# Correlation of Elementary Charge with Spin in a Singularity Free Electron Model

Christoph R. Caesar

München, Germany

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A singularity free model describes the electron as electromagnetic wave rotating with the speed of light. This rotary wave 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. The positive field component on the inside partly compensates itself. The ratio of the field energy forming the charge to the total particle rest energy is 1/137, the fine structure constant. With this dimensionless factor the correct elementary charge can directly be derived from the spin.

**Introduction**

Various disciplines of physics have 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. 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. Despite the tremendous effort, however, a physical description or a realistic model of the fundamental quantum characteristics, as spin or charge of a quark or electron, has not been found yet. Furthermore, the reasons for the apparent wave/ particle dualism of matter and for the equivalence of mass and energy are not known yet.

Several approaches for a quantum reality of the electron have been published, e.g. a model of Paul Dirac[1] with mass less particles circulating each other with the speed of light or models which regard the electron as a solid charged shell rotating with the speed of light[2]. Diracs approach recently was extended to a more or less complete particle model of the electron[3]. These models, however, cannot predict the elementary charge or the correct spin nor could the existence of the mass less particles be proven. A solid shell or mass, however, has never been observed to move with c, either.

A quantum reality of the electron should further reduce the number of the elementary constants (now approx. 20) or the number of the natural forces[4]. If merely the electron mass, spin or elementary charge could be correlated with each other this would be regarded as substantial progress[5, 6].

**The electron**

What is the electron? What is a rotating charge cloud with a negative electrical field, which behaves like a wave in interference 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 rotating 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 somehow hidden, a rotary or „wound up" photon. The energy of the electromagnetic field entirely forms the mass equivalent of the electron in this model.

How does the field of an electromagnetic sine wave 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 wave, the field strength corresponds to the classical sine wave as given in fig. 1.

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 - axis (x-z - plane) is repelled by the field of the positive half wave into the direction of the arrows, i.e. the field of the positive half wave acts like a positive charge “above” the plane. The same test charge, however, is drawn upwards, if placed below the path of the wave in the x-z plane. This, per definition, is the action of a negative field that attracts the positive test charge. The following negative half wave now attracts the positive test charge above, but acts as positive field geometrically below the plane.

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 circularly polarized photon) per revolution. The ribbon could also be a segment of a spherical wave in reality, but the internal twist of the zero transition is harder to visualize in a sphere. Therefore the model of the ribbon is kept in the further. The field intensity has the maximum of one half sine on the right and a zero transition. It shows the internal torsion of the Moebius ribbon. The field is perpendicular to the surface; the normal vector gives the direction, in which an 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. The field strength in radial direction $E_r$ of the Moebius ribbon surface is $E_r = E_o \cdot \cos \varphi/2 \cdot \cos\varphi/2$ which is always mathematically positive due to the internal torsion. The positive field on the inside is compensated in the long range effect to a certain fraction, as the maximum field strength, decreased by $1/r^2$, is counteracted by the positive field of the previous revolution pointing in the opposite direction. The fraction 1/X of the field energy that forms the external charge to the total field energy $E = h \cdot \nu_0$ can be calculated. The electron is regarded as sphere capacitor with the stored energy:

$E_{charge} = 1/2\, Q^2 /C = 1/X \cdot h \cdot \nu_0$. With the capacity $C = 4 \pi \varepsilon_0 r_{el}$, the charge Q is

$$Q = \sqrt{\frac{1}{X} 2\, h\nu_0\, 4\pi\varepsilon_0\, r_{el}} \qquad \text{equation (1)}$$

The values for the De Broglie frequency $\nu_0$ and the electron radius $r_{el}$ will be assessed below. With those values and the factor 1/X = 1/137, the electron charge is calculated correctly to 1.603 $10^{-19}$ C. The dimensionless fraction 1/X equals the fine structure constant $\alpha$, whose derivation may have been similar to the above approach. The figure 1/137 could be coincidence. If, nevertheless, the known formula of $\alpha = e^2 / 2 \varepsilon_0$ hc is inserted into eq. 1, the product inside the root equals to $e^2 \cdot 1$ and Q = e. The coupling constant $\alpha$ perfectly confirms the current model.

Above approach is regarded the quantum realistic origin and meaning of the coupling constant as the ratio of the electric field forming the charge of the electron to the

total field energy $h \cdot \nu_0$. This rotating photon 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 sine 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 clearly is met by this model. This natural and realistic explanation of the spin 1/2 is another strong aspect in favor of the current particle model.

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. The particle further can have the negative field or the positive field on the outside, thus representing the electron or the positron (Figs. 2 and 3).

The field of a circulating wave without internal torsion is negative in one revolution and positive within the next one, thus altogether neutral and regarded a candidate for the neutrino.

The model offers photons and leptons in a unified structure: as linearly propagating 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 consequently 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. 3. The similarity with the well known picture of the electron as small bar magnet is compelling. The paths of the magnetic fields form a figure "eight" during one full phase and the electric field passes the circumference twice. It is this synchronizing of the radial frequency of the magnetic field with the tangential frequency of the electric field that might ensure the stability of the particle.

This model of a circulating wave so far shows all characteristics of the electron:

- An either positive or 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
- the electron mass as per $E = m_{el}\, c^2 = h\nu$
- 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

**Radius determination from Spin**

As a test of this model it is examined whether characteristics like the spin are associated with the mass of the electron, if the mass equivalent of the electromagnetic

field rotates with speed of light „c" (compare with the particle model of P. Dirac). The classical electron radius is derived from the capacity of the electron as sphere condenser with charge e :

$$r_e = \frac{e^2}{4\pi\varepsilon_0 m_e c^2} = 2{,}81 \cdot 10^{-15}\,\mathrm{m}$$ equation (2) after: Mohr & Taylor[7]

The equatorial peripheral speed v of this classical electron would exceed the speed of light 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 (R. Gross[8]).

The peripheral speed „v" in the current model is assumed 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. If the approach is wrong, it 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: $L = r \cdot m_{el} \cdot v$

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 and with the angular momentum becomes

$L = r \cdot m_{el} \cdot c$ $\qquad L = r\,(0{,}51\,\mathrm{MeV}/c^2) \cdot c = r \cdot 0{,}51 \cdot 10^6\ /c\,.$

The electron spin is defined as $L = 1/2 \cdot h/2\pi$. Here the radius is the only unknown parameter and can be calculated:

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

which gives $r = 1.93 \cdot 10^{-13}$ 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 wavelength and also has been determined as electron diameter by Giese[9] and Mills[10]. 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 wave 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.

There are plenty of data suggesting that the diameters of electrons, protons or neutrinos are 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 accelerated to 1 GeV total energy has a diameter of $1.9 * 10^{-16}$ m according to eq. 3, which perfectly fits to the current model and to the observations concerning measured particle diameters or effective cross sections at high particle energies.

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. $\lambda = 2 \cdot C = 2 \cdot \pi \cdot d$. With the electron diameter $d = 2\,r = 3{,}86 * 10^{-13}$ m derived from the spin, the wavelength can be calculated to $\lambda = 2.425 * 10^{-12}$ m

and with $\nu = c/\lambda$ the circulation frequency of the particle in rest to $\nu_0 = 1.237 \cdot 10^{20}$ Hz. It is interesting that this rest mass frequency often is cited in physics books, but its nature rarely is explained or commented[11].

In a very clear way the natural frequency $\nu_0$ by de Broglie for an electron in rest gets a realistic meaning as the true frequency of the c-tron of the energy $E_0 = h\nu_0$. With $m = h \cdot \nu_0 / c^2 = 6.63 \cdot 10^{-34} \cdot 1.237 \cdot 10^{20} / (3 \cdot 10^8)^2 = 9.11 \cdot 10^{-31}$ 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. In the model, the c-tron wavelength of $2.4 \cdot 10^{-12}$ m differs from the de Broglie wavelength of an electron of 1 eV ($5.92\ 10^5$ m/s) of ca. $10^{-9}$ m. The movement of the electron, if accelerated by an external electrical field, will be like a spiral, whose projection to a diffraction grid or interference device is a sine oscillation. It is assumed that the displacement of the **E** - field maximum $\Delta x$ for a certain velocity is identical with the de Broglie wavelength.

**Outlook for quantum mechanics**

The interpretation of the electron as a circulating wave or "photon" leads from one elementary constant, the spin of the electron, to the elementary charge using another well known dimensionless factor, the fine structure or coupling constant. It gives a realistic meaning to the spin up and down characteristics and provides an approach for the neutrino.

The model solves the mystery of the application of the equation $E = h\nu$ to solid matter, which led to the wave aspects and the De Broglie wavelength of matter. At the

same time it opens a door to the equivalence of energy and matter itself. Electromagnetic energy and matter are equivalent because they are of identical nature, at least shown for leptons so far. The application to hadrons or quarks in a similar approach is assessed elsewhere[12].

The model postulates the following:

- Interactions with other particles (e.g. leptons and photons) occur by addition and superposition of the local fields and are strictly causal and local.
- As the field revolves with the speed of light c, a macroscopic prediction of the results other than with statistical quantum mechanics is hardly possible.
- Quantum physics of atoms describe real effects. The orbitals described by the Schroedinger equation are real wave equations. The Zeeman effect is the effect of the c-tron oscillating around the nucleus in reality.
- There is a real sense of rotation in c-tron particles. In collision experiments, a parity violation must be observable due to superposition of the local field strength - qed.
- The fine structure constant $\alpha = 1/137$ is the fraction of uncompensated field energy (charge) to total field energy. $\alpha$ should therefore increase, if the proportion of the total rotating field that is effective for an interaction increases e.g. for small distances to the rotary electromagnetic field or for high energies - qed.
- The model describes matter as closed loops of electromagnetic waves, which do not have a point like centre and therefore are free of singularities. Mathematical problems in dealing with point-like mass concentrations therefore are eliminated.

Questions and correspondence should be addressed to:

christoph.caesar@t-online.de

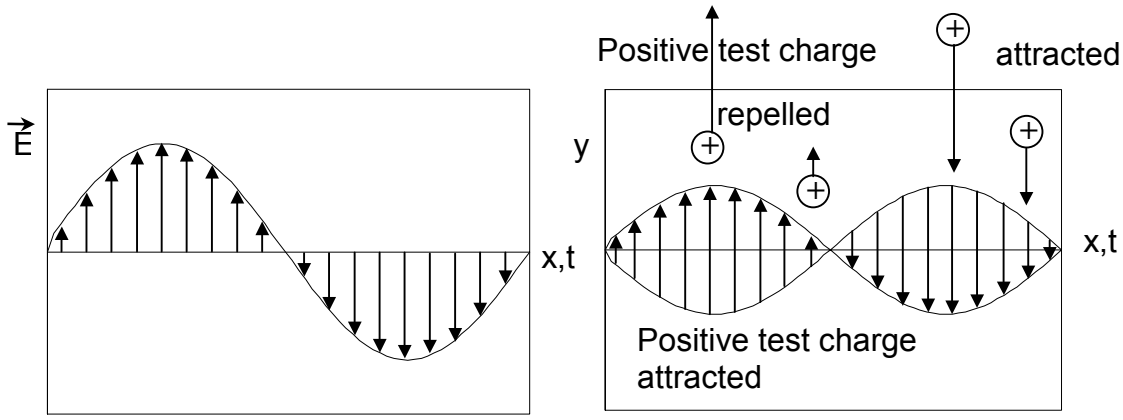
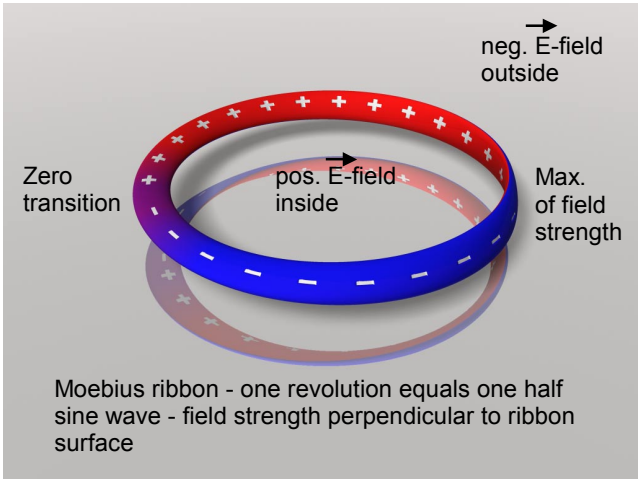
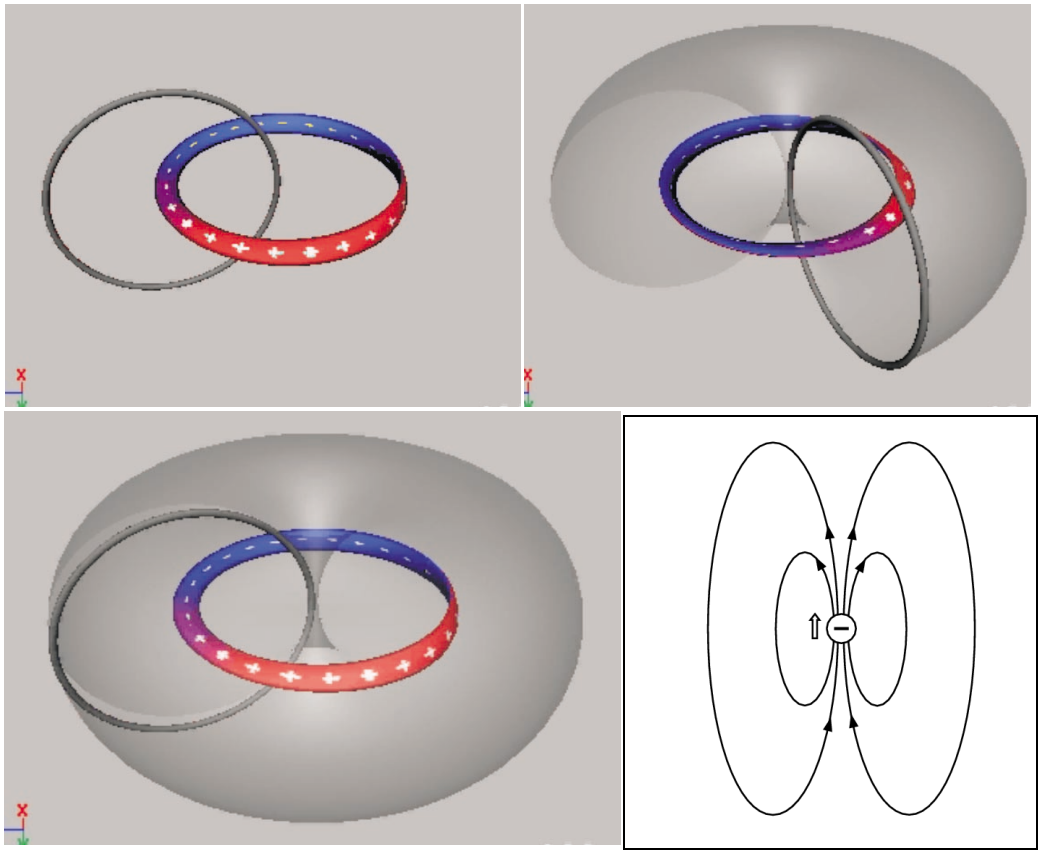



**Figure 1: Electrical field strength E of an electromagnetic sine wave (left side). Right side: Vector field of E in the x-y plane (z-axis out of plane): the vectors give the direction and magnitude of the acceleration of test charges**




**(Color online) Figure 2: Path of the rotating electromagnetic wave forming the electron in shape of a Moebius ribbon**



**(Color Online) Figure. 3: Schematic formation of the magnetic field of the positive c-tron in three steps with the classical notation of the electron as tiny magnet (lower right).**

**References**

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[1] P. Dirac, cited after Albrecht Giese, ref. 3

[2] R. L. Mills, http://www.blacklightpower.com/theory.shtml

[3] A. Giese, *Proc. Spring Meeting of the DPG*, (Dresden, Germany, March, 24, 2000), cited after http://www.ag-physics.org

[4] F. Grotelüschen, *Der Klang der Superstrings* (dtv, München,1999), p. 30

[5] O. Höfling, P. Waloschek, *Die Welt der kleinsten Teilchen*, **8474**, (rororo Sachbuch Reinbek bei Hamburg, 1988), p. 455

[6] F. Grotelüschen, *Der Klang der Superstrings*, (dtv, München, 1999), p. 30ff

[7] Mohr & Taylor *Physical Constants*, (1999)

[8] R.Gross, *Das Wasserstoffatom*, Vorlesungen, Chapter 4

[9] A. Giese, (Spring Meeting of the DPG, Dresden, Germany March, 24, 2000), after http://www.ag-physics.org

[10] R. L. Mills, http://www.blacklightpower.com/theory.shtml

[11] W. H.Westphal, , *Physik* (Springer Verlag Berlin 1963), p. 620

[12] C. Caesar, to be published.