3. Fermions require a mathematical description that allows knots.

This is a not yet finished first written explanation!!!

Step1: In http://quantumuniverse.eu/Step%201.html the required demand to end up with a mathematical (that is linear) description that complies with Einstein's CAP is explained. I.e. describe all non-reducible mathematical objects, i.e. elementary particles, as extended harmonic oscillating (exact mathematical) points in the 2D-plane orthogonal to the observed direction of motion (SR worldline), also see [2]. Actually in step1 the demand of any physical description to comply with Einstein's CAP is explained, based on the fact that any scientific analysis must be relativistic. Any mathematical analysis is linear, i.e. based on SR phenomena. The only way to yield a SR (mathematical) description in compliance with the CAP (i.e. also include curvature of space-time) implies 2D-extended elementary particles.

Step2: Two-dimensional extended elementary particles must be solved with two BC.

This is explained in: http://quantumuniverse.eu/Step%202.html

All so-called ***fermions***, i.e. conserved half-integer helicity particles, must be solved with **open** BC and all so-called ***bosons***, i.e. conserved integer helicity particles, must be described with **closed** BC.

Open BC imply massive elementary fermions, which always are observed with speeds v < c***!***
In any relativistic analysis, an object moving with a speed v < c, can always move both faster and slower with respect to an observer. Consequently the (exact) pointlike described extendedness of the elementary fermion as an harmonic oscillating point in the 2D-plane orthogonal to the observed direction of motion (worldline) allows knots. A simple SR description of the motion of the harmonic oscillating massive point as a result allows knots in the described path. The only requirement is a changing speed of motion of the observer, i.e. a non-inertial frame from which the fermion is described by an observer. But in any step of the motion of the observer, the description can always be described linearized with an inertial frame. This is the basic assumption of Einstein's GR, i.e. that a description of curved space-time can always be investigated SR locally.

To me, this mathematical (i.e. linear) fact resulted into the following conclusion:

The only mathematical space to describe any possible universe must be relativistic 4D-space-time.

The primary sources of all bosons are fermions. I.e. without fermions, with a certain amount of particle families, a universe isn't possible! All fermions are massive, of which all ***compound*** fermions, i.e. baryons, are uneven amounts (3) of spin1½ quarks bound together into stable spin½ baryons by chargeless and almost massless spin1 colored gluons (sets of combined stable color-quark – (different) anti-color-quark bosons). All stable quark compounds are accompanied by so-called glueballs, i.e. lots of stable mixed gluon *and* meson "balls" as fuel to glue quarks together into stable spin½ baryons. The fact that glueballs are mixed gluon and meson pairs made me conclude in 1999 that both mesons and gluons are combined quark – (anti-) quark bosons.

In the next step I'll explain why all possible elementary particles follow completely from a complete non-reducible symmetry groups analysis of our 4D-universe. From this analysis it's easily understood why quarks must be described as elementary spin1½ fermions, instead of spin½ fermions with additional so-called isospin, as assumed in the standard model.

Used work:

1. General Theory of Relativity P.A.M. Dirac, Princeton Landmarks in Physics. ISBN 0-691-01146-X
2. CAP (i.e. curvature) induced doubling of degrees of freedom is explained in the paper:
http://quantumuniverse.eu/Tom/Curvature%20and%20QM.pdf .