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Spin and handedness of elementary particles.

Spin as it is always explained by physicists is in fact intrinsic angular momentum of elementary (assumed point-) particles. As a result it is specified by a direction of rotation in 3D-space. The helicity is the spin projected along the direction of motion and this is the only conserved component of the spin. If the helicity is in the same direction as the direction of motion, given by the direction of the particle's momentum, it is characterized as being Right-handed. Left-handed orientation implies helicity opposite to the direction of motion.

Only massless particles possess frame-independent helicity, so only for these elementary particles the property helicity is used.

The chirality of a particle is related to transformation properties. If a particle transforms in a right- or left-handed representation of the SR-Poincaré-group it has right- or left-handed chirality. Dirac spinors have a mix of both handed portions and these components can be projected out with projection-operators $\frac{1}{2}(1 \pm \gamma^5)$ (plus is right-handed). Only in the case of massless particles the chirality is equal to the helicity. For massive (elementary) particles the chirality can change between different inertial-frames as a result of Lorentz-boosts.

The massless Dirac fermion fields exhibit chiral symmetry, but real Dirac fermion fields always possess mass and this fact breaks chiral symmetry explicitly. So, handedness of a massive elementary particle can change by Lorentz-boosts, so isn't a constant. But the total spin $\frac{1}{2}\hbar$ of a Dirac fermion is a constant of motion and only the observed direction depends on the observer.

A free moving elementary fermion with respect to the ”background” will always remain moving in the same direction and as a direct result of that also keeps its “handedness”, i.e. direction of rotation in the 2D-plane orthogonal to the direction of motion. And this simple fact implies that helicity is a conserved property of a free (not experiencing any force-fields) massive fermion too. But this ideal situation is never true for fermions due to the fact that both the graviton and the photon are massless, while all possible fermions are charged ánd massive!

This is why helicity can indeed be used as a conserved property of elementary particles. Because physics is nothing but a simple mathematical analysis and when describing, i.e. explaining always massive fermions, the helicity is the only conserved spin of these particles.

Just a short note on handedness of elementary particles.

If this explanation results into questions, please do not hesitate to give me your reaction:

Best greetings from Tom,

Ir. M.T. De Hoop
Bouwensputseweg 6
4471RC Wolphaartsdijk
Phone: 06 12 66 82 08
E-mail: tomdehoop@solcon.nl
Homepage: http://quantumuniverse.eu