And yet they turn

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Abstract

Although established, the fact that particles do not rotate is neither experimentally shown nor proven. In measurements and in the case of energetic relevance or exchange, the angular momentum is always quantized to a multiple of h/4π or h/2π, while the real unquantized angular momentum might be much lower. Using data that originates from the hadron accelerator CERN in Switzerland, the frequency of the hypothesized self-rotation of protons could be calculated. It is $\mathbf{2072.180437}\ \boldsymbol{Hz}$ and hence, unexpectedly low. The spike in the polarizability curve of protons at $\boldsymbol{Q^2 = 0.33\ GeV^2}$, published currently in the journal Nature, together with the rotation frequency calculated using data from CERN, provides reliable evidence that this might be an interference in terms of superposition of the particle wave of the scattered electrons with the rotation wave of the protons at the same energy level, doubling the expected curve value, which, since there are no other possible explanations, proves the existence of a real proton or particle rotation.

In particle physics, spin is the intrinsic angular momentum of particles. In the case of the fundamental particles, like the mass, it is an invariable inner particle property. It is a half or whole number multiple (spin quantum number) of the reduced Planck constant. Apart from the fact that it is thought not to be caused by the rotary movement of a mass (1-6), it has all the properties of a classic mechanical intrinsic angular momentum, in particular with regard to conservation of angular momentum and coordinate transformations.

The fact that particles have a real rotation has been always rejected in the past, since the same spin value for all particles was measured (ħ/2 or ħ). Using the spin, the scientists calculated much too high rotation velocity values, implying that the particles would then sometimes have to rotate faster than light. The so-called Zitterbewegung is a theoretical, rapid rotation of the particles that contradicts this conception, which could be simulated by trapped ions (7). Contrary to popular belief, which is now quite exactly 100 years old and is based on views by Stern and Gerlach (3), the spin of particles has something to do with the Heisenberg Uncertainty Principle. $\Delta E \Delta t$ ≥ h/2 has to be fulfilled in case of an energetic relevance or a measurement. Hereby, one must take into account that the Heisenberg inequality modified by Millette (8,9) correctly means $\Delta x \Delta p$ ≥ h/2 (and not ħ/2) and that the self-rotation of elementary particles is only quantized if it is involved in an energetic exchange process or measured. Here is an oversized radius and not the rotational velocity quantized or subject of quantization, since the velocity v cancels out from the equation [1], that we will show in the further. An oversized constant spin therefore does not mean that the particles do not rotate, because then they would be faster than c, but merely that energy is withdrawn from the particles for the purpose of measurement or exchange to satisfy the Heisenberg-Millette inequality. Hence the constant spin value only shows the value of the inequality.

The angular momentum of elementary particles is very small due to the small radius and mass of elementary particles and would not be measurable, if the spin measurements were not influenced by conditions described in the following. According to the Heisenberg-Millette uncertainty principle particles with a substructure like protons, electrons, neutrons, quarks and neutrinos have a measurable angular momentum (spin) s of:

$$\Delta L \, \Delta \varphi \ \geq \frac{h}{2} ; \ \Delta\varphi_{max} = 2\,\pi \ ; \ \Delta L = \frac{\Delta E_{rot}}{\frac{1}{2}\omega} = \frac{\frac{1}{2} h f_{rw}}{\frac{v_r}{2r}} = \ \frac{h \overline{v_r}}{\lambda_{rw}} \cdot \frac{r}{v_r} = \frac{h v_r}{2\lambda_{rw}} \cdot \frac{r}{v_r}$$

$$\frac{hr}{2\lambda_{rw}} < \frac{h}{4\pi} \rightarrow \frac{hr}{2\lambda_{rw}} := \frac{h}{4\pi r'}$$

$$r' = \frac{\lambda_{rw}}{2\pi} \rightarrow \Delta L = \frac{\hbar}{2};\ s = \frac{\hbar}{2} \quad [1]$$

(v_r is the mean rotation velocity, $\Delta\varphi$ is the error of the measurements of the rotation angle, s is the spin of the particle, λ_{rw} is the wavelength of the rotation wave, f is the frequency of the particle). Hence, the spin is solely determined by the Heisenberg-Millette principle.

If the rapid oscillatory motion expressed in the Zitterbewegung is a circular rotation, the rotation velocity could be increased by means of magnetic fields. In this context, I was able to calculate the hypothesized frequency value for protons using data from CERN. The key point of the calculation is that from the so-called Larmor frequency f'/B, which has a constant value, the excited frequency of the protons in the synchrotron can be calculated, since the field strength B of the magnets is known. By determining the factors by how much the frequency in the pre-accelerator and synchrotron has increased compared to the original value, the original, unexcited frequency of the proton can be calculated by simple division. Using this calculation, the rotation frequency of protons is approximately 2072.18 Hz. This fast rotation value agrees with the Zitterbewegung that was postulated for particles. The Zitterbewegung is a theoretical, rapid movement of elementary particle electrons or protons, which obey the (relativistic) Dirac equation (7). The results calculated here fit with the Zitterbewegung for protons. The existence of such oscillatory movement was postulated by Gregory Breit in 1928 and by Erwin Schrödinger 1930 as a result of his analysis of wave packet solutions of the Dirac equation for relativistic electrons confirmed in vacuum. The results obtained here can be also confirmed by the hypothesized velocity of protons mediated by the gravitation within the proton:

$$\frac{mv^2}{r} = \frac{m^2G}{r^2}, f = \frac{v}{2\pi r} = \frac{\left(\frac{mG}{r}\right)^{1/2}}{2\pi r} = 2071.87\ Hz \quad [2]$$

which matches exactly with the frequency determined by CERN data matches.

The used data from CERN and the calculations are described in the following. In the hadron accelerator in Geneva (CERN), protons are accelerated from 450 GeV pre-acceleration to 7 TeV through 8 cavity resonators from 5.5 MV/m and on the main orbit of the LHC through 154 main magnets in the 8 partial orbits (radius 445 m) of the magnetic flux density of 8.33 Tesla each in a circle, with a defined energy loss due to the synchrotron radiation, which occurs when a particle is accelerated in a synchrotron. The protons are accelerated during each circulation with an energy of 485 keV in the lines of 825 meters between the 8 partial circuits and circulated 11,245 main lanes per second. The pre-acceleration to 450 GeV leads to a proton velocity of 0.999997826c. The time to full velocity in the LHC (0.999999991c) is 1200.99 seconds (10).

First of all, if the hypothesized proton rotation velocity is < c, I considered that the used magnets in the LHC would probably raise this rotation frequency. Magnetic resonance tomography (MRI), which uses magnetic fields to excite the proton spin, provides evidence of this. But to what extent does an external magnetic field increase the intrinsic rotation of the particles? It is known that protons have a small magnetic field. However, the magnetic flux density of such a proton magnetic field has never been measured or calculated.

The next thing I thought about was how such a magnetic field occurs. Given the hypothesis of a real self-rotation, the explanation is relatively simple. The rotating, moving charged particle creates a magnetic field, as do all moving charges. It turned out that the natural rotation frequency fr increases proportionally to the external magnetic field B_0.

$$\frac{m_p' v'^2}{m_p v_r^2} = \frac{q r_0 v' B_0}{q r_0 v_r B_0'}; \frac{v'}{v_r} = \frac{B_0}{B_0'} = \frac{f'}{f_r} \quad [3]$$

m_p is the proton mass, r_0 is the proton radius, q is the proton charge, vr is the unaffected rotation velocity of the protons, $B_0{}'$ is the magnetic flux density of an external magnetic field before a deflection has taken place, f' is the rotation frequency of the protons influenced by the external magnetic field and v' is the rotation velocity of the protons influenced by the external magnetic field, which is caused by that the external magnetic field increases the angular momentum on the proton. This fixed ratio of the precession frequency and the external magnetic flux density is the so-called Larmor frequency (11) named after the Irish physicist Joseph Larmor, who was able to show that the angular momentum of a particle is proportional to a magnetic dipole moment around the direction of an externally applied magnetic field B_0.

$$\frac{f'}{B_0} = 42{,}577\frac{MHz}{T} = konstant \quad [4]$$

(f' is the excited rotation frequency of the protons). In order to determine the unaffected rotational frequency of a proton, I therefore first had to calculate the individual factors by which the natural rotational frequency of a proton increases in the LHC, which, when multiplied together, result in the total factor a. An important factor is the deflection of the protons in the LHC by the main magnets used. Another factor that should not be neglected is the generation of a magnetic field due to the very fast forward motion of the protons (which is a charged particle) in the LHC and in the pre-accelerating sections of the LHC (several synchrotrons that pre-accelerate the protons to an energy of 450 GeV before the protons enter the LHC).

When the proton reaches the end of the linear accelerator, first it does not have a higher intrinsic rotation frequency, since the proton's direction of motion is parallel to the force effect and therefore no magnetic field is induced. A first factor a_1 arises from the fact that the proton enters from the linear accelerator LINAC2 with a length l of 30 m in the booster, which is no longer linear but circular and build of 4 superimposed tubes with a radius r_B of 25 m. Here it experiences a change in angular momentum right at the beginning, since $\Delta Ft = \Delta p$.

The force change happens because at the end of LINAC2 and at the beginning in the booster before the deflection through the magnets the force acting on the proton is 2.4 times smaller than the centripetal force created by the magnets in the Booster which is generated on the proton.

$$a1 = \frac{\frac{m_B v_B^2}{r_B}}{\frac{\frac{1}{2} m_B v_B^2}{l}} = \frac{2l}{r_B} = 2{,}4 \quad [5]$$

In the synchrotrons (booster, PS and main circuit of the LHCs) the magnetic field of the main magnets and at the same time the magnetic field generated by the high velocity, whose magnetic flux density is the same as that in the main magnet and its field lines show in the same direction as the magnetic field of the main magnets. Because in the first case a circular motion in a synchrotron takes place, half the Landé factor (12) must be taken into account for the sum of the two magnetic fields for the first case, since with a charged particle the Larmor frequency from the synchrotron frequency at the same magnetic field differs by half the Lande factor.

$$a_2 = \frac{B_0}{B_B} = 201{,}1006413 \; a3 = \frac{g_2}{2} + 1 = (2{,}7929 + 1) = 3{,}7929 \quad [5]$$

(B_B is the magnetic flux density at the start of proton acceleration in the circular booster, g_2 is the Landé factor for protons). Another factor arises from the increase of the magnetic moment of the proton, causing the rotation frequency also to increase compared to the magnetic field increase, starting from the booster to the main circulation circuit of the LHC.

$$\frac{M_{Sm}}{M_{Bm}} = \frac{\frac{D_0}{B_0}}{\frac{D_B}{B_B}} = \frac{\frac{m_S v_{Sr}^2}{r_0} r_0}{\frac{m_B v_{Br}^2}{r_0} r_0} \frac{\frac{m_B v_B^2}{r_B q v_B}}{\frac{m_S v^2}{r q v}} = \frac{v}{v_B}\frac{r}{r_B} = \frac{f'}{f_{Br}}\frac{r}{r_B} = \frac{f'}{f_{Br}}\frac{r}{l}\frac{l}{r_B} = \frac{f'}{f_{Br}} \cdot 1{,}2 \cdot 93{,}466667 \quad [6]$$

m_S is the mass at the end of proton acceleration, m_B is the mass at the beginning of the acceleration in the booster, v is the final velocity, v_B is the initial velocity in the booster, r_B is the radius of the booster, r is the radius of the main circle of the LHC, M_{Sm} is the magnetic Moment of the proton at the end of the acceleration, M_{Bm} is the magnetic moment of the proton at the beginning in the booster, D is the angular momentum of the proton, B_B and

B_0 are the magnetic flux density of the external magnetic fields and r_0 is the radius of the proton. Those variables denoted by the index r refer to the intrinsic rotation of the proton. The fact that the factor f'/f_{Br} and the factor l/r_B are already included in a_3 and a_1 was taken into account, and the result is

$$a_4 = 93.4666667 \quad [7]$$

Only the factor a_3 indicates the factor by which the external and the induced magnetic field in the LHC is larger compared to the magnetic field at the beginning of the booster.

$$\frac{f'}{f_B} = \frac{B_0}{B_B} = a_3 \quad [8]$$

Finally, one obtains the unaffected self-rotational frequency fr of a proton, if one considers that the induced rotation frequency increase additionally by the factors independent of the external magnetic field a_1, a_3 and a_4:

$$\frac{f_r}{B_B} = \frac{f'}{a_1 a_3 a_4 B_0} = 42.577 \cdot 10^6 \frac{Hz}{T}$$

$$f_r = \frac{B_B}{a_1 a_3 a_4} \cdot \frac{f'}{B_0} = \frac{42.577 \cdot 10^6 \frac{Hz}{T} \cdot 4{,}14\, 10^{-2} T}{2 \cdot 3{,}7929 \cdot 93{,}466667} = 2072{,}180437 Hz \quad [9]$$

The natural rotation frequency of a proton is accordingly 2072.180437 Hertz. Hence, the rotation velocity, which is calculated using the formula $2\pi fr = 1.13271 \cdot 10^{-11}\ m/s$ is much less than the speed of light. As a result, protons might turn around themselves, they might have a real self-rotation, contrary to what is generally assumed in today's Standard Model.

As a proof of this frequency value, the main thing is that if the centripetal force is equated with the gravitational force and resolved to G by inserting the calculated frequency into the formula

$$G = 4\pi^2 f^2 r^3 m = 6{,}7401 \cdot 10^{-11} \frac{m^3}{kgs^2} \quad [10]$$

the value of $6{,}7401 \cdot 10^{-11} \frac{m^3}{kgs^2}$ comes out, the exact value of the gravitational constant G, proving the value of the hypothesized rotational frequency calculated using the data from CERN.

The Zitterbewegung only shows the frequency $2mc^2/h$ using trapped ions, in case of particles the angular momentum causes an oversized, quantized radius due to the Heisenberg-Millette inequality, while the rotational velocity v does not increase [1] and therefore enters with v and not with c in the formula for the frequency of the Zitterbewegung.

A fundamental property of the proton represents the system's response to an external electromagnetic field (EM). It is characterized by the EM polarizabilities, which shows how the charge and magnetization distributions inside the system are distorted by the EM field (13). Moreover, the generalized polarizabilities outline the deformation of the densities in a proton subjected to an EM field. They reveal essential information of the system dynamics and provide a key for deciphering the proton structure and the strong interaction with its elementary quark and gluon constituents (13). Of particular interest is a puzzle in the proton's electric generalized polarizability that remains unresolved for two decades (13). R. Li et al. (14) currently reported about measurements of the proton's EM generalized polarizabilities at low four-momentum transfer squared. They show evidence of an anomaly to the behavior of the proton's electric generalized polarizability with a spike in the curve that contradicts the predictions of nuclear theory. The reported measurements suggest the presence of a novel mechanism in the proton, which was reported before (13-15) and which might be associated with the presence of a rotation wave in the proton that behaves like a usual particle wave.

In the case of the elastic scattering of an electron on a nucleon, only one parameter remains:

$$W^2 = M^2 + 2M \cdot v - Q^2$$

$$W = M; \; 2M \cdot v - Q^2 = 0; \;\; E_e = \frac{Q^2}{4} = \frac{0.336 \, GeV^2}{4} = 2.1562 \cdot 10^{-30} \, J \quad [11]$$

(E_e is the wave energy of the scattered electron, $0.336 \; GeV^2$ is the maximal value of the spike determined from the enlarged published figure (2)). The hypothesized rotational wave energy of the proton E_p with its frequency $f_r = 2072.18 \, Hz$ [5] is calculated according to DeBroglie (9) as:

$$E_p = \frac{1}{2} m v^2 = \pi m v r f_r = \pi \cdot \frac{h}{2} \cdot f_r = \frac{1}{2} \pi h f_r = \frac{1}{2} \pi h \cdot 2072 \, Hz$$
$$= 2.1517 \cdot 10^{-30} \, J \;\; [12]$$

Due to the same wave energy hf of the electron and proton, both waves are superimposed during scattering, which leads to the spike in the polarizability curve in the experiments. The maximum of the spike corresponds to about twice the value expected by extrapolation for Q^2 = 0.336 GeV^2, which is caused by the interference of two waves of the same size. Hence, especially since other explanations are missing, the observed spike (14) is most probably due to the hypothesized real rotation of the proton.

In conclusions, due to the Heisenberg-Millette inequality $\Delta x \Delta p \geq h/2$, the angular momentum of the particles can only be measured as a multiple of $h/4\pi$ (17), the correct unquantized angular momentum depends on the actually existing rotation velocity of the particles and should usually be much lower. For photons with no rest mass, the angular momentum can be derived in a different way as $h/2\pi$ (17) and it just happens to be twice the angular momentum of fermions (17). The angular momentum of W bosons is 0.91 $h/2\pi$ (17) and can only be measured as $h/2\pi$. The fact that particles do not really rotate is simply wrong and neither experimentally shown nor proven. In measurements and in the case of energetic relevance or exchange, the angular momentum is namely always quantized to a multiple of $h/4\pi$ or $h/2\pi$. Rotational motion has been demonstrated by electron microscopy in molecules (18,19). In the case of the Thier-Haas effect, which is based on this effect, a macroscopically visible rotational movement can even be observed. The quantized proton radius is calculated as 0.8412 fm only under the assumption of a real proton rotation (20). The gravitation inside the proton leads to the same result for the rotation frequency compared to the result from the CERN data [9]. From the Zitterbewegung $f = 2mc^2/h$ multiplied by the quantization factor v/c, which corresponds to the particle rotation frequency, one obtains exactly the proton radius of 0.8412 fm (17). The magnetic field density of a proton is 43 µT (17), since this is in the order of magnitude of the earth's magnetic field, the gravitational constant is influenced by varying earth's magnetic field values (21,22) as observed. The spike in the polarizability curve of protons at $Q^2 = 0.33\ GeV^2$ (13-16), together with the rotation frequency calculated using data from CERN, provides reliable evidence that this might be an interference in terms of superposition of the particle wave of the scattered electrons with the rotation wave of the protons with the same energy level, doubling the expected curve value, which, since there are no other possible explanations, proves the existence of a real proton or particle rotation. Based on these results, a substantial rethinking in quantum physics and spin mechanics and the search for further reliable data on the real rotation of particles is mandatory.

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