Electromagnetic Particle Model of the Electron

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A particle model is presented which identifies the electron as electromagnetic wave rotating with the speed of light. This rotary photon shows the negative field of the first half wave at its exterior and after an internal torsion the lower part of the positive half wave, thus again the negatively acting field outside. It possesses all quantum characteristics of the electron such as charge, magnetic field, spin as well as wave characteristics. From the spin the electron diameter can be computed as the measured Compton wavelength. The polarity of the external field part defines the positron or electron. A positive or negative internal torsion of the wave corresponds to a lepton with spin up or down. Without torsion, it forms the neutrino. Quantum mechanics describes results only statistically. Interactions between particles are, however, strictly causal and local and can thus be simulated.

High-energy physics has been concerned with the investigation of structure and reactions of leptons and hadrons for decades. Higher and higher energies were used, in order to examine matter with increasing resolution. After the refusal to fund the Superconducting Supercollider in the USA 1993 an engineering newspaper quoted: „For 90 years it is known that elementary particles transfer energy in quants. For 70 years it is known that they rotate and possess wave and particle characteristics....Despite this neither the cause of the quant-like energy transfer, the cause of the rotation is known today nor a construction drawing of the elementary particles exists“[i]. A physical description or a model of the fundamental characteristics, e.g. the spin or the charge of a quark or the electron, is missing. The reasons for the wave/particle dualism of the electron and matter in general are not known. It is often even denied that a quantum

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reality exists[ii]. Also the reasons for the equivalence of mass and energy ($E = m c^2$), the odd quark charges of -1/3 and +2/3 of the elementary charge and the 3 additional theoretical quantum numbers of the quarks („colours“) definitely are unknown.

The success of quantum electrodynamics and quantum chromodynamics is beyond each doubt, as far as they describe the reactions of the particles and forecast results of measurements with quantum wave particles statistically. A quantum reality, however, is demanded further to reduce the number of the elementary constants (now approx. 20) or the number of the natural forces (e.g. Herbert[iii]). If merely characteristics such as mass, spin or charge of the electron or the nucleon could be correlated with each other this would be regarded as substantial progress (Höfling[iv], Grotelüschen[v]).

A new concept of the leptons and quarks is needed, which would have to explain the quantum wave nature of the elementary particles. Above all, however, a model should be able to explain the charge, i.e. the outside field of the electron and the proton / the quarks. Thus the „construction drawing” of the electron and the quarks is required.

Model of the electron

What is the electron? What is a rotary charge cloud with a negative electrical field, which behaves like a wave in diffraction experiments and can expel photons from some substances? A small stone with charge (classical assumption for the search for a solid particle with finite diameter)? An abstract quantum wave of statistical nature as placeholder wave? What is a rotary charge cloud with a negative electrical field, which behaves like a wave? An electromagnetic wave circulating with the speed of light “c”? Such a structure or particle wave electron could be imagined, if the negative field of the electron were formed as part of an electromagnetic wave, in which the negative part of the field always is on the “exterior” and where the positive half wave remains on the inside, a rotary or „wound up” photon. The energy of the electromagnetic field forms completely or partly the mass equivalent of the electron in this model.

How does the electromagnetic field of a photon look like? The electric field is defined as the direction in which a test charge would move; the intensity of the field corresponds to the acceleration the test charge is subjected to. Along the path of the photon, the field strength corresponds to the classical sinus wave as given in fig. 1.

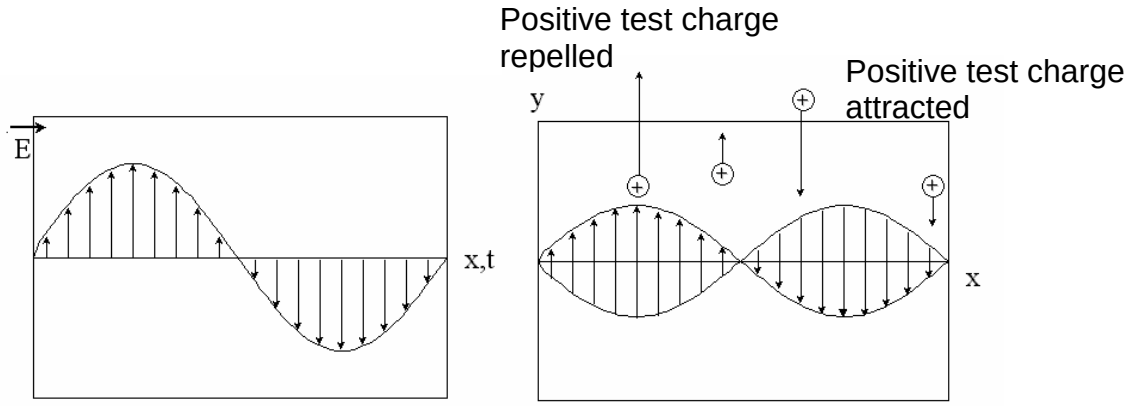

Fig: 1: Electric field strength E of an electromagnetic sinus wave.
Right side: Vector field of E in the x-y plane: the direction of acceleration of test charges gives the field direction

If looked at in space (Fig. 1 right side), the field has an underside and the field strength is defined as the length of the vector. The positive test charge above the x-y plane is repelled by the field of the positive half wave into the direction of the arrows, i.e. the field acts as positive charge “above” the plain. The same test charge, however, is drawn upwards, if placed below the path of the wave in the x-y plane. This, per definition, is the action of a negative field that attracts the positive test charge. Submicroscopically, the same field part can act as positive charge and as negative charge some distance apart. The following negative half wave now attracts the positive test charge above, but acts as positive field geometrically below. A possible construct for a particle that is “always” negatively charged (on the outside) and has the positive part somehow on the inside can be imagined, if the wave turns upside down after one half phase. Fig. 2 schematically shows a Moebius ribbon as path of such a circulating electromagnetic wave with an internal torsion (like a circular polarised photon) per revolution.

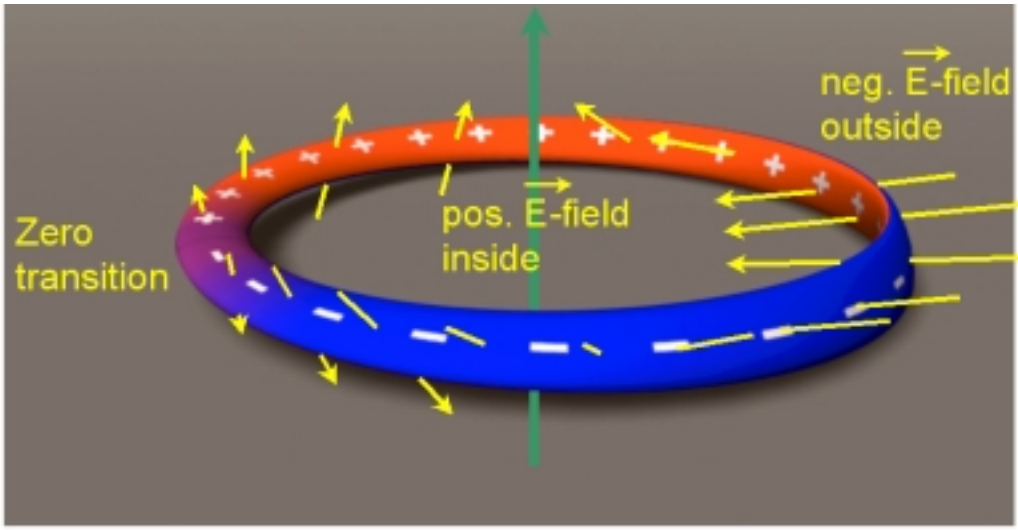

Fig. 2: Path of the rotating wave forming the electron.

The rotating electromagnetic wave on a path in form of a Moebius ribbon is shown with the rotation axis. The field strength and the field direction are drawn in as arrows. Note the zero transition with local change in field direction

The field distribution of the particle with a zero transition and the internal torsion of the Moebius - ribbon are schematically drawn in. The field direction indicates, in which direction the assumed test charge would move. Although there are no smaller test charges than the electron itself, this is a permissible thought experiment. The internal torsion of the Moebius ribbon ensures that only the negative half wave is outside and after zero transition the „lower surface" of the positive half wave is on the outside, which is again negative from their effect. If the field is negative outside, the effect of the field inside the "ribbon" thus corresponds to a positive surface. Here, the field is compensated to a large extent, since the field effect needs about as much time, to arrive at the other side, as the wave needs for a half circulation and to build up the counter field, which means there is no long range effect of the positive inner side of the electron. This rotating wave of the current model is suggested to be called "c-tron" because of the peripheral speed of light c.

Properties and variations of the c-tron

The field rotates around its axis - therefore the particle has a spin. During one revolution of the field along the path of the Moebius ribbon only the first half of the sinus wave is accomplished. The second half wave is completed after the internal turn during the second revolution. It is a very remarkable property of this model of the electron that two revolutions are necessary, in order to accomplish a full cycle or phase. This is the definition of the spin 1/2! The fact that some quantum particles need 2 revolutions to perform one full phase fills pages in physics books. The strange phenomenon is described with the analogy as if the earth needed 720 instead of 360 degrees to have turned completely - but this quantum feature is clearly met by this model. This natural and realistic explanation of the spin 1/2 is an extremely strong aspect in favour of the current particle model so far.

The ribbon loop can exist in two variations: with an outward torsion with respect to the direction of revolution and with an inward torsion seen in the same direction. The same can be imagined for the positron. If the field rotation is counter clockwise in Fig. 2, the torsion is shown as outward. An additional magnetic moment results from the change of the field orientation at the zero transition. This additional moment is reversed, if the torsion goes inward. In an external magnetic field, this moment will divert the c-tron either towards the north pole (“up”) or to the south pole (“down”), representing the "spin up" and "spin down“ leptons, which either orient parallel or antiparallel with an external magnetic field. The particle further can have the negative field or the positive field on the outside, thus representing the electron or the positron. Fig. 3 such shows a wave ribbon in these two possible configurations.

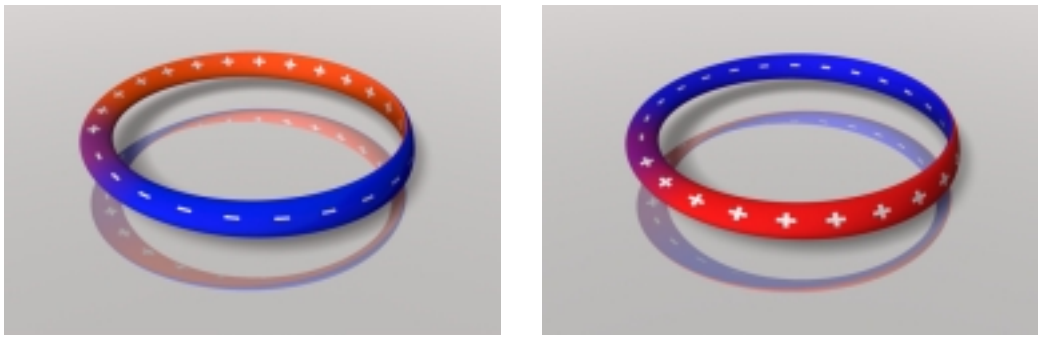

Fig. 3: The c-tron with negative and with positive field on the outside, representing the electron and the positron

The field of a circulating wave without internal torsion is negative in one revolution and positive within the next one, thus altogether neutral. This particle is regarded as a candidate for the neutrino. This change in polarity is represented in fig. 4.

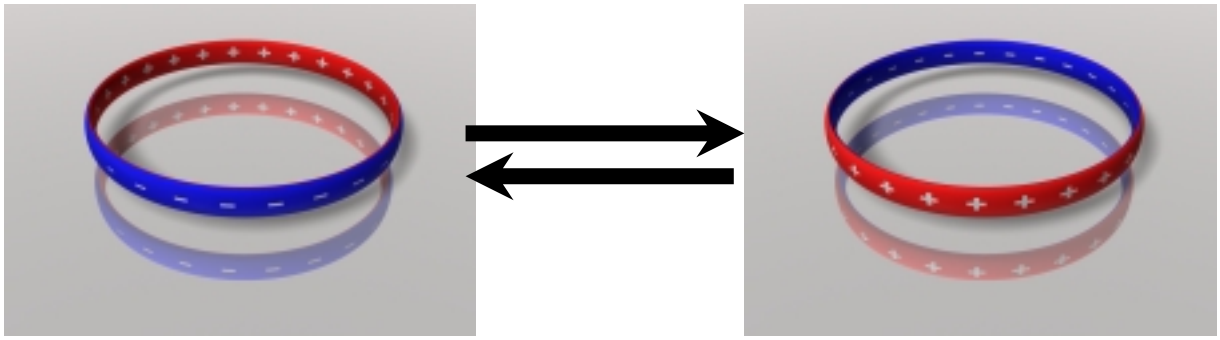

Fig. 4: Neutral C-tron without internal torsion
Left: 1st revolution: neg. E-Field outside, 2nd revolution: pos. E-Field outside

The alternating polarity of a c-tron without internal torsion (zero transition not shown) is neutral over time - the neutrino.

For this particle, a full phase is completed after 2 circulations with spin ½, again. The neutrino cannot be identified positively, as hardly any data are known on the genuine particle. The probability, however, that the most common neutral particle is of a similar and even simpler nature than the electron and positron is regarded very high. According to this model the mass of the neutrino is estimated to be in the order of magnitude of

that of the electron. Nature offers photons and leptons in a beautiful simplicity: as linear photons and as circulating photons or c-trons. The latter occur with internal torsion as electrons or with a phase shift as positrons, each with spin up or down, or as neutrinos with no internal torsion.

The change of the electric field induces a magnetic field which has its maximum at the zero transition of the electric field. It can be imagined that a closed loop of the magnetic field is formed - see fig. 5. The similarity with the well-known picture of the electron as small bar magnet is compelling. The magnetic flux through an area is divided in quants. The magnetic loop of the electron therefore is thought to be formed of one single magnetic flux thread.

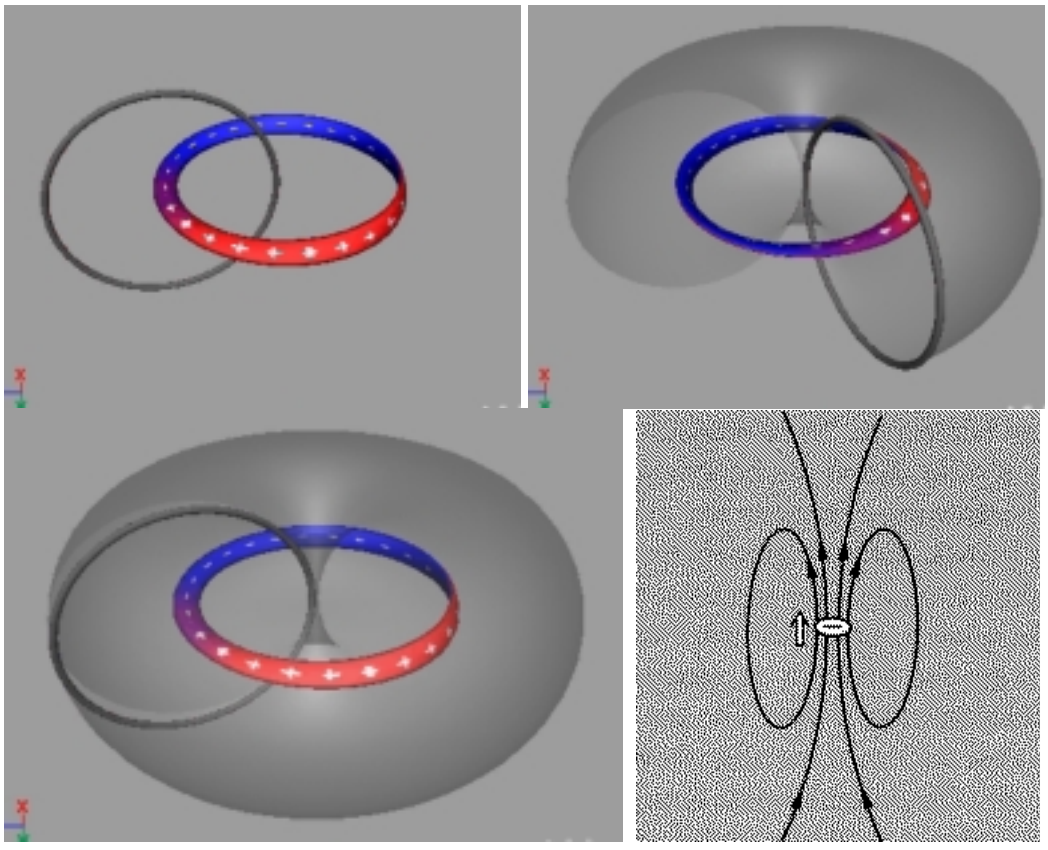

Fig. 5: Formation of the magnetic field of the positron
Simplified rotation of the positron until completion of the first half phase; compare the magnetic field of the rotating photon with the classical notation of the electron as tiny magnet (lower right).

This model of a circulating photon shows all characteristics of the electron:

- a negative electrical field on the exterior
- a spin and a magnetic moment, north and south pole
- the spin amounts to 1/2, as 2 circulations are necessary for a full phase
- a mass in the order of magnitude of the measured rest mass as per $E = m c^2 = h \nu$
- behaves like a wave in interferometer experiments (as it is a wave)
- has an antiparticle with the positive part of the wave on the exterior

The model postulates the following:

- Interactions with other particles (e.g. leptons and photons) occur by addition and superposition of the local fields.
- interactions with other fields/particles therefore are strictly causal and local
- as the field revolves with the speed of light „c", another prediction of the results than with statistic quantum mechanics is hardly possible.
- There should be a significant difference in the reaction rates between particle beams shot at each other, if the spiral - like waves in motion relative to each other have the same sense of rotation or an opposing one. The effective cross section - the probability of a reaction - should be much higher, if the spirals have the same sense in space. The same should be true for jets created in particle collision experiments: The spiral sense of the jets should be coupled, as the angular momentum of the wave conglomerate formed in the moment of collision has to be kept as well as the overall momentum itself.

Radius determination from Spin

As the first computational test of this model it should be examined whether characteristics like the spin are associated with the mass of the electron, if the mass equivalent of the electromagnetic field ($m = E / c^2$) rotates with speed of light „c". The classical electron radius computes itself from the capacity of the electron as sphere condenser with charge e^- (Formula 1 after: Mohr & Taylor[vi]):

$$r_e = \frac{e^2}{4 \pi \varepsilon_0 m_e c^2} = 2{,}81 \; . \; 10^{-15} \text{ m}$$

After R. Gross[vii], „no meaningful result" can be derived from the computation of the equatorial peripheral speed v of this electron in several approaches, although it is a postulate of quantum mechanics not to contradict the classical mechanisms. The classical approach leads to no meaningful result according to the "own" statements of modern physics.

The peripheral speed „v" is assumed in the current model as speed of light „c". This approach is strictly forbidden according to the standard model, since no „mass" can move with speed of light. Only „mass less" particles or photons - which nevertheless are provided with an exactly defined mass/energy equivalent - can move with "c". The above approach should therefore lead to an unreasonable result.

The angular momentum L of a mass (e.g. m_{el}) around an axis and the radius r is defined as: $L = r * m_{el} * v$.

The mass of the electron m_{el} (=field energy $/c^2$) rotates with „c" around the radius "r" in a first approximation. With v = c the angular momentum becomes

$L = r * m_{el} * c$ with $m_{el} = 0.51$ MeV/c^2 $L = r$ (0,51 MeV/c^2) $* c = r * 0{,}51 * 10^6 / c$

The electron spin is defined to L = 1/2 * h/2 π . Here the radius is the only unknown parameter and can be calculated (Formula 2):

$$r = \frac{1}{2}\ \frac{h}{2\,\pi\, m_{el}\, c} = \frac{1}{2}\ \frac{4{,}14\ \ 10^{-15}\ \ 3\ \ 10^{8}}{2\,\pi\ \ 0{,}51\ 10^{6}}\ \ \left[\frac{eV\ s\ m}{eV\ \ s}\right]$$

and r = 1.93 * 10^{-13} m.

This radius corresponds to a measured value for the scattering of an individual photon at the electron. The quantity d = 2 r = 3, 86 * 10^{-13} m is well-known as Compton - wave-length. What, if the Compton wavelength were more than a historical observation without further meaning? It should be considered that the analysis of atomic distances with x-rays is a usual procedure in physics and e.g. metallurgy. The measured Compton wavelength according to this model becomes the measured diameter of the circulating photon - of the electron. The computation of the electron radius from the spin as rotation of the electromagnetic field with speed of light “c” around the radius “r” thus leads to a meaningful result in contrast to classical computations of the electron radius.

Matter wavelength

The radius determined before has to be compatible with the classical quantum physics observations as the de Broglie wavelength and the mass - energy equivalence. One full phase of the c-tron of the current model is completed after passing the circumference "C" of the particle twice, i.e. λ = 2 * C = 2 * π * d. With the electron diameter d = 2 r = 3,86 * 10^{-13} m derived from the spin, the wavelength can be calculated to λ = 2.425 * 10^{-12} m and with ν = c/λ the circulation frequency ν_0 of the particle in rest to ν_0 = 1.237 * 10^{20} Hz. It is interesting that this rest mass frequency often is cited in physics books, but its nature is not explained or commented[viii].

In a very clear way the natural frequency ν_0 by de Broglie for an electron in rest gets a very realistic meaning as the true frequency of the c-tron of the energy $E_0=h\,\nu_0$. With $m = h * \nu_0 / c^2 = 6.63*10^{-34}*1.237*10^{20}/(3*10^8)^2 = 9.11*10^{-31}$ kg the mass is obtained as correct mass of the electron. The Compton wavelength as diameter of the electron is fully compatible with the approach of de Broglie in interpreting the electrons the same way as the photons by $E = h\,\nu$. The de Broglie wavelength of a moving particle, however, is interpreted as the group velocity of matter waves and cannot be derived directly from the model at the moment. In the model, the c-tron wavelength of $2{,}4 *10^{-12}$ m and the de Broglie wavelength of an electron of 1 eV ($5.92 *10^5$ m/s) of ca. 10^{-9} m are not identical. The E-field maximum, however, has to follow a certain path along the path of the electron. It is unlikely that the c-tron flies like a discus, as the forward pointing component would have to deal with the relativistic addition to c. So the movement of the electron, if accelerated by an external electrical field, will be like a spiral, whose projection to any diffraction grid or interference device is a sinus oscillation. It is assumed that the displacement of the E-field maximum Δx for a certain velocity v is identical with the de Broglie wavelength λ_{DB}.

The de Broglie wavelength is coupled with the impulse p = mv. With $m = h * \nu_0 / c^2$ and with $\nu_0 = 1/ T_0$ as the frequency of the particle in rest and the period T_0 the impulse gives $p = h/\lambda_{DB} = mv$. The velocity can be written as (formula 3):

$$v = \frac{hc^2}{\lambda_{DB} h\nu_0} \qquad v = \frac{T_0 c^2}{\lambda_{DB}} \qquad v = 1/(\nu_0\,\mu_0\,\varepsilon_0\,\lambda_{DB})$$

The de Broglie wavelength then is given as $\Delta x = \lambda_{DB} = (T_0/v)\,c^2$ (formula 4).

If checked with the data of the 1 eV - electron above, λ_{DB} can be calculated correctly to $1.23 * 10^{-9}$ m. This is merely a different way of writing the de Broglie equation as function of the energy (ν_0) of a particle.

There are plenty of data suggesting that the diameters of electrons, protons or neutrinos is "below a certain size" of e.g. 10^{-15} m. This would certainly be correct if looking for the small "stone with charge". It should be regarded, however, that the diameter will decrease at increasing energies of the particle/c-tron. An electron energy of 1 GeV corresponds to a diameter of $1.9 * 10^{-16}$ m according to formula 2, which fits perfectly to the current model and to the observations concerning measured particle diameters at high particle energies.

Outlook for quantum mechanics

The interpretation of the electron as a circulating photon solves the mystery of the application of the equation $E = h * \nu$ to solid matter, which led to the wave aspects of matter. At the same time it opens a door to the equivalence of matter and energy. Electromagnetic energy and matter are equivalent because they are of identical nature.

$m = h \nu / c^2$ is the definition of matter itself and can also be written as $m = \nu\ h \mu_0 \varepsilon_0$ with the frequency of the wave as the factor controlling mass and energy, coupled with three elementary constants, i.e. just depending on the magnetic permeability, the dielectric constant and the Planck constant giving the smallest unit of an effect unit as the product of energy and time.

The classical question of quantum mechanics, why a particle shot at a double slot "knows that the other slot is open" can only be answered in one way according to the present particle model: the particle passes the two slots at the same time without being absorbed and without reacting with the matter of the slots (or atoms), i.e. producing no effect. The German reading for the Planck - constant is "Wirkungsquantum", i.e. effect - quantum. The wave finally interferes with itself and is able to produce an "effect" on the screen only, where the E-field maxima add instead to annihilate to yield an electromagnetic field strength high enough to produce an effect, i.e. to release a photon from the screen..

A model of the quarks with the current model of charge and mass/energy of the c-tron is in preparation and accesses the -1/3 and + 2/3 charges as well as the colours.

The special way of writing the de Broglie equation as function of the energy (ν_0) in formula 4 suggests that space is divided into increments of T_0/v with the natural constant c^2 or $1/ \mu_0 \varepsilon_0$.

The model postulates measurable differences in the effect, if two jets with the same or with different rotation direction are forced to collide or result from particle collision.

The model describes matter as singularity-free closed loops of electromagnetic waves. It might have certain aspects in common with the string theory, but on a quantum - realistic basis.

Summary

The electron can be described as circulating electromagnetic wave, i.e. as photon with angular momentum which follows the path of a Moebius ribbon. This rotary photon with an internal torsion per circulation shows the negative field of the first half wave at its exterior and after an internal torsion the lower surface of the positive half wave, i.e. again the negative field. It possesses all quantum characteristics of the electron such as charge (constant negative exterior field), magnetic field, spin as well as the wave characteristics.

From the spin the electron radius can be computed. It corresponds to the Compton - wavelength, which is regarded as measured value of a physical dimension. As the peripheral speed is the speed of light "c", the particle could be called "c-tron".

According to whether the internal torsion of the c-tron is positive or negative with respect to the rotation direction, the spin up and down properties are found. If the

internal torsion is zero, the particle corresponds to the neutrino. There is therefore only one elementary particle forming the linear photon and the lepton in three variants: the circulating photon with positive or negative field on the outside or without internal torsion, in the variations e -, e+ and ν_e. Statistic quantum mechanics is necessary and appropriate for the macroscopic description of interactions, since the local rate of change of the electromagnetic field with "c" is extremely high. The result of two c-tron - particles meeting resembles the collision of a paper ball with a high-speed fan. Although the result is only statistically predictable, the interaction itself nevertheless could be caught in a high speed film recording collision angle and location. The result - the direction and momentum of the result particle, however, - is strictly local and causal.

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[i] Dr. Joachim Karweil, letter to the editor (translated) concerning VDI – Nachrichten **No. 45**, 1993.
[ii] Nick Herbert, ”Quantenrealität” Goldmann 1987, 32ff
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[iv] Höfling, Waloschek, ”Die Welt der kleinsten Teilchen”, rororo Sachbuch 8474, 1988, S. 455
[v] Frank Grotelüschen, “Der Klang der Superstrings”, dtv, 1999, S. 30ff
[vi] Physical Constants, Mohr & Taylor 1999
[vii] R. Gross, Das Wasserstoffatom, Vorlesungen, Kap. 4
[viii] W. H. Westphal, "Physik" Springer Verlag Berlin 1963, p. 620