding to a triplet ground state with parallel spins of the neutron and proton. Deuterons with opposite spin in the $I = 0$ singlet state do not exist.

The deuteron can be envisioned as a combination of two protons held together by a central contracted *d*-electron (*ed*) in a stable coaxial configuration with a separation between 0.583 fm s-protons of $z_{pp} = 1.648$ fm. With all spins aligned, the effective magnetic moment of the *d*-electron is $\mu_{ed} = \mu_d - 2\,\mu_p = -4.728\ \mu_N$ which leads to a radius of $R_{ed} = 0.987$ fm. A three dimensional illustration of the s-deuteron is shown in fig. 6 along with its electric and magnetic energy distributions.

The corresponding electric and magnetic fields are shown in fig. 7 for the s-deuteron with parallel spin, resulting in symmetric field and energy distributions. In contrast, deuterons with opposite spin as shown in fig. 8 cannot exist because of unbalanced repelling magnetic forces and asymmetric energy distributions, in agreement with observations. This behavior indicates a natural explanation for the Pauli Exclusion Principle and the empirical results that nature prefers anti-symmetric (↑↑ spin = 1) over symmetric (↑↓ spin = 0) wavefunctions for nuclei.

The total energy required to expand a *d*-electron from 0.987 to 384 fm is (2198–72 = 2126) keV which is 57 % greater than for the *n*-electron. This increased energy requirement explains the stability of the *d*-electron and hence the neutron within the confinement of the deuteron.

The axial forces exerted on the protons cancel at a proton separation of $z_{pp} = 1.648$ fm and a corresponding *d*-electron to proton spacing of $z_{pe} = z_{pp}/2 = 0.824$ fm. The attractive electric forces of (–618+394 = –224) keV/fm are balanced at this spacing by the repelling magnetic forces of (284–60 = 224) keV/fm. Thus, this stable configuration does **not** require the invention of spin dependent, strong nuclear forces. The axial electromagnetic forces **are** the strong nuclear forces, where the spin dependence is due to the magnetic field.

The energy required to move two far-spaced protons in a coaxial fashion to $z_{pp}= 1.648$ fm amounts to $E_{FZ} = (787 - 40 = 747)$ keV. Electron capture from $R_e = 384$ to 0.987 fm by such a proton pair releases an energy of $E_{FR} = (-2198+72= -2126)$keV. Hence, the net energy release during deuteron formation of $\Delta E_d^* = (-1411+ 32 = -1379)$ keV is within 4.4% of the measured energy defect of $E_{Bd}^* = (m_d - m_p - m_e)\,c^2 = -1443$ keV.

The reduction in *EM* energies by combining two s-protons with a *d*-electron are determined by the external *EM* energies for the proton $E_p = (1424 + 636 = 2060)$ keV,
for the *d*-electron $E_{ed} = (841 + 376 = 1217)$ keV
and for the deuteron $E_d = (2278 + 1334 = 3612)$ keV.
The difference is $\Delta E_d = E_d - 2E_p - E_{ed} = (-1441 - 314 = -1725)$ keV.
Adding the internal electric energy $E_{ei} = (286 + 0 = 286)$ keV
leads to a total of $\Delta E_d^{\blacklozenge} = (-1125 + 314 = -1439)$ keV.
which is within 0.3 % of $E_{Bd}^{*} = -1443$ keV.

The question arises how the binding energy manifests itself in the deuteron. In the center of mass frame with a central contracting electron the two protons are accelerated from opposite long distances to $\pm z_{pe}$. The accumulated kinetic energy leads to axial oscillations of the protons about their stable positions. The corresponding zero-point energy $E_{\mathbf{0}d}$ can be determined from the change in axial forces with spacing which amount to $dF_z / dz_{pp} = 248$ keV/fm^2. This results in

$$E_{\mathbf{0}d} = 0.5\,\boldsymbol{h}\sqrt{dF_z/dz_{pp}(m_1+m_2)/m_1m_2} \approx \boldsymbol{h}\sqrt{dF_z/dz_{pp}2m_p} = \pm 2.27\text{ MeV}. \qquad (12)$$

The zero-point energy is within 2% of the binding energy of 2225 keV for the deuteron which was released during ***d***-formation as γ-radiation and consequently balances out to $E_{Bd} - E_{\mathbf{0}d} \approx 0$.

For the ***d*** photo disintegration process $\boldsymbol{d} + \gamma \rightarrow \boldsymbol{p}^+ + \boldsymbol{n} + (E_\gamma - E_{Bd})$ γ-radiation of at least 2225 keV must be supplied to “eliminate” the zero-point energy and therefore $E_{\mathbf{0}d}$ may be considered a negative storage energy corresponding to the negative square root value.

10. APPLICATION OF THE ENERGIEWIRBEL CONCEPT

The same principles were applied to evaluate heavier nuclei. Examples of force-balanced configurations are illustrated in fig. 9 through 15 in www.energiewirbel.com.

The deuteron is the only stable dibaryon. The other five dibaryon configurations have not been observed and were found unstable as discussed in the original article.

The α-particle appears as a very compact symmetric cube and provides a unique building block for heavy nuclei by attaching protons, captured electrons and other α-particles. Stability of nuclei appears to correlate with symmetry and compactness as shown in fig. 9.

Combining two α-particles leads to an elongated asymmetric shape that represents the unstable $^{8}\boldsymbol{Be}$ nucleus. Removing one of two central protons leads to a compact and symmetric configuration, the stable and abundant $^{7}\boldsymbol{Li}$ nucleus. Assemblies with individual protons removed from internal proton pairs have stronger binding, in conformance with the observed trend of the stability criteria toward neutron-rich isotopes with increasing mass number. $^{7}\boldsymbol{Li}$ provides the first step toward this trend and presents another basic building block, referred to as α-cuboid.

The entire isotopic chart can be assembled with α-particles and cuboids in 2^3, 3^3 and 4^3 arrays with additions and subtractions of protons and captured electrons to cover intermediate isotopes. In short, the Energiewirbel concept is viable far beyond any other explanation.

A very compact neutron-4 configuration is force-balanced, but has not been observed. Since it has no electron-shell it would slip through any container right to the center of gravity in stars, which may explain dark matter.

11. INTERFERENCE

Both, the photon and *EMV*s represent pulsating entities that influence their surrounding space by inducing oscillations at the edges of an aperture or at a second slit, leading to interferences.

Interference due to moving particles is governed by the matter wavelength $\lambda_M = h / p$. These matter-waves can be interpreted as beat signals by expressing the total energy in equ.5 in the form of orthogonal wave-numbers or frequencies $E^2 = h^2(\nu_o^2 + \Delta\nu^2) = m_o^2c^4 + p^2c^2$ (13)
which leads to $h\,\Delta\nu = p\,c$ or $\lambda_M = c / \Delta\nu = h / p = h / m\,v$ (14)
where $\Delta\nu$ appears as an orthogonal frequency component relative to the fundamental oscillations $\nu_o = m_oc^2 / h$ of the circulating rest energy.

The matter waves can be envisioned as beat signals due to the frequency difference $\Delta\nu$ between moving particles with frequency ν interacting with stationary particles with frequency ν_o.
In other words, the extended ν field of a moving electron interacts with the external ν_o fields of the electrons at an aperture or slit, leading to matter waves caused by beat signals.
In kind, moving protons would interact with stationary protons and so on because particles with similar frequencies are able to resonate and have significant amplitudes in the matter waves.

Representing matter waves as beat signals due to frequency differences $\Delta\nu$ between interacting particles provides easy explanations for relative motions since the effective frequency difference $\Delta\nu$ depends only on the relative velocity. In other words, if the aperture or slits move with the same velocity and in the same direction as the particle, then $\Delta\nu = 0$ and neither beat signal nor interference exists. The indeterminable wave particle duality problem of quantum theories with collapsing wavefunctions does not really exist. Matter does not have either particle or wave character, but instead inseparable extended waves are an integral part of all localized particles.
The Energiewirbel with extended oscillating fields provide plausible explanations.

The time-averaged external electrical fields of *EMV*s represent electrostatic fields that diminish with the square of distance and hence mimic charged particles. These “electrostatic” fields are modulated by oscillatory electrical field components of frequency $\nu = mc^2 / h$. Overlapping oscillating field components from different particles can form standing waves that contain but do not transmit energy. The transverse electrical field oscillations of these standing waves induce radial magnetic field component and form weak standing electromagnetic (*SEM*) fields.

From experimental evidence these fields extend over large distances and contain little energy since interference can easily be destroyed by attempting to measure which way a particle travels in double slit experiments. In other words, active sensors placed at slits alter the extended field component easily and thus prevent interference. The extended *SEM* fields must be very tenuous and/or be able to retract and expand almost instantaneously while the particle is passing through an aperture or slit, otherwise it should be possible to strip at least portions of the field from the particle and observe a loss in energy in the form of a redshift in wavelength.

A phase shift in the electromagnetic components of the *SEM* waves alone may provide such fast reactions. Since these fast responses are confined to the internal structure of *EMV*s they do not violate special relativity, which limits the velocity of the *EMV*s but not its internal constituents. The “spooky actions at a distance”, also labeled superluminal or nonlocal interactions, are really not as “spooky” when confined within *EMV*s.

The nonlocal behavior of correlated particles indicates that the external fields or *SEM* quantum potentials extend over very large distances and are able to interact by phase-shifts in a coherent manner almost instantaneously. Interference generated with beamsplitters indicates a similar remote response capability. Spatially confined, companion wave packets are apparently induced at beamsplitters and travel a separate path toward the recombination point. At this location the experienced phase information (±delay) guides the photon or *EMV* toward an interference pattern in a statistical manner. These companion waves can be spatially separated by large distances but still remain connected with their source like correlated particles.

The wave particle duality dilemma can be traced to the extreme mathematical simplifications in quantum theories of zero-size particles, infinite plane waves and spherical shapes and symmetries. QED breaks down at small sizes and therefore artificial integration limits corresponding to the Compton radius $\boldsymbol{\lambda}_C = \lambda_C/2\pi = \boldsymbol{h}/mc$ were introduced to avoid divergences and infinite self-energies.

This concept of finite-size toroidal Energiewirbel and photon cores with extended waves resolves this dilemma.

12. GRAVITATION

A plausible explanation for the tenuous guide field is the gravitational field that is 39.3 ± 3.3 orders of magnitude weaker than the electrostatic field. Only such tenuous fields could be stripped without affecting particle properties to a noticeable degree.

The companion waves do not need significant energy or momentum because they deflect particles only at symmetric small ± angles. The integrated transverse momentum is zero or negligibly small ($\leq \boldsymbol{h}$) for all known cases and can be mediated by zero-point fluctuations. Nevertheless, a small residual energy loss over galactic distances may be partially responsible for the observed redshift of aged photons and may mimic an accelerating universe.

It is feasible that gravitation can be represented as a residual force of *SEM* waves generated by interacting particles since the gravitational force has the identical inverse square dependence with distance as the electrostatic force. In addition, gravitation increases for fast moving particles according to their relativistic mass and consequently by their enhanced electromagnetic energy.

There is really no empty space in our universe. The vacuum contains background radiation, gravitational fields, *EM* fields, etc. and the vacuum exhibits a finite impedance of $Z_o = 377\ \Omega$ that impedes the acceleration of Energiewirbel, perceptible as inertia and hence mass. The extended oscillating *EM* fields from different sources interfere and lead to energy-fluctuations akin to ripples on the surface of oceans. Surface tension reduce ripples on water and entropy dampens energy-fluctuations leading to attractive gravitational tension.

If particles interact gravitationally by *SEM* waves, only quantum jumps in the particles approach can be expected, as has been verified experimentally with slow neutrons.

The 39.3 orders in magnitude difference in strength may be related to the minute change in field-strength within a single standing wave of length $\lambda_C = h/mc$ with distance. Entropy requires an attractive equalization force to reduce field gradients, perceptible as gravity.

Standing waves extending to the beginning of time ($\tau_U \approx 13.5$ billion years) result in potential strength ratios $\lambda_C/c\tau_U$ of 39.3 ± 1.6 orders in magnitude. Is this just a remarkable coincidence or is

$$\tau_U = e_o^2\, h / G\, c^2\, (m_p m_e)^{1.5} = 4.3\ 10^{17}\ \text{s} = 13.6 \text{ billion years.} \tag{15}$$

the long-sought answer to join the micro- to the macro-cosmos via gravity?

With this correlation the gravitational “constant” $G = 1.32\ 10^{-63}\ c^4$ m/ev could be expressed in the form $G = e_o^2\, h / \tau_U\, c^2\, (m_p m_e)^{1.5} = 1.33\ 10^{-63}\, c^4$ m/ev, which agrees with the present value of G.
This suggests that gravitation may have been much stronger eons ago and would have been equal to the electrostatic force at $\tau_U = \lambda_C /c$. The reduction in gravitational force with time could be correlated to the expanding universe diluting the energy fluctuations in the vacuum, mimicking dark energy. Hence, the gravitational field may be considered a residual oscillatory fraction of the electrical field.

These basic concepts probably require not only refinements but corrections. The tentative remarks are intended to inspire curiosity and constructive help. Nevertheless, the *EMV* concept appears much less speculative than the QCD standard model that offers little realism. It is time to shift toward more promising concepts.

13. SUMMARY

An Energiewirbel or *EM*-vortex concept is presented that unites all four fundamental forces of nature into one. The strong, weak and gravitational forces are all different manifestations of the electromagnetic (*EM*) field and forces.

The weak force has been identified with radial *EM* contraction forces of a proton capturing a free electron to form a neutron. The calculated energy difference is within 0.4% of the experimental value. The strong force has been identified with axial *EM* forces holding the nucleus together. The calculated binding energy for the deuteron is within 2% of the experimental value.

Mass is recognized as the embodiment of trapped *EM* energy in the form of toroidal shaped vortices. These Energiewirbel are created during the collision of an energetic γ photon with a strong field (nucleon). The neutral *TEM* wave of the photon is split apart into two *TE* fragments with unstable longitudinal magnetic fields that form closed loops to minimize energy. As a result the fragments are coiled into two oppositely charged *EM* vortices. These localized energy vortices with $v < c$ resist change of motion v, perceptible as particles with inertia and hence mass.

Massive elementary particles (EP) can all be derived from such Energiewirbel. The muon and tau leptons are energetic resonance states of the electron. Charged pions are the lightest mesons, bosons and hadrons and appear as muons rotating at relativistic speed around a radial axis. The rotational energy is equivalent to the mass difference between the pion and muon of 35 MeV.

The hadrons are all considered combinations of pions characterized by pion numbers analogous to nuclei that are characterized by proton and neutron numbers. The proton is the only stable four-pion state, while all other hadrons decay via pions and muons into stable electrons, neutrinos and photons. This basic unity of all particles explains the identity of all particle charges. In contrast, the fractional charges of the quarks would have to be matched to the unrelated electron with a precision of over 36 orders in magnitude to reduce residual electrostatic forces below the gravitational forces. This appears to be an unrealistic if not absurd proposition and neither fractional quark charges nor individual quarks have ever been observed.

All EP's are surrounded by extended oscillating field components induced by their internal oscillations. Interference is caused by the interaction of the field of a moving particle with the field of a stationary particle. The velocity dependent difference in frequency of these oscillating fields causes beat-signals equivalent to matter-waves that guide the particle's path.

Gravitation can be traced to *EM* vacuum fluctuations generated by standing *EM* waves between interacting particles that experience quantum jumps as observed with slow neutrons.
On that basis, gravity can be correlated via microscopic quantities to the age of the universe of 13.5 billion years.

While the concept and coarse outline has been completed, a lot more work is required to refine the Gedanken experiment. The agreements of the evaluations done so far with experimental observations are very encouraging and represent quite remarkable advances for such a totally new concept or universal theorem explaining all basic natural forces, matter and particles as different manifestations of electromagnetic energy.

FIG 1: PAIR CREATION CONCEPT

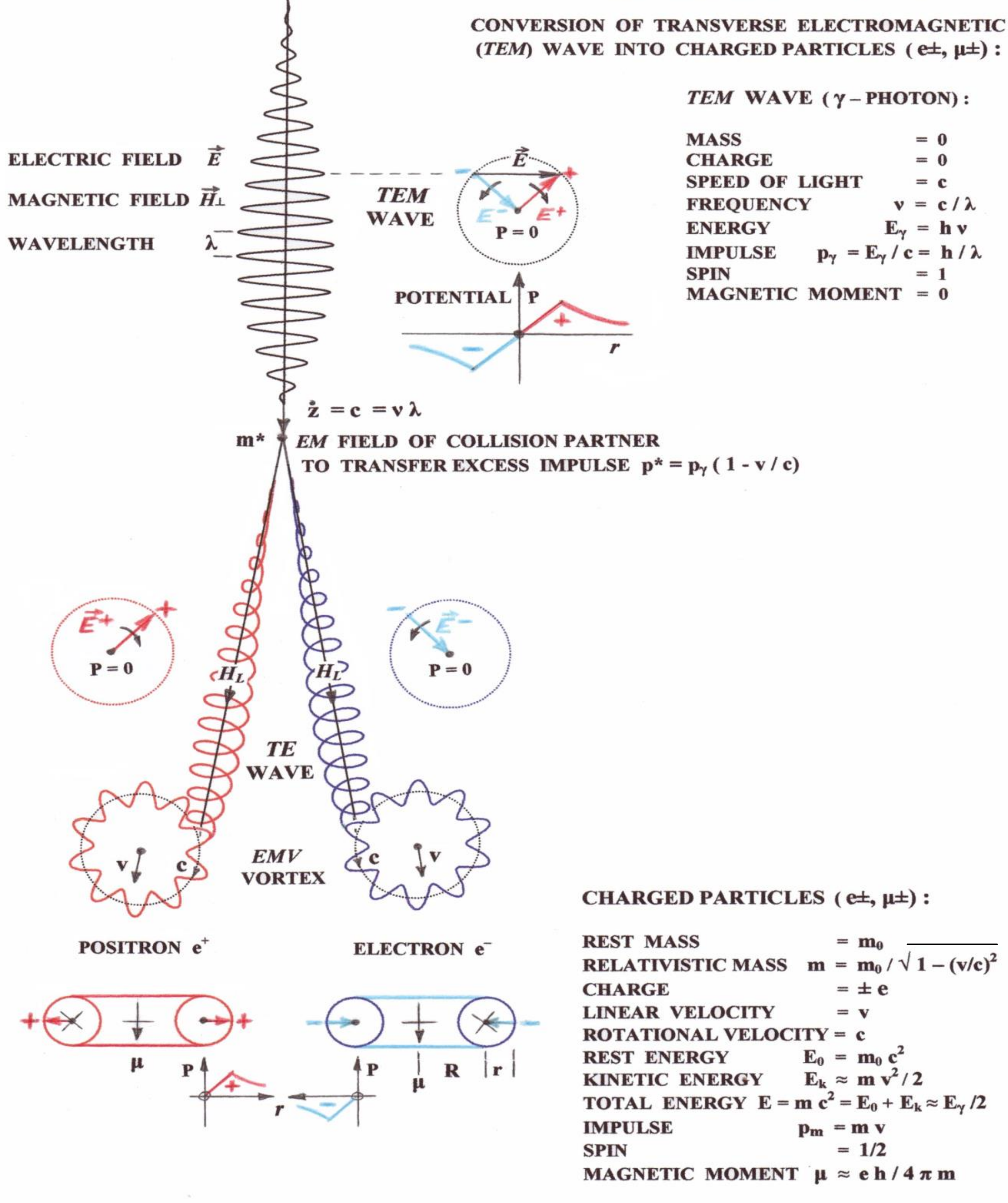


FIG 2 : DECAY SEQUENCE
TRANSITIONS FROM EXCITED LEPTON STATES AND MESON RESONANCES

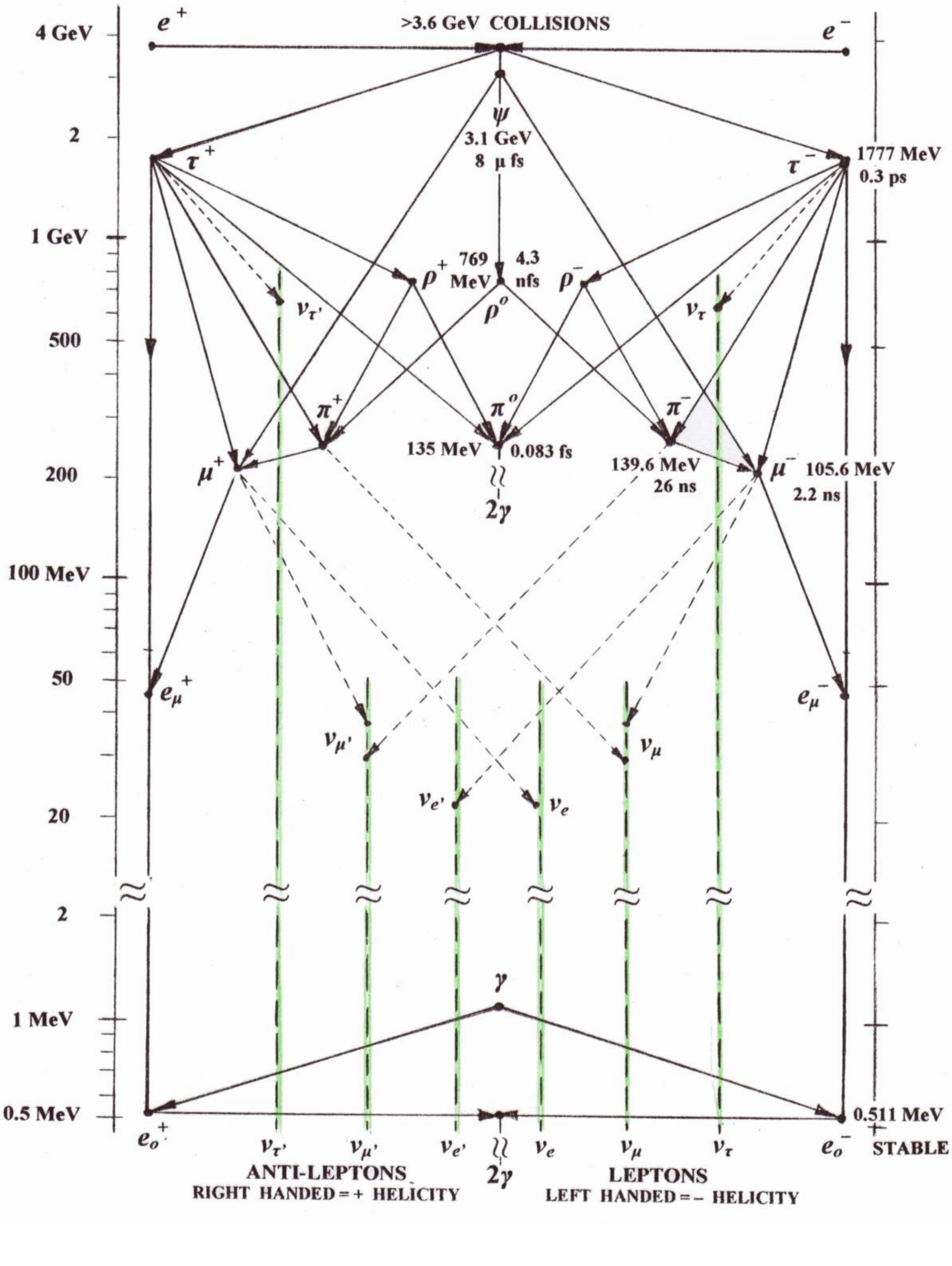


FIG 3: MUON DECAY $\mu^- \rightarrow e^- + \nu_\mu + \nu_{e'}$

INDUCTION OF NEUTRINOS BY RADIALLY EXPANDING *EMV*

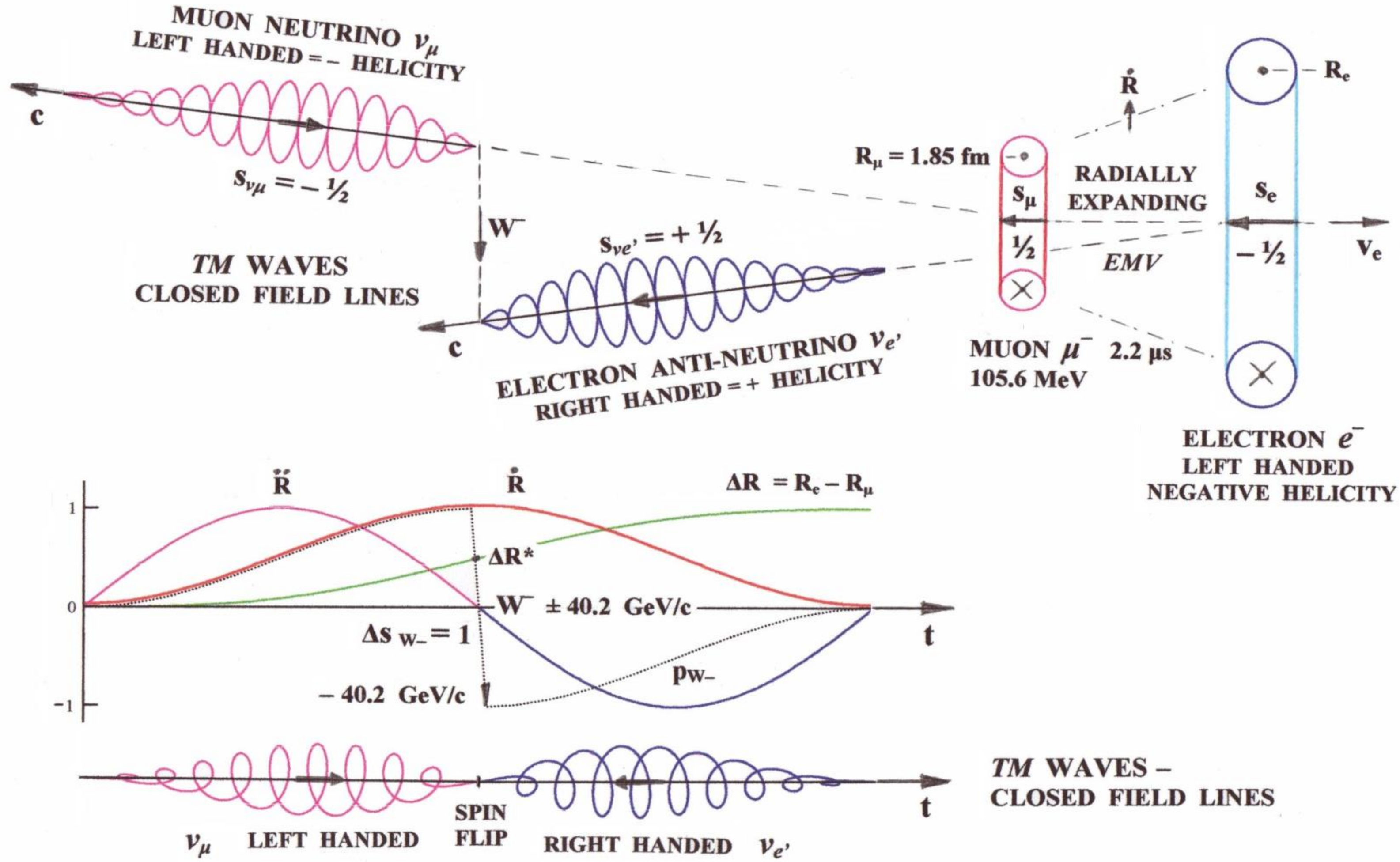


FIG 4: ELEMENTARY PARTICLES AS MULTIPLE PION STATES
MASS CORRELATION OF HADRONS WITH PION NUMBER

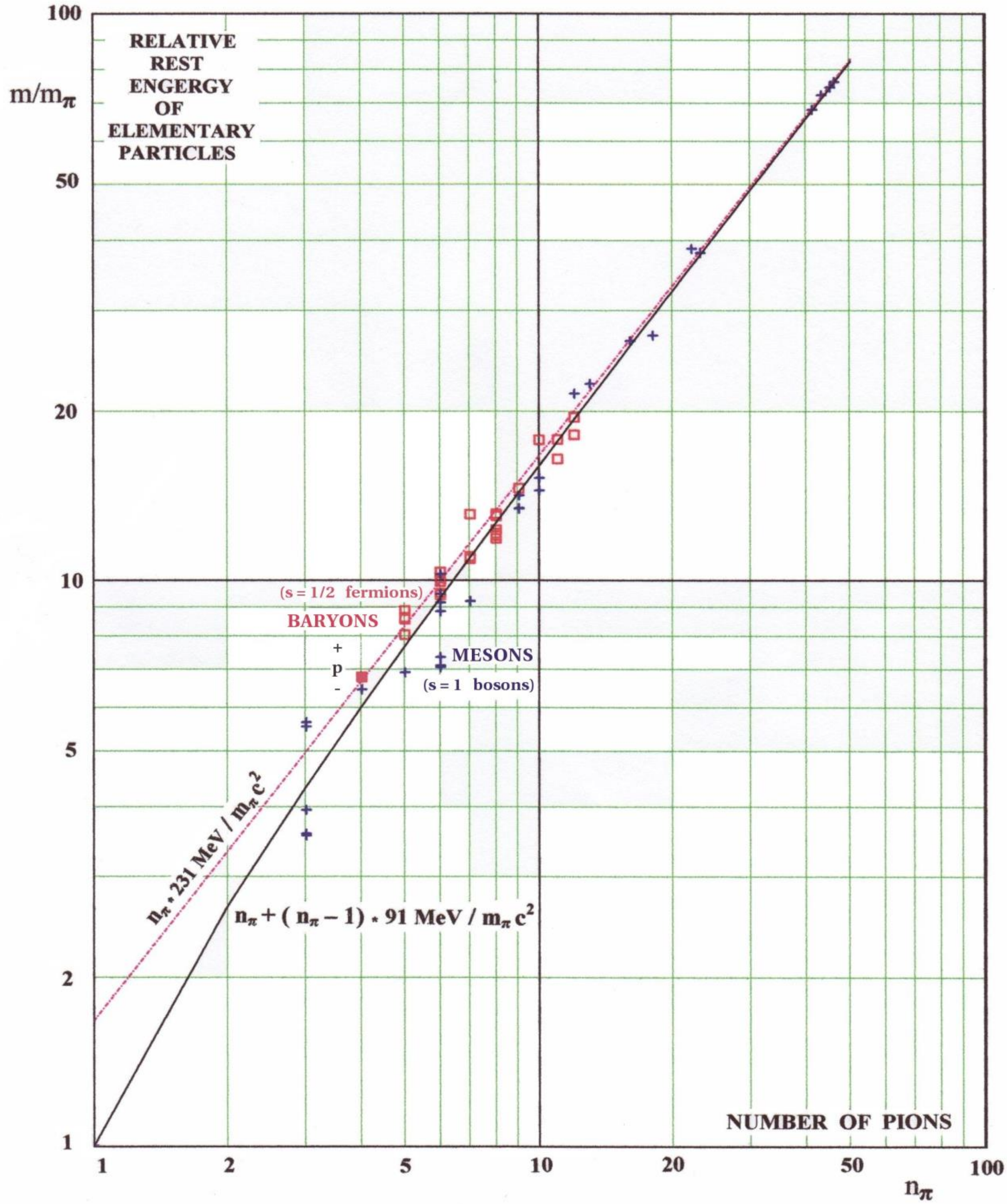


FIG 5 :   ENERGY DISTRIBUTIONS OF NEUTRON

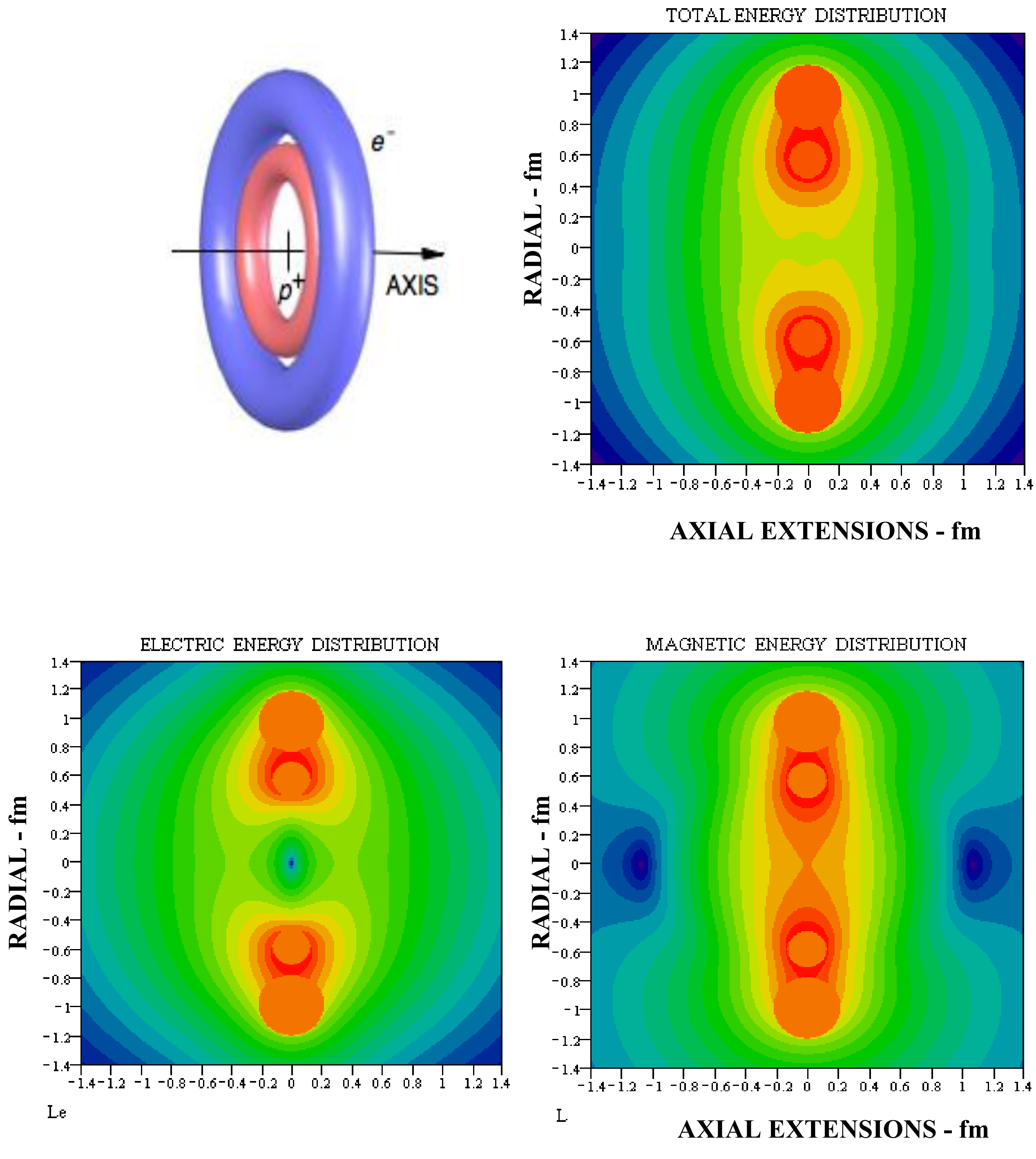


FIG 6 : ENERGY DISTRIBUTIONS OF DEUTERON

EXHIBITING LOCATIONS OF ZERO FIELD AND ENERGY

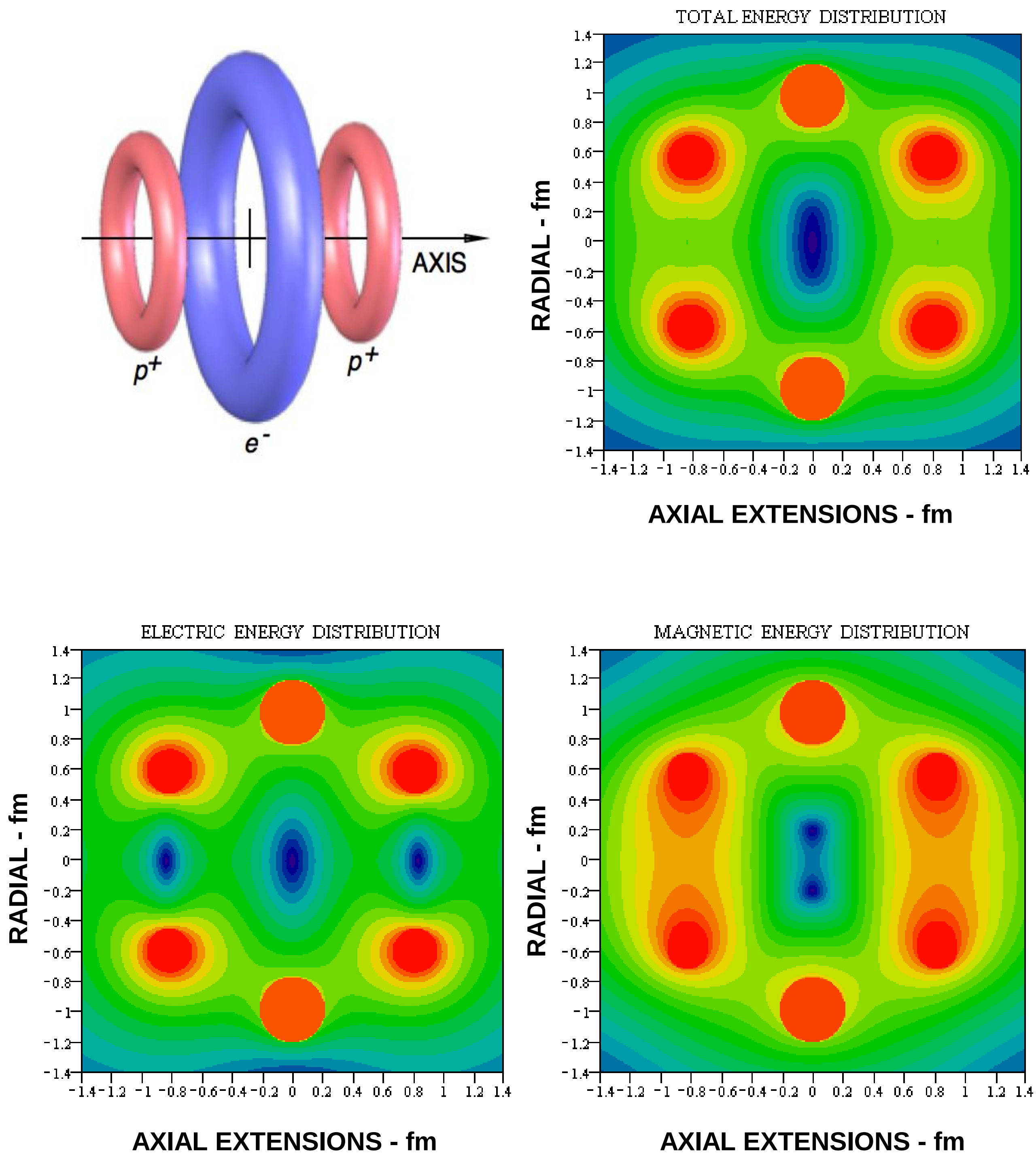


FIG 7 : FIELD DISTRIBUTIONS OF DEUTERON

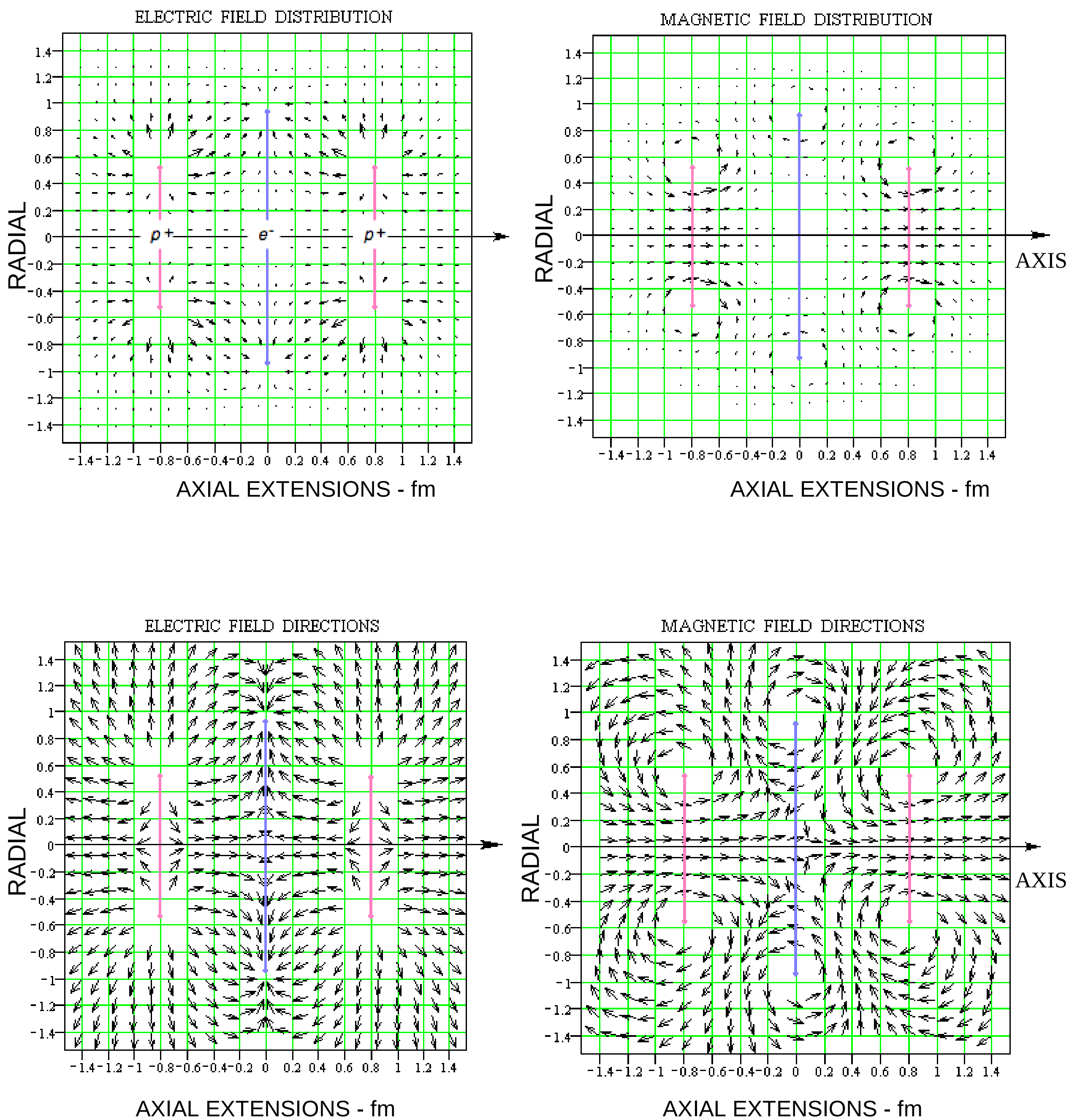


FIG 8 : NONEXISTENT SPIN = 0 "DEUTERON"

OPPOSITE SPINS LEAD TO REPELLING MAGNETIC FORCES
AND ASYMMETRIC ENERGY DISTRIBUTIONS

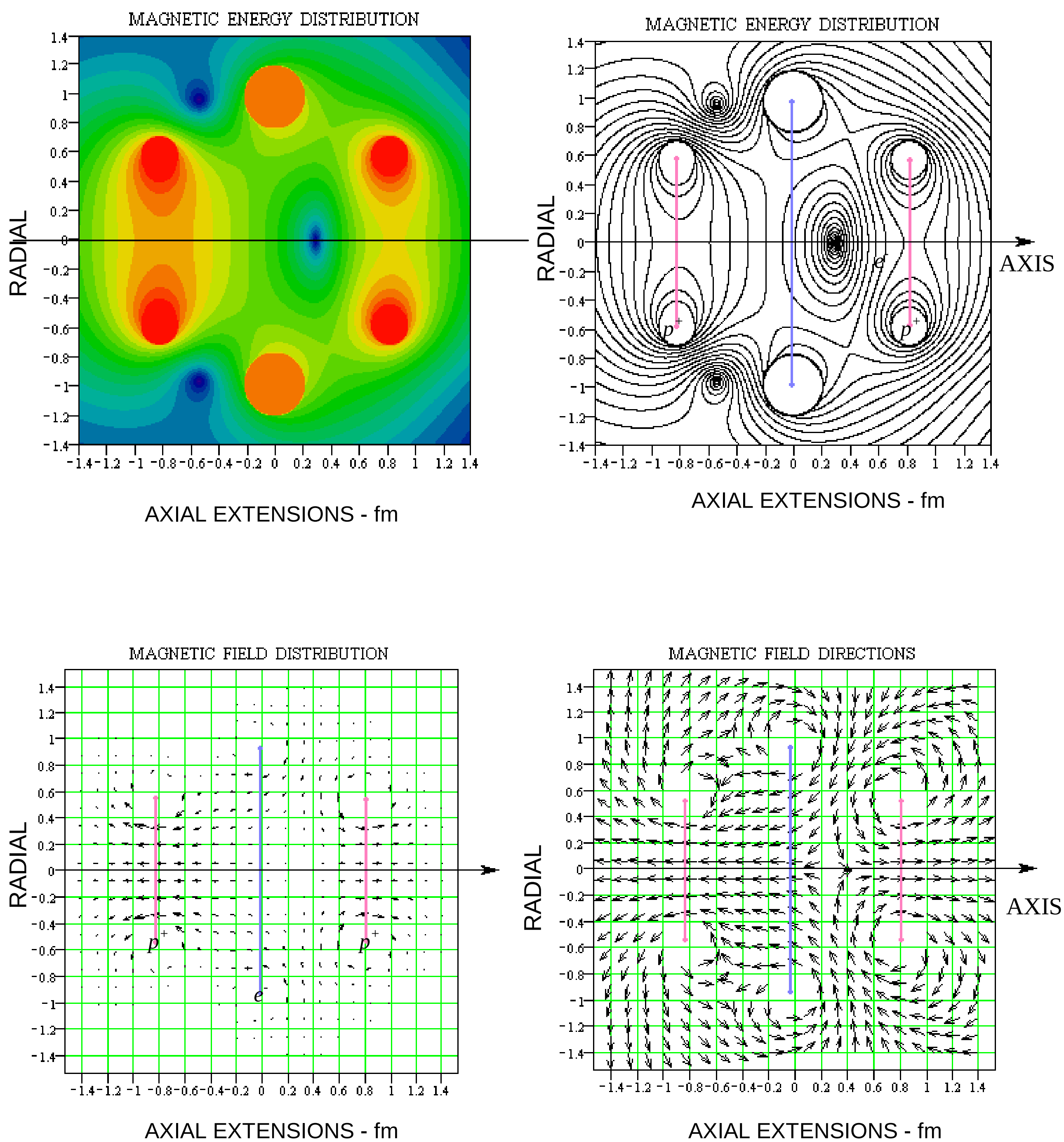
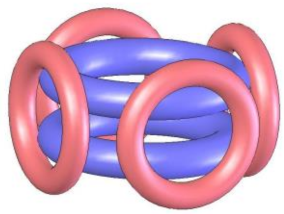


FIG 9 : NUCLEAR GEOMETRIES

HELIUM - 4 = α
99.9863 % 28.296 MeV
I = 0 $\mu_\alpha = 0$ $r_c = 1.45$ fm

Re = 0.8 fm ze = ± 0.283 fm
Rp = zp = ± 0.954 fm

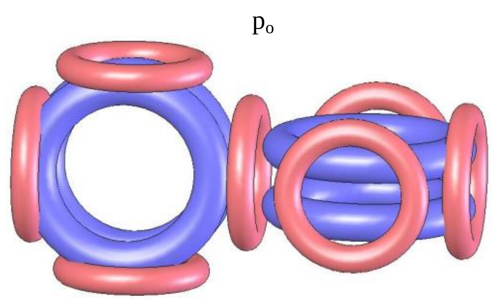
α - cube



LITHIUM – 7
92.5 % 39.24 MeV
I = 3/2 +3.2564 μ_N $r_i = 2.23$ fm

Re = 0.8 fm ze ≈ ± 0.27 fm
Rp ≈ 0.94 fm zp_op ≈ ± 1.97 fm

α - cuboid



NEUTRON – 4 ?

Re = 0.43 fm *Rp* = 0.6385 fm
ze = ± 0.204 and ± 0.69 fm

n-4 - cube