Uniformly accelerated motion in a quantized space

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Abstract

The starting point for this paper is the assumption that all processes follow the cause and effect principle. Because of this causality, the world is completely deterministic. Knowing the locations and impulses of all existed particles at a specific point in time means that the past and the future can in principle be calculated indefinitely. But knowing the location and momentum of a particle at a specific point in time contradicts Heisenberg's uncertainty principle. The solution to this dilemma, as will be shown in the introduction, is quantized space. The effects of a quantized space on the movements of particles and thus also time and acceleration are the focus of the second part of this paper. It is shown, that the laws of a quantized space with a uniform acceleration of a particle compared to the relativistic laws of motion of the special relativity theory for the continuous space come to differing results in some points. These deviations are measurable. An experimental confirmation would be a strong indication of the existence of a quantized space, of causality and of an ontological explanation of the Heisenberg`s uncertainty principle and other, not yet been understood, physical phenomena. These points are discussed in the third part of the paper and summarized again in the conclusion.

1. Introduction

A quantized space requires the definition of quantities that a continuous space does not need. The same applies to time, since a continuous flow of time does not appear to make sense, if the space exists quantized. On the one hand, counting variables are required with which space and time can be specified as the number of quantized parts and, on the other hand conversion variables, with which the number of space parts can be converted into a distance measured in meters and the number of time parts can be converted into a time measured in seconds.

- R_Q Number of quantized space lengths, usually identical to the number of a quantized space volume, called space quanta
- s_q Conversion factor from the number of quantized space lengths into the unit meter (length factor [m])
- Z_Q Number of quantized sections of time, called time quanta
- t_q Conversion factor from the number of quantized sections of time into the unit seconds (time factor [s])

There is a fixed relationship between the two quantities s_q and t_q, the speed of light in a vacuum (derived from the constancy of the speed of light according to the special theory of relativity):

$$c = \frac{s_q}{t_q} \qquad 1/1$$

Another fixed point is, that the conversion factors s_q and t_q are not constant quantities. Only the relationship s_q / t_q is constant. But this fact can be ignored for now. All results comparisons between quantized and continuous space carried out in Chapter 2 are independently of s_q and t_q.

In addition to its function as a conversion factor of time quanta in seconds, the time factor t_q also reflects the time interval in which neighboring space quanta interact with one another. It is postulated that the space quanta exchange information regarding their own state and adapt to each other with each other. Due to the mutual adaptation, the interaction between the space quanta correspond to a step by step transmission of information at the speed of light. This information transfer can also be interpreted as a force effect, for example gravity. In this sense, gravitation could be described as a function of s_q.

A further assumption under the assumption of a real existing quantized space is, that really fundamental particles (elementary particles with mass) can to be equated with the volume of a space quantum. The mass (or the energy) of an elementary particle thus becomes a factor for the size of s_q. On the one hand, this requires great flexibility from s_q and on the other hand, and this is elementary in relation to the subject of movement, the space quantum clearly defines the position of the particle at a specific point in time (time quantum). A position between two space quanta is excluded with this assumption. This exclusion is only possible if the time is also quantized in addition to the space.

Under these conditions, there can be no continuous movement of elementary particles in a quantized space. The elementary particles move from one space quantum to the next in only a single interaction. Due to the relationship $c = s_q / t_q$ (see formula 1/1), this movement step, like the information transfer between the space quanta, takes place at the speed of light. Speeds below the speed of light therefore also contains interactions without a movement of the elementary particles. Under this condition, movement is an interplay between dwell phases and movement steps at the speed of light. This movement at the speed of light does not contradict the special theory of relativity, since a permanent, continuous speed of light, as will be shown in chapter 2 of this paper, can never be achieved.

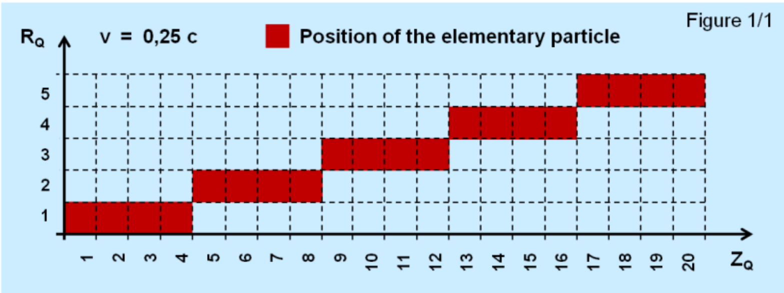

Figure 1/1 illustrates that each conclusion of an interaction is linked to a specific spatial position of a moving particle.

The interplay between the dwell phase and the movement step explains the Heisenberg`s uncertainty principle, at least in principle, but without limiting the uncertainty (h / 4π). Either there is no impulse with precise local knowledge (dwell phase) or in the case of the movement step the impulse m c. Both reflect the objective reality of the movement, but not the subjective reality of the supposedly continuous movement, which is the basis of the uncertainty principle. In order to be able to determine the impulse with the greatest accuracy under the conditions of the step-by-step movement, one needs the mean value from an infinite number of movement steps. A 100% exact impulse determination is therefore not possible.

When the following chapters speaks of "normalized" sizes, they are sizes that are defined without the usual units meter (m) and second (s). These variables are usually calculated using the counting variables R_Q and Z_Q listed above. Speed is generally given as a proportion of the speed of light (c). The "denormalization" takes place via the conversion factors s_q and t_q and via c.

2. Quantized mechanics

2.1. Theoretical basics

An acceleration information that acts on an elementary particle is generally referred to as P_F. It is really an information that starts about the properties of the space quanta (e.g. volume) from a source (e.g. mass or electrical charge) in quantized space, comparable to an information field (F). The information is normalized and can be converted into the acceleration (a) size of Newtonian mechanics using the conversion quantities s_q and t_q:

$$a = P_F \frac{s_q}{t_q^2} \qquad 2.1/1$$

Assuming that each concrete movement step is carried out at the speed of light, the effective speed is calculated from the speed of light (c) divided by the sum of the time quanta of the dwell phase plus the time quantum of movement step (Z_Q):

$$v = c / Z_Q \qquad 2.1/2$$

The following applies to the number of Z_Q per movement step at a speed v:

$$Z_Q = c / v \qquad 2.1/3$$

According to formula 2.1/1, P_F of the quantized space corresponds to the acceleration (a) of the continuous space. Taking into account Newton's acceleration relationship

$$a \approx s / t^2 \qquad 2.1/4$$

and the following equations

$a \triangleq P_F$
$s \triangleq R_Q\, s_q$, at a distance of 1 R_Q, s normalized has the value 1
$t \triangleq Z_Q\, t_q$ and thus normalized: Z_Q

there is a completely new relationship between acceleration and speed on the normalized level (only applies to $s = 1\ R_Q$):

$$P_F = \frac{1}{Z_Q^2} \qquad \text{(applies only to } s = 1\ R_Q\text{)} \qquad 2.1/5$$

or together with formula 2.1/3

$$P_F = \frac{v^2}{c^2} \qquad 2.1/6$$

On a normalized level, acceleration in the immediate vicinity of the accelerated particle corresponds to the square of a speed. This is fundamental and basically applies in quantized space and forms the basis of the "Theory of Movement in Quantized Space" presented below.

Newton's law of acceleration is correctly $a = ½\ s / t^2$. The fact that the factor ½ does not appear in the formula 2.1/5 is due to the fact that elementary particles basically move on spiral tracks in a quantized space. This paper focuses on the differences between the equations of motion of the theory of relativity, i.e. the movement in a continuous space, and the movement in the quantized space, so that the explanation of such details is dispensed with.

If, according to formula 2.1/6, speed and acceleration are linked without any other factors, this means that every speed is associated with an acceleration effect. This also applies to the constant speed. There is therefore no force-free movement in a quantized space.

It can be deduced from this that with a uniform movement of an elementary particle every movement step in quantized space induces a new acceleration field in the adjacent space quantum of the particle. This acceleration field is referred to below as $P_{F\text{-}v}$. This self-induced $P_{F\text{-}v}$ ensures that the elementary particle takes a next step in the movement.

If a further, constant acceleration ($P_{F\text{-}a}$) causes the increase of a movement and every existing movement of an elementary particle already triggers an acceleration field ($P_{F\text{-}v}$) corresponding to the speed, the ultimately acting acceleration field ($P_{F\text{-}ET}$) on the elementary particle does not remain constant. It will be increase continuously with each step of the movement by the part of the constant acceleration.

The following relationships therefore apply to the calculation of the $P_{F\text{-}ET}$ of a constant and rectified accelerated elementary particle without an initial velocity:

$$P_{F\text{-}ET} = P_{F\text{-}a} + P_{F\text{-}V} \qquad 2.1/7$$

$$P_{F\text{-}V} = P_{F\text{-}a} (R_Q - 1) \qquad 2.1/8$$

$$P_{F\text{-}ET} = R_Q \, P_{F\text{-}a} \qquad 2.1/9$$

Figure 2.1/1 is intended to clarify this summary. It shows how the $P_{F\text{-}ET}$ changes with each movement step by a constant external acceleration ($P_{F\text{-}a}$).

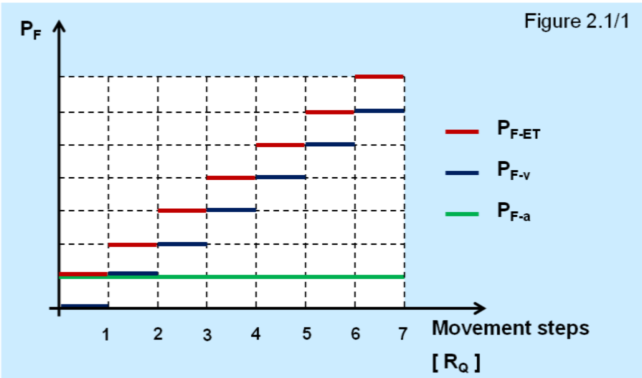

Figure 2.1/1 shows the development of the acceleration field $P_{F\text{-}ET}$ by linear addition of the acceleration fields $P_{F\text{-}a}$ and $P_{F\text{-}v}$.

A constant acceleration leads to a linear increase in the effective acceleration information and, due to the relationship of formula 2.1/6, to a quadratic increase in the speed per movement step.

At the theoretical maximum achievable speed (speed of light) the elementary particle moves one quantum of space per time quantum. In this case:

$$P_{F\text{-}ET} = \frac{v^2}{c^2} = 1 \quad \text{und} \quad v = c \qquad 2.1/10$$

Formula 2.1/10 clearly defines the limits of acceleration and speed development in a quantized space. The maximum value which can be transmitted from a space quantum to the neighboring space quanta ($P_{F\text{-}ET}$) is the normalized value 1. However, this also means that the linear addition of the acceleration information according to formula 2.1/9 and the representation in figure 2.1/1 do not reflect reality. Taking into account the information limit 1 of the space quanta, the formulas for the addition of the acceleration fields under "relativistic" conditions are:

$$P_{F\text{-}ET}\,(R_Q = 1) = P_{F\text{-}a}$$

$$P_{F\text{-}ET}\,(R_Q = 2) = P_{F\text{-}a} + (1 - P_{F\text{-}a})\,P_{F\text{-}a}$$

$$P_{F\text{-}ET}\,(R_Q = n) = 1 - (1 - P_{F\text{-}a})^n$$

and in general with $n = R_Q$ as the length of the acceleration path:

$$P_{F\text{-}ET} = 1 - (1 - P_{F\text{-}a})^{R_Q} \qquad 2.1/11$$

Combining formulas 2.1/10 and 2.1/11 gives the relativistic speed formula of constant, rectified acceleration without initial speed as a function of the distance covered (R_Q), assuming the existence of a quantized space:

$$\frac{v}{c} = \sqrt{1 - (1 - P_{F\text{-}a})^{2R_Q}} \qquad 2.1/12$$

The factor 2 in the exponent under the root of the formula 2.1/12 does not result from the combination of the formulas 2.1/10 and 2.1/11, but is again explained by the spiral path movement, which will not be discussed further here.

2.2. Comparison of results; quantized space versus continuous space

2.2.1. Speed

Movements in a continuous space are described by theory of relativity and quantum field theory. The previous calculations in quantized space always used the image of a moving particle. In this case the mechanics of the theory of relativity fit best with this. Therefore, the formulas of Special Relativity (SRT) are used for the following comparison of results. Because the calculation of the movement in the quantized space takes place as a function of R_Q, the SRT formula of the speed calculation is used as a function of the path (v (s)) for the comparison of results.

The relativistic formulas of the SRT for uniform acceleration without initial speed from the point of view of a stationary observer are, as is commonly taught:

- Speed as a function of time (t):

$$v\,(t) = \frac{a\,t}{\sqrt{(\frac{a\,t}{c})^2 + 1}} \qquad 2.2.1/1$$

- Time as a function of the distance covered (s):

$$t\,(s) = \frac{c}{a}\sqrt{(\frac{a\,s}{c^2} + 1)^2 - 1} \qquad 2.2.1/2$$

- In summary, the formula 2.2.1/1 and 2.2.1/2 give the speed as a function of the distance covered (s):

$$\frac{v(s)}{c} = \sqrt{1 - \frac{1}{\left(\frac{a\,s}{c^2} + 1\right)^2}} \qquad 2.2.1/3$$

With

$$R_Q = s / s_q \qquad 2.2.1/4$$

and

$$a = P_{F\text{-}a} \frac{c^2}{s_q} \qquad 2.2.1/5$$

see 1/1 together with 2.1/1

formula 2.2.1/3 can also be expressed as a function of R_Q and the acceleration force $P_{F\text{-}a}$ (see formula 2.2.1/6):

$$\frac{v}{c} = \sqrt{1 - \frac{1}{(R_Q\,P_{F\text{-}a} + 1)^2}} \qquad 2.2.1/6$$

With a given acceleration a or $P_{F\text{-}a}$, the results of formulas 2.1/12 and 2.2.1/6 (figure 2.2.1/1) can now be compared with each other regardless of the length factor s_q.

Figure 2.2.1/1 shows the speed development according to the theory of quantized movement (v_{qR} according to formula 2.1/12) and according to the theory of continuous movement (v_{SRT} according to formula 2.2.1/6) as a function of R_Q. The value $P_{F\text{-}a} = 10^{-15}$ was set for the acceleration (even smaller values are rounding by Excel in the calculation from $1 - 10^{-15}$ to the value 1, see formula 2.1/12). As has already been shown, the value for s_q has no influence on the result of velocity per space quantum (R_Q). However, the value s_q influences via formula 2.2.1/5 the SRT-calculation of the acceleration a according to formula 2.2.1/3. With a value of $s_q = 10^{-15}$ m (approx. Proton radius), an acceleration a of $8{,}99\ 10^{16}$ m s^{-2} is calculated. That is a very high value. At this acceleration (Formula 2.1/12), elementary particles would already approach the speed of light after 2,5 m ($25\ 10^{14}\ R_Q\ s_q$). The speed v_{SRT} after 2,5 m and an acceleration of $a = 8{,}99\ 10^{16}$ m s^{-2} is 0,96 c (calculation with formula 2.2.1/3).

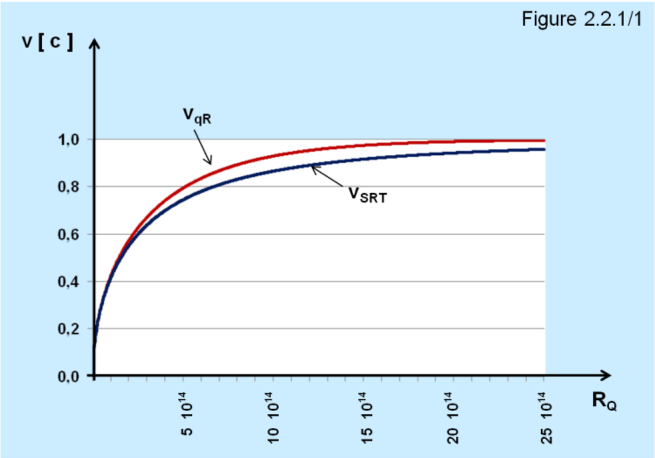

Figure 2.2.1/1 shows the development of the velocities v_{qR} (calculation of quantized space) and v_{SRT} (calculation of special relativity).

The following chapters shows that not only the results of the speed calculations between quantized space and continuous space differ, but also the acceleration to be taken into account in the respective formulas and the time required to reach a certain speed with a constant acceleration to reach.

2.2.2. Kinetic energy

According to the SRT formula for calculating the kinetic energy of a moving elementary particle,

$$E_{kin}\,[J] = m_x\, c^2 \left(\frac{1}{\sqrt{1 - v^2/c^2}} - 1 \right) \qquad 2.2.2/1$$

an elementary particle that moves with constant acceleration in quantized space has a higher kinetic energy at the end of an acceleration path due to the higher final speed (see graphic 2.2.1/1) than the elementary particle, which was accelerated in a continuous space (SRT space) over an equally long distance. At least if formula 2.2.2/1 is valid for both spaces. This is assumed in this paper.

If a simply charged elementary particle (e.g. electron or proton) travels a distance with a potential difference of e.g. 1000 V between the start point and the end point of the path, the elementary particle is supplied with a kinetic energy of 1000 eV. Based on the assumption that the formula 2.2.2/1 calculates the kinetic energy correctly, the speeds after the acceleration distance must have the same value, independent if they are calculated on the formula of quantized space (2.1/12) or on formula of SRT (2.2.1/6). If this is the case and both formulas provide correct results, the respective "acceleration fields" (P_{F-a}) must differ from each other. For this reason, a distinction is now made between the following acceleration fields:

- "Acceleration field" quantized space (P_{F-qR}) and
- "Acceleration field" continuous space (P_{F-SRT})

$$a = P_{F-SRT}\, \frac{s_q}{t_q^2} \qquad 2.2.2/2$$

compare to 2.1/1

The two "acceleration fields" are calculated using the respective speed formulas 2.1/12 and 2.2.1/6 and the formula 2.2.2/1 of the kinetic energy. Therefore, for P_{F-qR} and P_{F-SRT} as a function of R_Q and E_{kin}:

$$P_{F-qR} = 1 - \sqrt[R_Q]{\frac{m_x\, c^2}{E_{kin}\,[J] + m_x\, c^2}} \qquad 2.2.2/3$$

$$P_{F-SRT} = \frac{1}{R_Q}\, \frac{E_{kin}\,[J]}{m_x\, c^2} \qquad 2.2.2/4$$

and for calculation from each other:

$$P_{F-qR} = 1 - \sqrt[R_Q]{\frac{1}{R_Q\, P_{F-SRT} + 1}} \qquad 2.2.2/5$$

$$P_{F-SRT} = \frac{1}{R_Q} \left(\frac{1}{(1 - P_{F-qR})^{R_Q}} - 1 \right) \qquad 2.2.2/6$$

The correct formulas for calculating the speed of a constant acceleration are:

$$\frac{v}{c} = \sqrt{1 - (1 - P_{F-qR})^{2\, R_Q}} \qquad 2.2.2/7$$

compare to 2.1/12

$$\frac{v}{c} = \sqrt{1 - \frac{1}{(R_Q\, P_{F-SRT} + 1)^2}} \qquad 2.2.2/8$$

compare to 2.2.1/6

The following figures show the different results of $P_{F\text{-}qR}$ and $P_{F\text{-}SRT}$ depending on E_{kin} (figures 2.2.2/1 and 2.2.2/2) and R_Q (figures 2.2.2/3 and 2.2.2/4) and from v/c (figure 2.2.2/5). The basis of the analyzes is the acceleration of an electron.

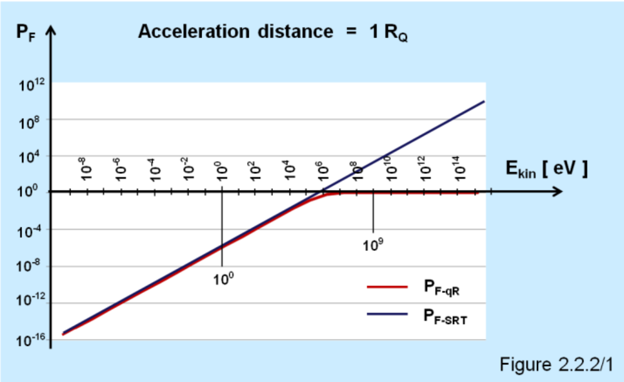

Figure 2.2.2/1

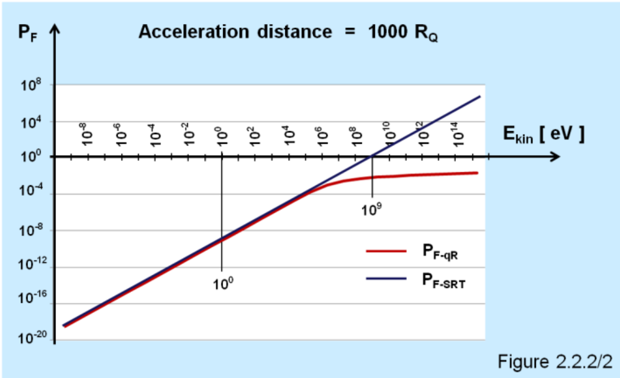

Figure 2.2.2/2

Figure 2.2.2/1; Acceleration distance = 1 R_Q:
Due to the proportionality between E_{kin} and $P_{F\text{-}SRT}$ (see formula 2.2.2/4), $P_{F\text{-}SRT}$ becomes greater 1 with an acceleration distance of 1 R_Q and E_{kin}> E0 (rest mass). This is not possible for the $P_{F\text{-}qR}$ (see theory in chapter 2.1).

Figure 2.2.2/2; Acceleration distance = 1000 R_Q:
In principle, the curve is the same as for the acceleration distance of 1 R_Q. The two marking points $E_{kin} = 10^0$ and 10^9 eV clarify the energy values, which are shown in figures 2.2.2/3 and 2.2.2/4 as a function of R_Q.

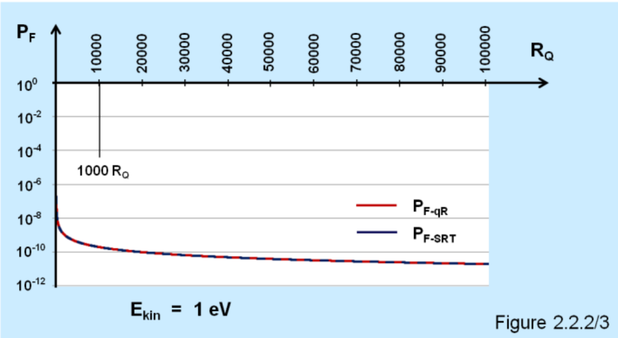

Figure 2.2.2/3

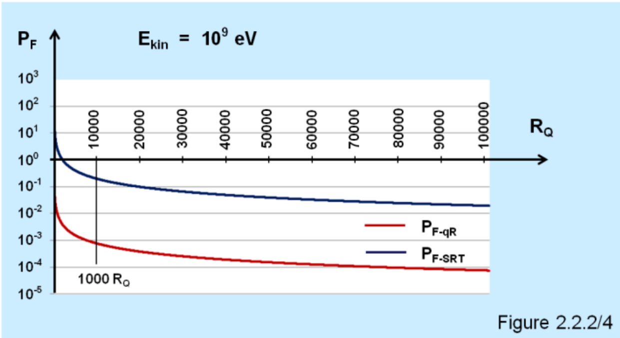

Figure 2.2.2/4

Figure 2.2.2/3; E_{kin} = 1 eV:
As expected (compare with figures 2.2.2/1 and 2.2.2/2), both curves are congruent, so that the curve $P_{F\text{-}SRT}$ has been shown with a dashed line for better visibility.

Figure 2.2.2/4; $E_{kin} = 10^9$ eV:
Both curves obviously run parallel to each other and decrease with increasing acceleration distance.

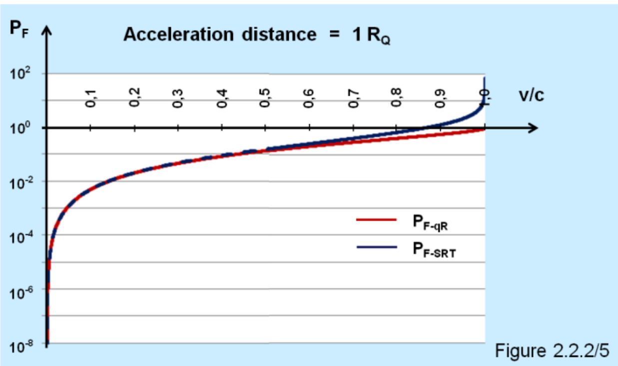

Figure 2.2.2/5

Figure 2.2.2/5:
In the area of relatively low top speeds, both curves run congruently, so that the curve $P_{F\text{-}SRT}$ has been shown with a dashed line for better visibility.

The figures shows that in the low energy range the acceleration field of the continuous space (SRT) and the start acceleration field of the quantized space (qR) are almost identical. Deviations arise at higher energies. The decisive difference is that the formula of continuous space (2.2.2/4) allows a normalized acceleration greater than 1 (if $E_{kin} > R_Q E_0$ (rest mass)), while this is impossible for the quantized space (2.2.2/3) (see also chapter 2.1). This is documented by the first two figures (figures 2.2.2/1 and 2.2.2/2). With increasing acceleration distance and high final kinetic energy, the difference between the $P_{F\text{-}qR}$ and the $P_{F\text{-}SRT}$ increases disproportionately. The $P_{F\text{-}SRT}$ increases linearly, while the start-$P_{F\text{-}qR}$ deviates from the maximum value 1 by the length of the acceleration distance (number R_Q). The P_F can only approach this at the end of the acceleration distance (see chapter 2.1 and formula 2.1/11), which is exactly the case at end speeds of approximately the speed of light at high energies depending on the accelerated mass.

Calculations with different acceleration fields (P_F), which result in the same final speeds for a fixed acceleration distance, require acceleration times that differ depending on the respective P_F (see chapter 2.2.3).

2.2.3. Acceleration time

The starting points for the following considerations are the formulas for calculating the acceleration duration as a function of the acceleration distance at a given top speed.

The following applies in continuous space:

$$t(s) = \frac{c}{a} \sqrt{\left(\frac{a\,s}{c^2} + 1\right)^2 - 1} \qquad 2.2.3/1 \text{ see } 2.2.1/2$$

Analogous to formula 2.2.1/6 (v/c as a function of R_Q), also this formula can be normalized to quantization quantities.

$$\frac{a\,s}{c^2} = \frac{P_{F\text{-}SRT}\ s_q}{t_q^2} \ \frac{R_Q\ s_q\ t_q^2}{s_q^2} = R_Q\ P_{F\text{-}SRT} \qquad 2.2.3/2$$

$$\frac{c}{a} = \frac{t_q}{P_{F\text{-}SRT}} \qquad 2.2.3/3$$

$$t(s) = Z_Q\ t_q \qquad 2.2.3/4$$

Now this is Formula 2.2.3/1 in normalized way:

$$Z_{Q\text{-}SRT} = \frac{\sqrt{(R_Q\,P_{F\text{-}SRT} + 1)^2 - 1}}{P_{F\text{-}SRT}} \qquad 2.2.3/5$$

or with $P_{F\text{-}SRT}$ as a function of E_{kin} (see formula 2.2.2/4):

$$Z_{Q\text{-}SRT} = \frac{R_Q\,m_x\,c^2}{E_{kin}\,[J]} \sqrt{\left(\frac{E_{kin}\,[J]}{m_x\,c^2} + 1\right)^2 - 1} \qquad 2.2.3/6$$

and finally as a function of v/c (see formula 2.2.2/1):

$$Z_{Q\text{-}SRT} = \frac{R_Q \frac{v}{c}}{\sqrt{1 - (1 - v^2/c^2)}} \qquad 2.2.3/7$$

The normalized formula for Z_Q in quantized space depending on the P_F increase per movement step $(1 - (1 - P_{F\text{-}qR})^{R_Q}$, see formula 2.1/11) is:

$$Z_{Q\text{-}qR} = \frac{R_Q}{\sqrt{1 - (1 - P_{F\text{-}qR})^{1/2\, R_Q}}} \qquad 2.2.3/8$$

The derivation of the formula is based on the theory described in chapter 2.1. The root part in the denominator corresponds to the mean speed after an acceleration of R_Q space quanta. As in Formula 2.1/12, the factor 1/2 in the exponent under the root of formula 2.2.3/8 is explained by the spiral path movement, which will not be discussed further here.

With $P_{F\text{-}qR}$ replaced by E_{kin} (see formula 2.2.2/3) is the formula for $Z_{Q\text{-}qR}$:

$$Z_{Q\text{-}qR} = \frac{R_Q}{\sqrt{1 - \left(\frac{m_x c^2}{E_{kin}[J] + m_x c^2}\right)^{1/2}}} \qquad 2.2.3/9$$

and finally with E_{kin} as a function of v/c (see formula 2.2.2/1):

$$Z_{Q\text{-}qR} = \frac{R_Q}{\sqrt{1 - (1 - v^2/c^2)^{1/4}}} \qquad 2.2.3/10$$

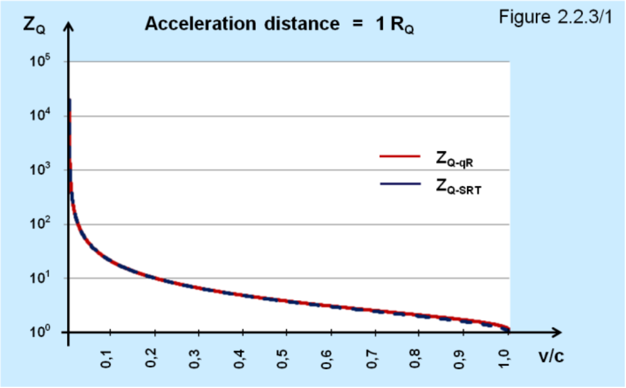

Figure 2.2.3/1:
Number of time quanta as a function of v/c with an acceleration distance of 1 R_Q.

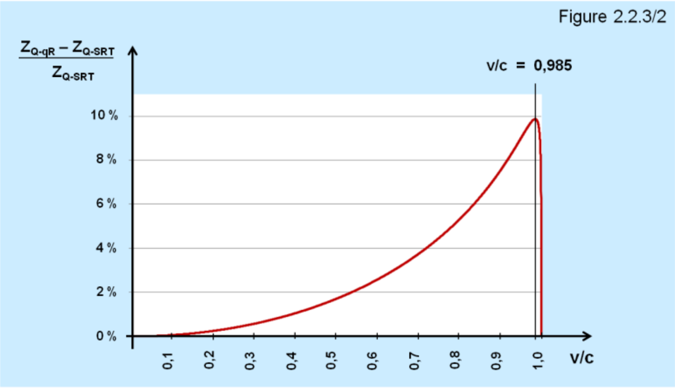

Figure 2.2.3/2:
Difference of the time quanta qR and SRT in relation to the number of time quanta SRT; the result is independent of the length of the acceleration distance.

An electron has a kinetic energy of not quite 2,5 MeV at a speed of 0,985 c. This means that a linear accelerator with a voltage of 2,5 MV can be used for experimental testing, if at the same time enables the acceleration time to be measured over the acceleration distance.

The more accurate values for the maximum deviation are:

deviation:	9,868411347 %
v:	0,985171431 c
E_{kin} (electron):	2,467317132 MeV

2.2.4. Formulars of force

The force laws of Newtonian mechanics are:

$$F = m\,a \qquad 2.2.4/1$$

$$F = E_{kin}\,[J]\ /\ s \qquad 2.2.4/2$$

According to the "Theory of Movement in Quantized Space" (see Chapter 2.1) there is no continuous movement. After each movement step, there is a rest phase depending on the current speed. Every movement begins out of the rest position of the "moving" particle. This explains that the movement in the quantized space in a constant external acceleration field does not mean a constant acceleration for a particle with the mass m_0, but that on the one hand the acceleration according to formula 2.1/11 increases with every movement step, and secondly that also the mass "m_0" increases with every movement and the increasing of the kinetic energy. Under this condition, the following applies for m and a in the quantized space:

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}} \qquad 2.2.4/3$$

$$a = (1 - (1 - P_{F\text{-}qR})^{R_Q})\ \frac{s_q}{t_q^{\,2}} \qquad 2.2.4/4$$

The force formula in quantized space (F_{qR}) based on formula 2.2.4/1 is thus:

$$F_{qR} = \frac{m_0}{\sqrt{1 - v^2/c^2}}\ (1 - (1 - P_{F\text{-}qR})^{R_Q})\ \frac{s_q}{t_q^{\,2}} \qquad 2.2.4/5$$

and together with the formula 2.1/12 it becomes:

$$F_{qR} = \frac{m_0\,s_q}{t_q^{\,2}}\ \left(\frac{1}{(1 - P_{F\text{-}qR})^{R_Q}} - 1 \right) \qquad 2.2.4/6$$

This corresponds exactly to the result of formula 2.2.4/2 if $P_{F\text{-}qR}$ is replaced by formula 2.2.2/3 and the value of the length factor of the space quanta s_q is used for s:

$$F_{qR} = E_{kin}\,[J]\ /\ s_q \qquad 2.2.4/7$$

Formulas 2.2.4/5, 2.2.4/6 and 2.2.4/7 are used to calculate the force required to move the elementary particle from position $R_Q - 1$ to position R_Q. Always assuming that the particle was at rest in position $R_Q - 1$. The force laws of Newtonian mechanics, except for the first step of the movement, always assume a basic speed, which increases continuously due to the constant acceleration. Accordingly, the force is constant with constant acceleration during the entire acceleration process (see formula 2.2.4/1). This is also confirmed by the formula 2.2.4/6, which under the condition $R_Q = 1$ together with the conversion formula 2.2.2/6 corresponds exactly to the force calculation SRT:

$$F_{SRT} = m_0 \, P_{F\text{-}SRT} \, \frac{s_q}{t_q^{\,2}} = m_0 \, a \qquad 2.2.4/8$$

In principle it is possible, analog to formula 2.2.4/7, a force F_{SRT} corresponding to the force F_{qR} would have to be calculated for each movement step. However, this is only in the case of principle possible, because the real v_{qR} (R_Q) differs from v_{SRT} (R_Q) with constant acceleration (see chapter 2.2.1 and figure 2.2.1/1). Therefore also E_{kin} (qR) is different to E_{kin} (SRT) as a function of R_Q. Even taking differentiated acceleration fields into account does not make up for the difference. The difference would be far too small. For a direct force comparison, it would have to be taken into account that the length factor (s_q) has different values in quantized space than in continuous space due to its dependence on E_{kin}.

An equivalent comparison of the force calculation with constant acceleration is therefore only useful for the first movement step. In all other cases, just as with acceleration, in a calculation, the respective theory must be considered before physical conclusions can be drawn from the results.

3. Discussion

In chapter 2.2 it was proven that the "theory of movement in quantized space" presented in chapter 2.1 at high energies leads to different results compared to the special theory of relativity as a theory for continuous space. E.g.: Bridging the acceleration path in a linear accelerator requires a higher acceleration time under the conditions of a quantized space than in a continuous space. The difference can be checked experimentally due to the magnitude.

The starting point for the considerations was the cause-effect principle and the associated conflict with the Heisenberg`s uncertainty principle. An experimental confirmation of the "Theory of movement in quantized space" presented in chapter 2.1 eliminates this conflict. The Heisenberg`s uncertainty principle loses its "principle character", but it still shows the limits of the measurable (h / 4π). This limit is explained in the context of quantized space by the movement of the elementary particles on spiral paths.

This new interpretation of Heisenberg's uncertainty principle shows what potential a physical theory has on the basis of a quantized space. Now it seem to be possible, that the great riddles of quantum theory and relativity theory be understood and explained ontological. In this discussion, I present some further examples without providing any relevant evidence, because this would go beyond the scope of this paper.

What are curved spaces, what are relative lengths and times? Curved spaces can be explained e.g. through the energy-dependent conversion factors s_q and t_q for normalization and denormalization. There are no time, there are interactions that can be converted into seconds using the time factor t_q. The 10-fold length contraction for high-energy muons that fly towards the earth's surface with v = 0,995 c can be explained by a tenfold increase in the interactions compared to the resting "low-energy" muon. High energies shorten the interaction times, and thus the number of interactions per time interval increases. On this basis, the energy-time uncertainty relation can be explained as real as the uncertainty between impulse and location.

The so-called measurement problem of quantum mechanics means that for all possible measurement results, only the probability of their occurrence can be calculated. The possibility of a precise prediction seems to be excluded in principle. With the movement of the elementary particles over spiral trajectories, as is expected in a quantized space and reflected in the formulas of the theory, here too the "principle character" changes within limits of the measurable, because the exact position on the spiral path, e.g. in the case of diffraction in a double slit experiment, eludes recognition. The wave / particle duality of quantum theory could thus prove to be an emergent property that can be explained solely by the particle movement on a spiral path. This would also make the "measurement problem" compatible with the causality requirement of the cause-effect principle.

Even in cosmological order of magnitude, a quantized space shows a different physical behavior than a continuous space. The "fall of masses" towards a singularity in a "black hole" predicted by the formulas of the theory of relativity is not possible in quantized space. In addition to the event horizon, from the inside of which no light can escape the black hole, the quantized space requires another "horizon", which is within the event horizon. It is the horizon on which no further mass compression is possible because the gravitational acceleration (P_F) reaches the value 1.

There is another aspect as a consequence of the "Theory of Movement in a Quantized Space" that has not even been hinted at so far. The self-induced acceleration field $P_{F\text{-}v}$ postulated in chapter 2.1, which ensures that elementary particles take a next step in the movement, was introduced without damping. This is real but not to be expected. Since no damping was measured in previous physical experiments with constant force-free movements in a vacuum, it must be very small. A damping by a factor of 10^{-42} would not be measurable and could at the same time form the basis for an explanation between the force difference between gravitation and Coulomb force. Such damping would also affect the movement of a light quantum. Depending on the concrete size of the length factor s_q, the limit of the visible universe can be calculated.

In our everyday world, the difference between quantized space and continuous space doesn't matter. The acceleration due to gravity of 10 m s^{-2} corresponds to an acceleration field $P_{F\text{-}SRT}$ of approx. 10^{-31} at a value of $s_q = 10^{-15}$ m (approx. Proton diameter) (see formula 2.1/1). At a distance of $R_Q = 1$, the difference to the value $P_{F\text{-}qR}$ is approximately 0.000 ... 01 10^{-31} (see formula 2.2.2/5). There are 30 zeros between "0," and "1". The difference becomes important in the high energy range of particle accelerators. It is possibly that in the case of an experimental confirmation of the "Theory of movement in a quantized space", some result calculations have to be re-analyzed here. But a better understanding of quantum mechanics seems to me to be even more important. It is almost certainly to be expected that this better understanding e.g. will lead to technological breakthroughs in the development of quantum computers. Such technological breakthroughs are unlikely to be expected in cosmology. However, I am convinced that the theory of the development of our universe must be completely rethought.

4. Conclusion

The physicist Dr. Sabine Hossenfelder writes in her book (Das Hässliche Universum, page 307 [1]) "Wir wissen, dass die Naturgesetze, die wir heute haben, unvollständig sind. Um sie zu vervollständigen, müssen wir das Quantenverhalten von Raum und Zeit verstehen und entweder die Gravitation oder die Quantenphysik generalüberholen, vielleicht auch beide." ("We know that the laws of nature that we have today are incomplete. To complete them, we have to understand the quantum behavior of space and time and overhaul either gravity or quantum physics, or maybe both.").

If the calculations with the formulas of the "Theory of Movement in a Quantized Space" listed in this paper are confirmed experimentally, is that not an indication that the theory of relativity (gravitation) and quantum physics do have to be completely overhauled, but it is an indication that these theorys lose their fundamental status.

The quantized space was postulated on the basis of a generally applicable cause and effect principle. In addition to the potentials of the quantized space shown in the discussion section, an indirect confirmation of a generally applicable cause- effect principle and thus a thoroughly deterministic world has considerable philosophical effects. Affected are among others on awareness, intelligence and free thinking and acting. It can therefore be assumed that, despite the negligible effects on our everyday world, the quantized space will completely, philosophically, legally and technologically, turn our everyday lives upside down.

References

All statements about quantum theory and all SRT comparison calculations are taught in general. Corresponding sources were therefore omitted.

All assumptions and calculations for the uniformly accelerated motion in quantized space are my own ideas.

[1] Dr. S. Hossenfelder, "Das Hässliche Universum", 3. december 2018 edition, S. 307