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What is spin?

Spin as used in physics is a fundamental property of all Elementary Particles. This property ***spin*** is called this way because it is a characterization of rotation of the particle around the axis of motion. The only conserved spin, i.e. the so-called intrinsic property of an assumed Point-Particle, is actually called its helicity. Helicity just is rotation of the properties of an elementary particle around the axis of motion, i.e. the **S**(pecial) **R**(elativistic) worldline.

In physics both Samuel Goudsmit and George Uhlenbeck first introduced the concept spin in 1925.

They proposed that electrons should be described as elementary spin½ particles at the University of Leiden under Paul Ehrenfest, where Samuel Goudsmit obtained his Ph.D. in Physics in 1927.

However, they didn't understand why electrons had to have this property of spin½, but only used it to explain line spectra of atoms and molecules. In fact it was at that time only an experimentally discovered property of elementary Fermions called Leptons. This property "spin" of Leptons was soon extended to be a fundamental property of all elementary particles.

In 1928 Paul A.M. Dirac was the first theoretical physicist who showed using a **SR** description of the **Q**(uantum) **M**(echanical) electron, that the electron and other related elementary fermions (Leptons) had to be described as spin ½ particles and so-called antiparticles, with the same characteristics except for an opposite charge in the case of all charged leptons and an opposite chirality in the case of the uncharged neutrinos. The spin½ together with the particle-antiparticle doubling of degrees of freedom resulted into the famous 4D- **SR** **QM** Dirac equation. Just like all other physicists of those days Paul Dirac used a 1D-Point-Particle description to describe all Elementary Particles, which actually can't explain the necessary property called spin.

In all QM descriptions, elementary particles are analyzed/described mathematically as point-particles with so-called intrinsic characteristics and moving along the SR worldline.
Paul Dirac showed that spin is also a required characteristic of all Leptons in this 1D-SR QM analysis. But, spin wasn't really understood by Paul Dirac, just like it is still not understood by most physicists up to this day!

Spin can only be explained using a **G**(eneral) **R**(elativistic) analysis of Elementary Particles.

And in this analysis Einstein's **C**(omprehensive) **A**(ction) **P**(rinciple) must be used in the math. description of all elementary particles. Also see Paul Dirac's booklet about the General Theory of Relativity [1]. The **CAP** implies for all descriptions of physics that the gravitational action must be included, i.e. the mathematical description must also include curvature of 4D-spacetime!

Why only a 4D-spacetime analysis is allowed was discovered in the beginning of the 21st century by Grigori (Grisha) Perelman. He investigated so-called Ricci Flow (analyzing flow of space and time mathematically according to the theory of **GR**) together with Prof. Dr. Richard Hamilton at the Stony Brook univ. in New York. Grigori Perelman helped Richard Hamilton in solving/proving the Poincaré-conjecture with his 3 publications (also given at [2]). In these analyses Grigori Perelman also proved that mathematical Closed-Knots are only possible in 3D-space, i.e. with easy imaginable height, width and depth. In other words, the only possible correct mathematical analysis must use a 4D-spacetime, just like the space everyone always imagines in his or her thoughts.

In this analysis, everything can only be understood after a more logical view on the science 'mathematics' is given. So only after explaining the use of mathematics, ***spin*** can be explained as the result of **GR**, i.e. using the **CAP**, as being a necessary characteristic of all Elementary Particles!

After that, it is easily proven that spinless elementary particles are not possible.

Mathematics, as it is always used and analyzed is 2Dimensional. All mathematical analysis is always performed in a 2D-plane, like a flat sheet of paper. However any possible description must use 4D-spacetime to allow knots in 3D-space. This implies that all mathematical, that is 2D-analysis, must be used in a 3D-space. Fortunately a 3D-mathematical analysis can be described with a direct sum of two orthogonal 2D-mathematical analyzes. In this case all developed mathematics of the past remains useful and necessary to rewrite **QM** such that it becomes a real science. In fact, this mathematical fact already shows why all degrees of freedom in any mathematical description must be doubled.

Curvature of space and time implies for the used (2D-) mathematical analysis a doubling of the used degrees of freedom. This extensiveness of elementary particles must be described using an ***Ideal Harmonic Oscillating point description*** in the 2D-plane orthogonal to the direction of motion (**SR**-worldline) of this harmonic oscillating elementary particle. The average extensiveness in this 2D-plane is proportional with the (almost always Lorentz contracted) Planck-length.

On mathematical grounds the proportionality constant of the solution of the **D**(ifferential) **E**(quations) of the extensiveness of the mathematical point in the 2D-plane orthogonal to the worldline (described from the inertial frame moving with origin at the average position of the harmonic oscillating point, i.e. the worldline which gives the actual position of the 1D-particle in all **QM** analyzes) is the well-known Golden Ratio: Phi = ½(√5+1).
The average extensiveness from the inertial-frame moving with the particle is given in polar-coordinates by:

$$2\langle\rho\rangle = \rho_{max} + \rho_{min} = 1\tfrac{1}{2}\rho_{max} = 3\rho_{min} = s \cdot l_h \cdot \text{Phi},$$

with s the half-integer ***CAP-dual*** spin $s \in \{\tfrac{1}{2}, 1\tfrac{1}{2}\}$ of Elementary Fermions or integer ***CAP-dual*** spin $s \in \{1, 2\}$ of Elementary Bosons, l_h the Planck-length and Phi = ½(√5 + 1) > 1 the Golden-Ratio.

The **CAP** implies including the spin2 ***dual*** Gravitational Action in any analysis of Theoretical Physics: When a spin2 Graviton is rotated a complete circle of 2π radians around the axis of motion, the wave-function of the Graviton repeats itself twice. This is why all CAP effects must be analyzed math. in two orthogonal ways. This explains why the possible spin-values of Elementary particles $s \in \{\tfrac{1}{2}, 1, 1\tfrac{1}{2}, 2\}$ must all be described ***dual*** as Ideal Harmonic Oscillators in the 2D-plane Perpendicular to the Direction-of-Motion. And all characteristics of all Elementary Particles must also be analyzed in a Complete Non-Reducible ***CAP-dual*** manner:

- Particles: Fermions with Open-BC or Bosons with Closed-BC
- Conserved spin: Helicity of massless particles (the ***dual*** spin1 anti-symmetrical Photon of the EM-Field & the spin2 symmetrical Graviton of the Gravitation-Field) or Chirality of all massive particles.
- Elementary Fermions have ***dual*** conserved spin in the Direction-of-Motion $s \in \{\tfrac{1}{2}, 1\tfrac{1}{2}\}$
- Elementary Bosons have ***dual*** conserved spin in the Direction-of-Motion $s \in \{1, 2\}$
- Besides the spin1 U(1)-Photon we have the mixed SU(2) Gauge-Symmetry of the weak nuclear-forces and the ***dual*** SU(3) Gauge-Symmetry of the spin3/2 Quarks.

Curvature of 4D-spacetime comes to life in two different ways in this 2D-mathematical analysis:

First of all on macroscopic scale through curvature of space and time, as described by Karl Schwarzschild, to describe the rotational motion of all planets around a symmetrical non-rotating massive sphere which describes the sun.

And in the second place on microscopic scale, i.e. **QM**, using a mathematical description in the 2D-plane orthogonal to the observed direction of motion. In this description the describing point oscillates Ideal Harmonically in this 2D-plane with minimum and maximum distances from the origin of the inertial frame with origin at the position of the elementary particle as it is described **SR QM** on its worldline. Both distances are larger than zero, i.e. the oscillating particle is not able to be on its average position itself! The time-like constant is the energy H of the elementary particle, H = hf, with h the constant of Planck and f the frequency of oscillation in the 2D-plane orthogonal to the worldline. The corresponding space-like constant just is the conserved 3D-Spacelike momentum of the particle. The ***CAP-dual*** conserved spin in the direction of motion, i.e. the Helicity in the cases of the 2 massless Bosons and constant Chirality in all other cases.

The mathematical analysis is only correct on local scale described using an inertial frame with origin at the average position of the moving elementary particle. Einstein always said that **GR** can be analyzed **SR** on local scale. However at larger distances curvature of space-time cannot be neglected on so-called macroscopic scale, i.e. when the square root of the absolute value of the determinant of the fundamental tensor $g_{\mu\nu}$ changes from the **SR** value of 1 to smaller values. And this is one of the main reasons why **SR** **Q**(uantum) **F**(ield) **T**(heories), like the **S**(tandard) **M**(odel), still yield the most exact mathematical description of our reality on the microscopic scale of **QM**. On the surface of our earth curvature of space-time is negligible and $\det(g_{\mu\nu}) \approx -1$. However this **SM** neglects curvature on microscopic scale because it does not comply to the **CAP**. And as a result of this fact **QM** is in general analyzed in a not-understood way! Right now you will never find any physicist who is able to explain mathematically what spin actually is!

As a result of Lorentz contraction the wavelike harmonic oscillation in the 2D-plane orthogonal to the direction of motion results into zero extensiveness of the massless spin1 photon and also massless but of-course invisible spin2 graviton, and very small extensiveness of all massive elementary particles. This is why a photon always rotates around itself even though it is described as a point-like particle in **QM**. But in a microscopic description of Elementary Particles, for instance when particles interact, the description only is possible **SR** with extended particles. Because during interactions there is always the moment of first contact in which all oscillating particles are at rest with respect to an inertial frame. The spin of (elementary) bosons must be described with closed **B**(oundary) **C**(onditions), while the spin of (elementary) fermions must be described with open **BC**. This at once explains why only fermions have more families.
The fact that fermions are described with open **BC** explains why there are no fermions with zero rest mass or zero charge-density (the Bohr-magneton of all different Elementary Fermions never is zero). As a result of this fact a **SR** analysis of the harmonic oscillating fermion always allows knots in the traveled path. I.e. any mathematical space that does not allow knots cannot describe fermions correctly in compliance with the **CAP**.

All elementary particles are explained in [3]. From this Complete Non-Reducible **GR** symmetry analysis of the only possible 4D-spacetime reality in accordance to the **CAP**, it follows that the only possible spins are $s \in \{2, 1½, 1, ½\}$. Of which only the reduced set $s \in \{2, 1, ½\}$ are possible stable spins. Elementary particles without spin are again not possible in this analysis. Besides that, ***elementary*** spinless particles are up to this day not observed in real life!

This is why I'm very curious to meet a physicist who is able to explain existence of elementary spinless particles, like the seemingly very massive elementary spinless Higgs boson!

I guess Albert Einstein just was right, and almost all quantum physicists do not understand the mathematical truth behind **QM**, including all Super String theorists. The String theorists also use the **SM** as a first step, without understanding why **QM** has to be solved in the infinite dimensional complex Hilbert-space and why particles have spin as a so-called "***intrinsic***" property. Besides that, a 2D-string is always also allowed to be on the **SR** worldline. As a result of this fact the same divergences occur in this analysis as in **SR** **QFT**. Only now not just one Higgs boson, but a couple of Higgs bosons and the strange use of Super Symmetry are required.
All these additional hypothetical particles are needed to end up with a renormalizable perturbation description, just as in the **SM** of **SR** analyzed (that is 'local') **QM**, however with an additional perturbation constant called α', related to the 2D-strings.

Only when I really am confused about the usage of mathematics, an ***elementary*** spinless boson will ever be detected anywhere. Like for example the assumed spinless Higgs boson. The only thing I actually want to say is the simple fact that **QM** must comply with Einstein's **CAP** to be analyzed correctly. And this implies a mathematical description of elementary particles as Extended Ideal Harmonic Oscillating mathematical-points in the 2D-plane Orthogonal to the Direction-of-Motion.

And this explains why elementary particles are only allowed with ***non-zero*** spins: $s \in \{2, 1½, 1, ½\}$, of which the only stable particles with spins $s \in \{2, 1, ½\}$ are possible. This at-once explains why quarks must be unstable elementary spin1½ Fermions without isospin.

This is why I expect that the only discoveries at the LHC will be more exact characteristics of all possible particles described in [3] and possibly also not yet experimentally observed spin1½ quark (without isospin!) combinations of Hadrons.

My view on Quantum Mechanics is given at: http://quantumuniverse.eu

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Used work:

1. General Theory of Relativity, P.A.M. Dirac, *PRINCETON LANDMARKS IN PHYSICS*, ISBN 0-691-001146-X
2. http://quantumuniverse.eu/TomResults.htm
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