Date: 05/26/2014 Time: 10:04:36

Spin in Quantum Mechanics.

The property called "***spin***" of elementary particles, as used in the Standard Model [1] of Special Relativistic Quantum Field Theories, still is a not understood property.
This is because "***spin***" of elementary particles is a property which cannot be a property of a mathematical point, but requires extension of the particles in the two-dimensional plane perpendicular to the direction of motion.

Literally "***spin***" is rotation of momentum around the direction of motion, as is shown in the following figure:

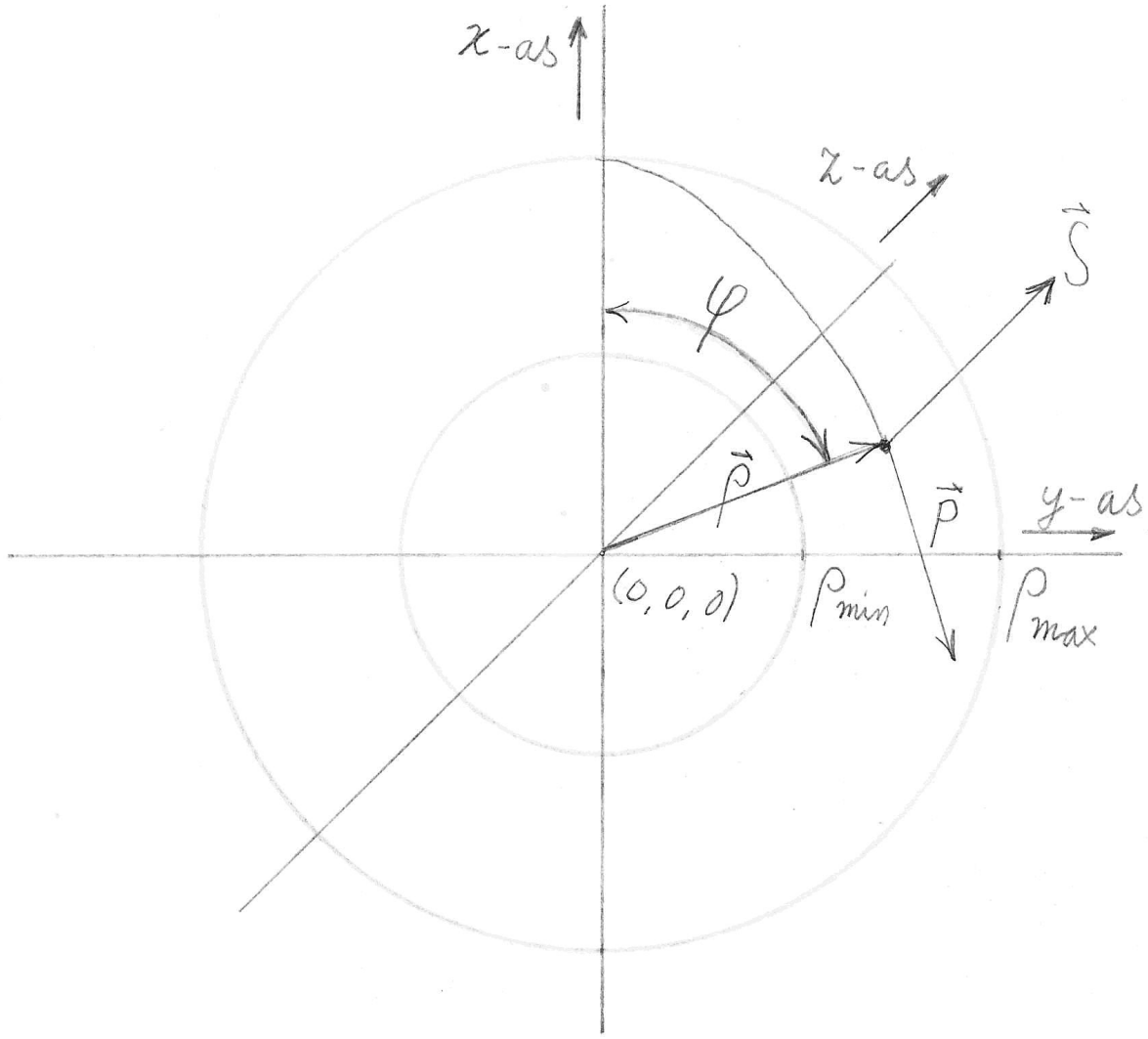

Figure 1 The harmonical oscillation of an elementary particle moving in the positive z-axis. The inertial-frame moves with origin (0, 0, 0) with the particle, so we have to solve oscillations in the 2D-plane (ρ, φ, 0). These Differential Equations can be solved exactly for the square of ρ. And because ρ > 0 this also solves ρ exactly.

The momentum given here is not the momentum of the particle in the direction of motion, i.e. the momentum of an elementary particle in QM, but the angular momentum described from the inertial-frame moving with the particle in the positive z-axis. This will be explained later. This explicitly described

$$\vec{S} = \vec{\rho} \times \vec{p}$$

angular momentum is the conserved spin and is always oriented in the direction of movement, i.e. the selected positive z-axis. For massless particles this description is also valid and these most easily solved solutions are of the form of incomplete elliptical integrals of the three different kinds needed to specify ρ and φ exactly.

In the SM [1] the possible eigenvalues of spin are given not-understood by:

$$S = s \cdot \hbar \qquad [\text{kg m}^2\ \text{s}^{-1}],\ \text{with } s \in \{0, ½, 1, 1½, 2, 2½, \ldots\} \tag{1}$$

With ħ the constant of Dirac, i.e. the constant of Planck h divided by 1 complete rotation, that is 2π radians.

All elementary particles which represent forces, i.e. bosons, have integer spin and all elementary particles with half-integer spin, the fermions, appear to be the primary sources of these force-fields.

On mathematical grounds, the spin of elementary particles appears to be fully explained by Albert Einstein his General theory of Relativity:

Spin S (1) of elementary particles must be greater than 0 in order to comply to the Comprehensive Action Principe [2] of Albert Einstein. So if the gravitational action and the mathematical implications are taken into account, in other words, when curvature of the only possible 4D-spacetime analysis is taken into account.

Most theoretical physicists seem to ignore the mathematical discovery of Grigori Perelman [3]. In the period from 2003 to 2005 he studied GR Ricci flow together with Richard Hamilton [5] with the aim to proof Thurston his Geometry assumption [6]. In this work [4] Grigori Perelman [3] showed that mathematical knots are only possible in 3D-space, i.e. the SR 4D-spacetime. It will later be explained why only a mathematical analysis which allows knots can be used to analyze physics, i.e. our "reality".

In QM elementary particles are described by wave functions in the infinite dimensional complex Hilbert-space [7]. But why this Hilbert-space has to be used, no Prof. I have met could ever explain this to anyone.

A wave function with spin s has symmetry when rotated around the direction of motion of the described elementary particle. The symmetry rotation-angle experimentally appears to be:

$$\varphi_{\text{symmetry}} = \frac{2\pi}{s} \tag{2}$$

The wave function of a spin½ lepton must be rotated 4π radians to end up with the same wave function. Rotation of the de spin½ wave function for one complete circle of 2π radians results in "minus" the wave function. No theoretical physicist will deny this fact.

The invisible, not EM detectable, spin2 graviton has a wave function which is already identical after a rotation of π radians, consequently a complete rotation over 2π radians result in the wave function of the spin2 particle duplicated twice. This property of spin must be analyzed mathematically to be able to understand this property.

This property of spin2 implies on linear mathematical grounds that gravitation should always be analyzed on 2 mathematical independent ways to be able to make the analysis comply to the CAP [2], i.e. curvature of 4D-spacetime must be taken into account in two independent mathematical ways. And this "***dual***" characteristic of spin2 can be described with the following sentences:

The first effect of GR curvature is a simple macroscopic effect for the first time described by Karl Schwarzschild [8]. In the first world-war Karl Schwarzschild used Einstein's GR equations of motion to describe the paths of the planets around our sun. To make the mathematical analysis easier he assumed our sun to be a non-rotating point-mass. In this way he showed that all planets of our solar system orbit around the sun in slowly precessing elliptical orbits. Just after the first world-war two British experimental physicists confirmed this GR description and this finally resulted in a Nobel prize for Albert Einstein.

This macroscopic effect of curvature only takes into account curvature in the direction of motion.

The only way to also include curvature in the other two directions must be in the 2D-plane orthogonal to the direction of motion and this mathematical demand can easily be included as a microscopical QM effect:

Describe the wave function for each possible elementary particle as an extended harmonic oscillation in the 2D-plane perpendicular to the described direction of motion, i.e. the SR-worldline [9].

In this way, "***spin***" so explicitly modeled mathematically can be analyzed quite easily , because with easy linear, "mathematical" tools.

The 2D-oscillation is most easily described from the inertial frame moving with its origin at the average position of the harmonic oscillating "extended" particle, i.e. the point-position of the elementary particle in the SM [1] (SR-worldline [9]).

As long as the extended elementary particle is described SR the used coordinate system is indeed an inertial frame. Polar-coordinates (ρ, φ, z) result into the most easily solved equations of motion. Choose the positive z-axis as the direction of motion. From this chosen SR inertial frame one only has to solve a simple SR harmonical oscillation in the orthogonal 2D-plane $(\rho, \varphi, 0)$.Also see figure 1.

In the mathematical description of this oscillation, the best choice is to take the eigen-time τ measured at the origin of the chosen inertial frame, because this time is equal to the used eigen-time as used in the SM [1] when analyzing an elementary particle.

The Differential Equations can be presented as two consecutive first-order eigen-time τ derivatives and this results in two different integration constants needed to solve the DE..

The harmonic oscillation described by the DE of course has rotational symmetry (2) for rotation about the z-axis, i.e. the axis of movement. This can be solved exactly using Boundary Conditions.

The BC are either open or closed. Open-BC implicate interactions in all possible 3D-spacelike directions, so must describe always massive fermions. Open-BC also allow more solutions, i.e. families of fermions. As a result always massive fermions can move forwards, backwards and forwards again, i.e. the harmonic oscillating path of fermions must allow mathematical knots to comply to the CAP. This is why fermions, the primary sources of all bosons, can only be described mathematically in the easy imaginable 4D-spacetime of SR of Albert Einstein. This mathematically proves completely that the ONLY mathematical analysis of "everything" must take place in 4D-spacetime.

Closed BC also allow elementary particles which only interact with other objects in the direction of motion, i.e. are able to be massless. So, closed BC must describe elementary bosons, which as a result of this mathematical fact cannot possess more so-called "***families***".

The average extensiveness described from the inertial-frame moving with origin with the average position of the oscillating particle is given by:

$$E_{xtendedness} = 2\langle\rho\rangle = \rho_{max} + \rho_{min} = 1\tfrac{1}{2}\rho_{max} = 3\rho_{min} = s \cdot l_h \cdot \mathrm{Phi} \qquad (3)$$

With s the integer or half-integer spin, l_h the Planck-length [10] and $\mathrm{Phi} = \tfrac{1}{2}(\sqrt{5}+1)$ the Golden Ratio [11]. Formula (3) shows directly that elementary particles always have spin $s > 0$, because otherwise they mathematical possess no analyzable existence. This shows immediately that spinless elementary particles are just simple analyzed "misunderstood human fiction"!

In the only possible 4D-spacetime analysis all possible variables are 4-vectors of a certain degree $\mho \geq 0$, with $\mho = 0$ describing a scalar, $\mho = 1$ describing a 4-vector and all $\mho > 1$ describing invariant GR tensors of order $\mho$ and of course other non-invariant matrices. Some examples: A scalar can be given as the in-product of two 4-vectors, a transformation matrix just is a second order tensor and the Riemann-Christoffel-tensor is a fourth order tensor. N.B. Not all matrices are GR tensors.

Symmetry transformations result in conservation laws and this is why all possible symmetry transformations will be analyzed in a non-reducible manner to enable us to obtain linear, i.e. “mathematical” knowledge of our ónly possible mathematically analyzed reality in a complete non-reducible manner.

First of all we'll analyze all possible transformations of the only possible 4D-spacetime reality:

All possible 4-vectors can be analyzed linear, i.e. microscopical SR QM, without including GR curvature, by the operation of a 4 x 4 transformation-tensor with 16 degrees of freedom. This transformation-tensor $T^{\mu\nu}$ is unique described as the sum of a anti-symmetrical tensor $A^{\mu\nu}$ and a symmetrical tensor $S^{\mu\nu}$:

$$T^{\mu\nu} = A^{\mu\nu} + S^{\mu\nu} \tag{4}$$

In order to make the mathematical analysis comply to the CAP [2] elementary particles have to be described as harmonic oscillators in the 2D-plane perpendicular to the direction of movement with extensiveness given by (3). Through this microscopic CAP [2] condition every possible spin > 0 of an elementary particle must have an extensive mathematical representation.

The two independent transformation tensors (4) are representable with mathematical spin-representations from which causes and effects can be discovered:

$$A^{\mu\nu} = \text{spin}½ \text{ x spin1} \tag{5}$$
$$S^{\mu\nu} = \text{spin}½ \text{ x spin2} \tag{6}$$

Experimentally the following characteristics are known:

- Anti-symmetric transformation actions are caused by electrical spin½ charges.
- Symmetrical transformation actions follow from spin½ mass positions and movements.

This does not mean that other half-integer spin values are not possible than spin½ for elementary particles.

Other than stable spin½ fermions are never observed experimentally. Charged, and thus massive, bosonen may also be sources of force-fields, but bosons are primary present as a result of fermions.

The spin1 action describes the anti-symmetrical EM-field, in addition to other (anti-symmetrical) actions. All anti-symmetrical actions can be derived from the complete non-reducible gauge-symmetry [12]. In the only possible4D-spacetime analysis the complete non-reducible gauge-symmetry [12] is exactly the beautiful gauge-symmetry of the SM [1]:

$$U(1) \times SU(2) \times SU(3) \tag{7}$$

The U(1) x SU(2) gauge-symmetry describes, mixed by the Weinberg-angle θ_W [13], the EM-field and the weak-nuclear forces [14] and the SU(3) gauge-symmetry describes all possible quarks and their interactions. As a result of the mixing of the EM-field and the massive $\{W^{\pm}, Z\}$ gauge-bosons, all four electroweak elementary particles must be spin1 bosons. The elementary particles representing the weak-nuclear forces [14] $\{W^{\pm}, Z\}$ must also possess charged bosons, i.e. a particle and its anti-particle.

Charged particles interact with the EM-field in all spacelike directions and therefore must have rest-masses greater than zero. Therefore, the weak-nuclear forces must all have rest-masses greater than zero. All quarks with all their characteristics are a result of the SU(3) gauge-symmetry. In the SM [1] quarks are assumed to be spin½ particles with additional isospin½ [15]. However QCD does not explain this because it is a misunderstood feature of QCD. Therefore QCD can not explain why quarks are never observed separately, but always in groups of at least 2 quarks.

From (4) it follows, with the used spin-representations (5) en (6), that the only stable, or not immediately disintegrating composite particles have spin-values given by:

$$s \in \{½, 1, 2\} \quad (8)$$

These particles are not only elementary particles, but also composite particles. The SU(3) gauge-symmetry mathematically shows that all composite particles are just the hadrons [16]. From (8) the following possible spin values of elementary particles are possible:

$$s_{\text{elementary particle}} \in \{½, 1, 1½ , 2\} \quad (9)$$

Both experimentally and theoretical it appears that quarks posses 4 degrees of freedom for spin and not just 2 such as for elementary spin½ particles, besides that it is experimentally a known fact that quarks cannot be observed as stable elementary particles. This is why quarks aren't elementary spin½ particles with additional isospin½ [15], but on mathematical grounds must be unstable elementary spin1½ particles.

In QCD it is assumed that gluons [17], which describe the strong-nuclear forces, are elementary spin1 particles with very low rest-masses. However, the SU(3) gauge-symmetry group mathematically only describes elementary spin1½ fermions and no elementary bosons at all. This is why gluons [17] must be particles composed of 2 spin1½ quarks in such a way that the composed gluon has spin1. This also explains why gluons aren't massless.

All observable, that is stable, electric charges can be specified with ±1 electron-charge e. Quarks are always surrounded by a so-called "quark-sea". The only possible charges of stable quark combinations are {-1, 0, 1}. From this simple logical analysis the possible electrical charges of (anti-)quarks are given by:

$$q_{\text{quark}} \in \{-⅔, -⅓, ⅓ , ⅔\} \quad (10)$$

These possible charge-values of quarks are a second reason for the experimental fact that quarks cannot be observed on their own as stable entities.

The total amount of different quarks is determined by the amount of different fermion-families and the amount of quarks for each family. Quarks are elementary spin1½ particles, i.e. have 2 x 2 different (anti-)particles (2 quarks and 2 anti-quarks). This is why our 3 elementary fermions family has 6 different quarks:

Our 3 families universe has 2 x 3 = 6 different quarks, with opposite charged anti-quarks:

First family:	Second family:	Third family:
up-quark	charm-quark	top-quark
down-quark	strange-quark	bottom-quark

The upper row of quarks has charge $q_{\text{quark}} = ⅔$ and the lower row quarks has charge $q_{\text{quark}} = -⅓$ which makes them fundamental different, just like two different "families", however these elementary particles are just 2 different eigenstates of the spin1½ quark and not the consequence of mathematically incorrect assumed additional isospin½. The associated anti-quarks of course posses $q_{\text{antiquark}} = -⅔$ and $q_{\text{qntiquark}} = ⅓$.

The total amount of different *elementary* particles is equal to the amount of different elementary bosons and the amount of different elementary fermions.

The amount of different *elementary* bosons are easily given mathematically as the massless spin1 photon of the anti-symmetrical EM-field and the only other massless spin2 graviton of the symmetrical gravitational field and of course the 3 elementary spin1 bosonen of the also electrical charged, so massive, weak-nuclear forces $\{W^{\pm}, Z\}$: This is why every possible universe *only* has 5 different elementary bosons.

The amount of different elementary fermions is equal to the amount of fermion-families multiplied by the amount of different elementary fermion particles for every family: The leptons are on their own stable charged with charge ±1 e and because they are elementary must also posses an uncharged massive "neutrino". This characteristic is not valid for hadrons. The hadrons have according to the SU(3) gauge-symmetry 2 x 2 = 4 different elementary particles for each family, and this mathematical analyzed fact results in a total of elementary fermions given by n · 7.
As a result of this simple mathematical analysis the total amount of different elementary particles is completely given by the amount of different fermion-families n:

$$\sum_{\text{elementary particles}} = 5 + n \cdot 7 \text{ different elementary particles.} \qquad (11)$$

Our 3 elementary fermion-families universe has 26 different elementary particles. Thus, there exist no spinless elementary particles, because spinless elementary particles can not vibrate in accordance with a simple linear mathematical analysis and as a result of that cannot posses "intrinsic" energy proportional to a detectable frequency.
Right now, from the simple mathematical analyses, the following conclusions can be derived on pure mathematic grounds:

- Elementary particles must posses spin > 0 given by formula (9), and this implies that the now assumed "detected" SM [1] Higgs-boson [18] just is simple "human" fiction.
- The 4D-Energy-impuls 4-vector (E, **p**) of all particles is a conserved 4-vector for all not force experiencing particles. This is due to the symmetry of the 4D-transformation symmetry of the QM position of an elementary particle under Lorentz-boosts. In other words, conservation laws of elementary particles mathematically come to life in two independent ways, in the first place "macroscopic" in the direction of motion (the SR-worldline) and in the second place "microscopic" via the 2D-extendedness in the 2D-plane orthogonal to the direction of motion n the 2D-direction of motion, i.e. the SR-worldline. The last property explains on mathematical grounds spin completely, because mathematical completely derivable "intrinsic" angular momentum, i.e. "spin", as conserved quantity.
- Gauge-symmetry [12], a complete anti-symmetrical actions (7) symmetry, must always be analyzed to take into account the anti-symmetrical *electric charge related* interactions and appears to take into account all hadrons [16] and the weak-nuclear forces [14] together with all their SR characteristics.

In our daily experienced 4D-spacetime reality other elementary particles are not possible on simple mathematical grounds, because this mathematical analysis is complete and non-reducible. In other words, our everyday experienced reality is mathematically only analyzable in 4D-spacetime and this simple analysis describes also the only possible, i.e. non-reducible Theory Of Everything [19].

The mathematical equations of motion described from the selected SR inertial-frame that moves with the average position of the harmonic oscillating particle exactly explains all features of the QM [1]and the always used Hilbert-ruimte of the SM [1].

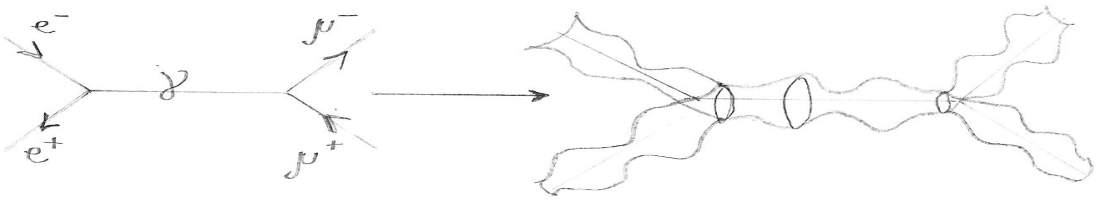

Figure 2 In the SM elementary particles are described as points which move along the SR linear worldline. The analysis should be adapted to comply to the CAP, i.e. with harmonic oscillating particles in the 2D-plane orthogonal to the direction of motion. Use BC to solve the DE. The merging lepton anti-lepton electrons oscillate harmonic with open-BC and together melt into one boson with closed BC which allows it to be massless. After some time by influences from surrounding elementary particles this resonance will brake-up again in for example a muon and an anti-muon both described with open-BC. The 1D-Feynman graphs become 2D-harmonic oscillating waves orthogonal to the direction of motion of the described particles.

But without the work [4] of Grigori Perelman [3] I would never had the sense to realize that mathematical knots are only possible in 4D-sapacetime. This was the only point in the mathematical analysis that still had to be proven, but Grigori Perelman helped me out! And emotionally, I am sorry that this also proves that all beautiful conceived String theories are incorrect. But logical understanding of our reality offers probably every human brain more pleasure!?! And in my logical analysis String theories are incorrect because they use 10D-spacetime and even an 11D-spacetime analysis used for the "Magical" M-theory [22] developed by Edward Witten and used to show that the 5 different Super-string theories all describe the same 10D-spacetime analysis from a different viewpoint. But the viewpoints with other than 4D-spacetime are incorrect. Curvature implies extensiveness in a 2D-plane, also see figure 1, and the only possible mathematical analysis must use 4D-spacetime.

Besides that from the above it is also obvious that Super Symmetry is not possible, because fermions possess more families and boson never allow more elementary families. This is a second reason that String Theories cannot be correct.

Grigori Perelman his work [4] had a very decisive impression on scientific analysis and showed me real understanding of very difficult QM, i.e. turned it into now completely understandable "simple" SR SM [1]. But without the work of Grigori Perelman and Richard Hamilton I would probably still be busy with mathematical analyses of higher dimensional mathematical spaces and their beautiful mathematical constructions to analyze our "objective" reality in a not-understood manner. Only because Grigori Perelman proof that knots are only possible in 4D-spacetime, I was able to derive the SR Quantum Field Theories [20] completely by rewriting it in compliance with the CAP. And this resulted in a simple mathematical explicit description of *spin* [21] of elementary particles. And this at once yielded a Theory Of Everything [19] for every possible reality.

With this short explanation of Spin in QM I sincerely hope to offer people better understanding of the still in general not understood QM.

Because mathematics is indeed simple linear analysis that uses a perpendicular linear 3-axis coordinate frame as inertial-frame that can easily be imagined.

Experimentally the LHC of CERN has on statistical basis shown that the Higgs-boson is not discovered, because only about 170.000 Higgs-bosons where detected among a total amount of 10^{19} detected particles (hadrons and elementary particles)! The amount of detected Higgs resonances was of the same order as the detected pairs of top-quarks. The amount of detected bottom-quark pairs was of the order 10^{10}, so for each detected "Higgs"-boson about 100.000 bottom-quark pairs were observed. And when realizing that the detected decay-time of the Higgs was about 10^{-22} seconds it at once shows that this scarcely discovered Higgs-boson cannot explain an attractive force between an electron and its attracting hydrogen-nucleus! So, the discovered resonance cannot explain mass of particles in QM. In any correct statistical analysis this also shows that the found resonance does not represent the Higgs-boson. In this experimental view one should realize that according to the SM the Higgs-boson as mechanism for mass should be the most frequently detected elementary particle!
Besides this, the LHC has experimentally almost ruled out validity of SuSy and without stupid SuSy all Super-String theories are on mathematical grounds in-correct! With the restart in 2015 this will be the first discovery made by the LHC experimentalists.

For more information or if you are interested in the mathematical solutions, please contact me via my given address data:

Ir. M.T. De Hoop
Bouwensputseweg 6
4471RC Wolphaartsdijk
Telephone: 0 (+31)612668208
E-mail: tomdehoop@solcon.nl
Homepage: http://quantumuniverse.eu

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