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What is Spin?

From 1986 up to 1990 I studied physics at the T(echnical) u(niversity of) D(elft) and State University of Leiden (RUL) at institute Lorentz. During these studies I kept wondering why Q(uantum) M(echanics) had to be solved in complex Hilbert space. I asked many professors about many to me troublesome facts about QM, but it appeared my teachers also didn't understand the axioms of QM. For example, no Prof. was able to explain to me why elementary particles possess 'spin' or what this characteristic of elementary particles actually is. Also see [16] for the general view on spin. At last in 1998, I finally really understood why elementary particles possess spin after a thorough analysis of QM. I tried to derive all characteristics of QM using Albert Einstein's S(pecial) R(elativity) and G(eneral) R(elativity) theories. This was analyzed using a complete non-reducible relativistic symmetries analysis. The most troublesome fact of QM appeared to me the fact that QM does not comply to the C(omprehensive) A(ction) P(rinciple). I.e. the gravitational action is not taken into account in this analysis in complex Hilbert space. This is also why the use of complex Hilbert space is not understood. The gravitational action is a spin 2 action and implies a doubling of degrees of freedom. This is why space-time is curved in GR analysis. And this doubling of degrees of freedom is also necessary in any microscopic QM analysis. This will be explained below.

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 its axis of motion. The only conserved spin, i.e. intrinsic property of an elementary particle, is actually called its helicity. Helicity just is rotation of the properties of an elementary particle around its axis of motion, i.e. its SR worldline.

In physics both Samuel Goudsmit and George Uhlenbeck [1] first introduced the concept spin in 1925. They proposed that electrons should be described as elementary spin½ particles at the University of Leiden [2] under Paul Ehrenfest [3], where Samuel obtained his Ph.D. in 1927. However they didn’t understand why electrons had to have the property of spin½, but only used it to explain line spectra of atoms and molecules. In fact it was an experimentally discovered property. In 1928 Paul A.M. Dirac [4] was the first theoretical physicist who showed using a SR description of the Quantum Mechanical electron, that the electron and other related elementary fermions (i.e. Leptons [5]) 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 helicity in the case of the uncharged neutrinos [5].
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-description, which can’t explain spin. In all QM descriptions, elementary particles are described mathematically as point-particles with so-called intrinsic characteristics and moving along the SR worldline [16]. In any case Paul Dirac showed that spin is also a required characteristic of all Leptons in this 1D-SR QM analysis. But, and I want to emphasize this fact, spin wasn’t really understood by Paul Dirac, just like it is still not understood by most physicists up to this day!

Spin is explained using a GR analysis of elementary particles. And in this analysis Einstein’s CAP must be used in the mathematical description of all elementary particles. Also see Paul Dirac’s booklet about the General Theory of Relativity [6], chapter 30. 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 [7]. He investigated so-called Ricci-flow [14], i.e. analyzing flow of space and time mathematically according to the theory of GR. Also see the works of Grisha at [15]. In this analysis he proved that knots are only possible in 3D-space, i.e. with 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, spin becomes a logical and also necessary characteristic of all elementary particles.

Mathematics, as it is always used and analyzed is 2Dimensional. All mathematical analysis is always performed in a 2D-plane, like a 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 analyses. 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 extendedness of elementary particles must be described using an harmonic oscillating point description in the 2D-plane orthogonal to the direction of motion (SR-worldline) of this oscillating elementary particle. The average extendedness in this 2D-plane is proportional with the (almost always Lorentz contracted) Planck-length [8]. A massless photon always moves with the speed of light for any observer. As a result of that fact the photon must be described as a point particle with so-called intrinsic properties, like its spin1 and energy proportional to a detected frequency.

On mathematical grounds the proportionality constant of the solution of the D(ifferential) E(quations) of the extendedness 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 analyses) is the well-known Golden Ratio: Phi = $\frac{1}{2}(\sqrt{5}+1)$ multiplied by its spin s. This is why spinless bosons aren't extended in the 2D-plane orthogonal to the particle's worldline.

And the mathematical fact that this 2D-mathematical analysis explains the Golden Ratio, besides explaining that QM has to be solved in the complex Hilbert-space, gave me complete confidence that this 2D-mathematical analysis can be trusted. What has been finished up to today, seems enough to explain everything of QM using a simple 2D-analysis of GR (i.e. in compliance with the CAP).

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 [9], 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 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 space-like constant just is the spin in the direction of motion, i.e. the helicity. 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 the SM neglects curvature on microscopic scale because it does not comply with the CAP. And as a result of this fact QM is in general analyzed in a not-understood way! I'm convinced that you will never find any physicist who is able to explain mathematically what spin actually is [16].

As a result of Lorentz contraction the wavelike harmonic oscillation in the 2D-plane orthogonal to the direction of motion results into zero extendedness of the massless spin1 photon and also massless but invisible (visibility implies interaction with the spin1 EM-field, i.e. photons) spin2 graviton, and very small extendedness 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 also explains why there are no fermions with zero rest mass. 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 [9]. From this complete GR symmetry analysis of the only possible 4D-space-time reality in accordance with the CAP, it follows that the only possible spins are s ∈ {2, 1½, 1, ½}. Of which only the reduced set s ∈ {2, 1, ½} are possible stable spins. The spin1½ fermions are the quarks, which are never observed on their own, but always in sets yielding bosons (gluons and mesons) and spin½ fermions (baryons), which together are called the hadrons. I.e. quarks are not spin½ fermions with so-called additional 'isospin½', but symmetry analysis deduced spin1½ fermions. Elementary particles without spin are again not possible in this analysis.

Besides that, ***elementary*** spinless particles are up to this day not observed in any experiment!

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 [10]! 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 complex Hilbert-space and why particles have spin as an 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 [11] are required.
All these additional hypothetical particles are needed to end up with a re-normalizable 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 elementary 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 correct. And this implies a mathematical description of elementary particles as extended harmonic oscillating points in the 2D-plane orthogonal to the direction of motion. Also see [12].
And this explains why elementary particles are only allowed with ***non-zero*** spins: s ∈ {2, 1½, 1, ½}, of which only stable particles with spins s ∈ {2, 1, ½} are possible.

This is why I expect that the only discoveries at the LHC will be more exact characteristics of all possible particles described in [9] and possibly also not yet experimentally observed spin1½ quark (without isospin!) combinations of Hadrons [13].

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

Used work:

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