Uniqueness of Unification

of general relativity and the standard model with massive neutrinos:

The lack of alternatives yields estimates of particle masses.

Christoph Schiller

motionmountain.net/research

Preprint at researchgate.net/publication/389673692

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Constituents of nature

Black holes have entropy.

Thus, black holes are made of *fluctuating constituents*.

Black holes can be formed by amassing particles.

Black holes can be formed by curving space.

Thus, black holes, particles and space are made of *common* fluctuating constituents.

All of nature is made of common fluctuating constituents.

Properties of the constituents of nature

Black hole horizons and space are extended. Space is empty.

Black hole entropy depends on the black hole *surface* and on the *Planck area*.

Thus, black hole constituents cannot be of Planck size in all directions.

Thus, black hole constituents cannot be membranes.

Thus, black hole constituents cannot be of finite size but must reach the cosmological horizon.

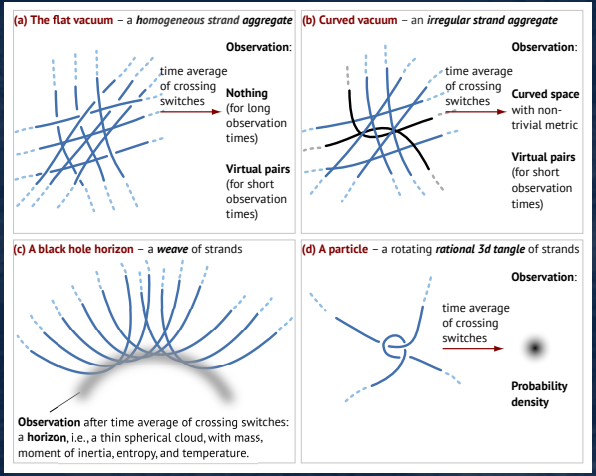
Thus, black hole constituents cannot have branches or crossings.

Thus, black hole constituents must be *unobservable* and thus obey *no equations*.

Thus, nature's constituents are *filiform* with *Planck area* cross section.

They fluctuate in 3d and are called *strands* (Fäden, fils, fili, draaden).

Claim: only strands yield all structures and all laws of nature

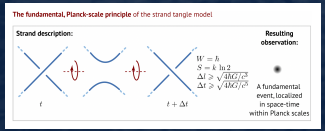


Phys. Part. Nucl. 50 (2019) 259 and a dozen more, listed at motionmountain.net/strands

Fluctuating strands of Planck radius yield particle physics and general relativity.

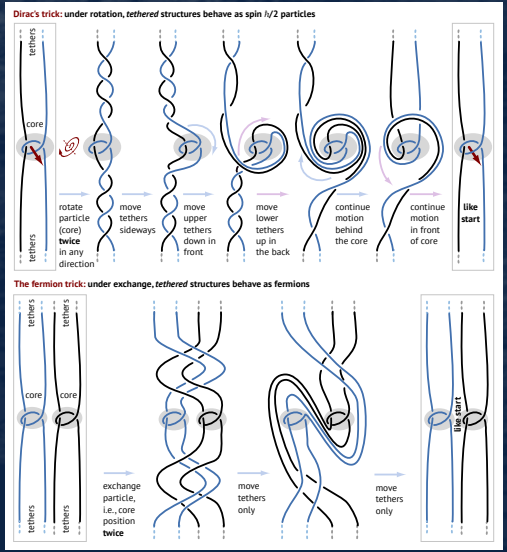
Fluctuating strands agree with all observations.

This follows from a single fundamental principle:



All observables are *composed* of crossing switches.

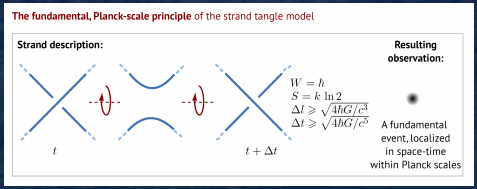
Only strands explain and derive $\hbar$ and spin 1/2 fermions



Spinning fermions are *rotating tangle cores* continuously performing Dirac's trick.

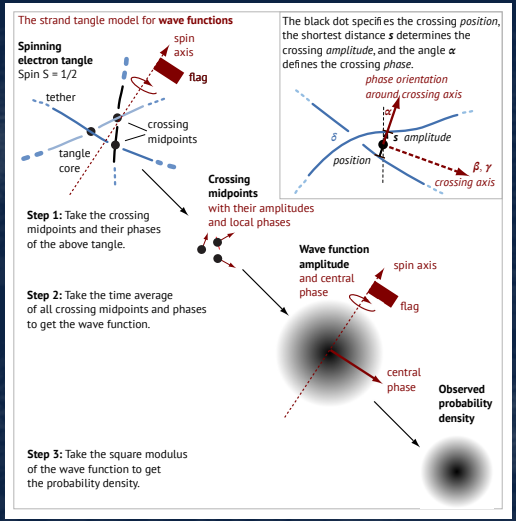
When moving, fermions spin like a moving windmill or a maple seed.

Each crossing switch produces a quantum of action $\hbar$:



Predictions: there are no elementary spin 3/2 particles, no particles with spin between 0 and 1/2, and no anyons; no action below $\hbar$ is observable; there is no other model for $\hbar$ and spin 1/2.

Only strands explain and derive wave functions and quantum theory

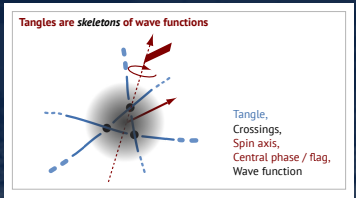


Wave functions are *oriented crossing densities* and form a Hilbert space.

Particles are *tangles*. This explains antiparticles and leads to the free *Dirac equation*. Reactions arise.

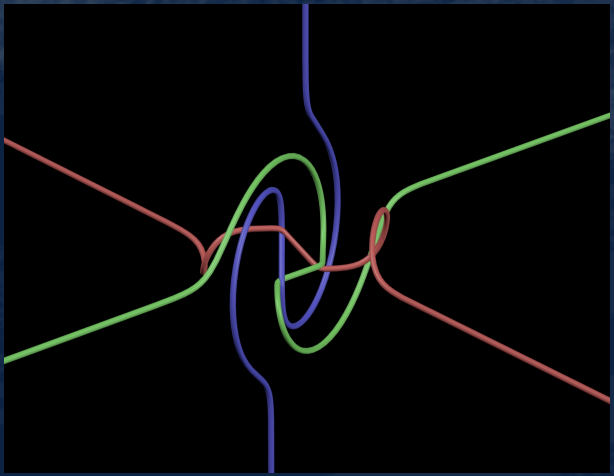
See researchgate.net/publication/361866270

Tangles are *skeletons* of wave functions:



Predictions: there are no measurable deviations from quantum theory; there is no other model for wave functions.

A Desmos animation of a spinning electron, programmed by Ronwnor



(Click.)

Animation at desmos.com/3d/46kkmamfwy

The *central triangle* is the spinning *chiral electron* core; each chiral crossing yields an electric charge e/3.

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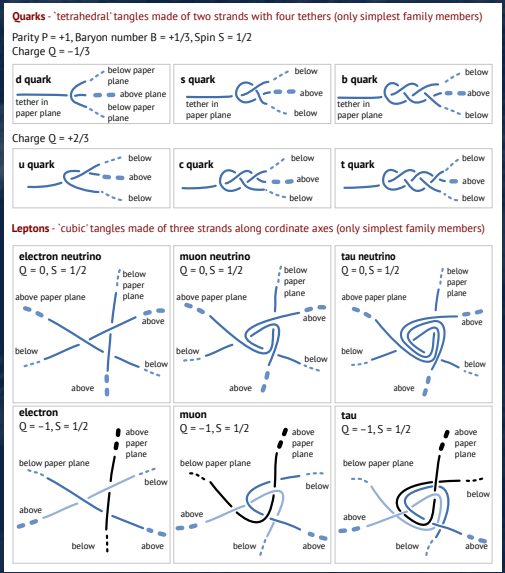
Only strands explain and derive the elementary fermion spectrum and quantum numbers



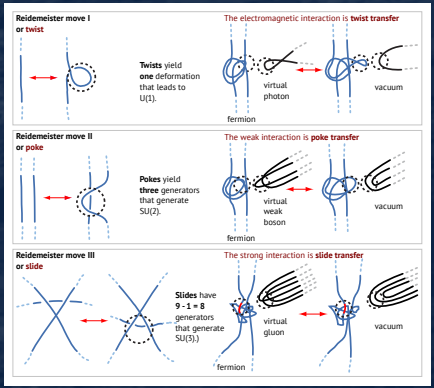
Classifying tangles allows classifying elementary particles, yielding *three generations* of fermions and all their quantum numbers.

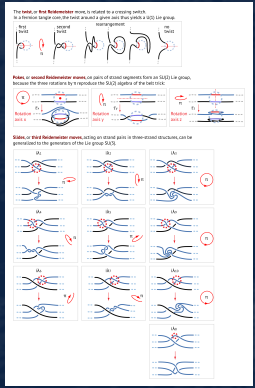
Topological chirality, 1/3 of the signed crossing number, yields electric charge.

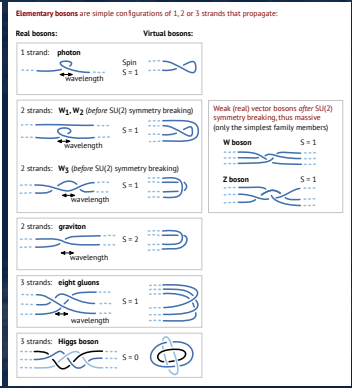
Geometric chirality yields parities and mass values for nonzero spin.

Predictions: there is no other elementary fermion and no elementary dark matter; neutrinos have mass; there is no other model for elementary particles.

Only strands explain and derive gauge interactions, Lie groups and coupling constants





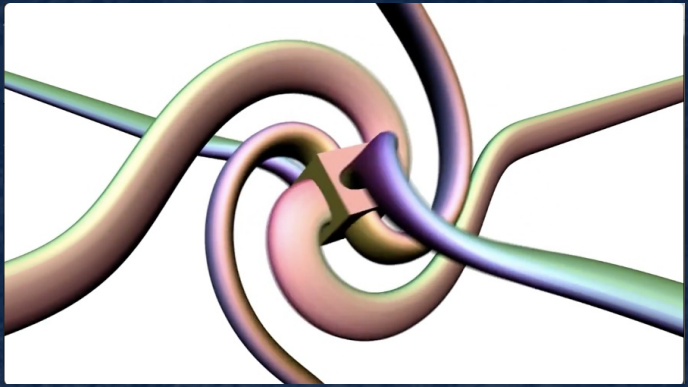


Reidemeister's theorem from 1926 allows classifying gauge interactions, gauge bosons, and *deriving the three gauge groups.* Int. J. Geom. Meth. Mod. Phys. 21 (2024) 2450057

The average shape of chiral cores determines the electromagnetic and the strong coupling constant. J. Geom. Phys. 178 (2022) 104551, Int. J. Geom. Meth. Mod. Phys. 20 (2023) 2350095

Predictions: there are no additional gauge interactions; there is no other model for them.

Jason Hise's animation illustrates the motion of spinning leptons



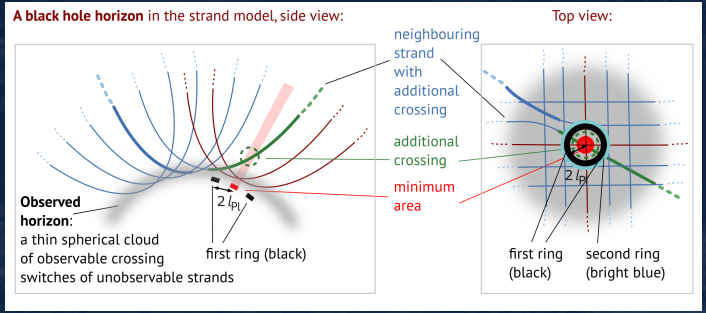
(Click.)

motionmountain.net/videos.html#strands

The rotating cube represents the chiral tangle core of the spinning lepton.

Classifying the possible core topologies leads to the *observed lepton spectrum*.

Only strands with Planck radius *also* explain general relativity



Black hole entropy follows from the statistics of crossing switches of strands.

Ind. J. Phys. 96 (2022) 3047

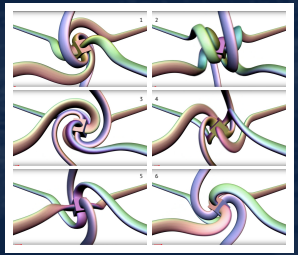
Also black hole temperature and energy follow from crossing switches of strands.

This implies the field equations of general relativity, as shown by Jacobson in 1995.

Predictions: no deviation from general relativity and no new quantum gravity effect will be observed; no other model of general relativity will explain elementary particles.

Only strands with Planck radius explain and derive particle masses

Leptons:



Bosons:

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Dirac's trick implies an *upper limit for lepton mass* given by $44\,\mathrm{GeV}/c^2$.

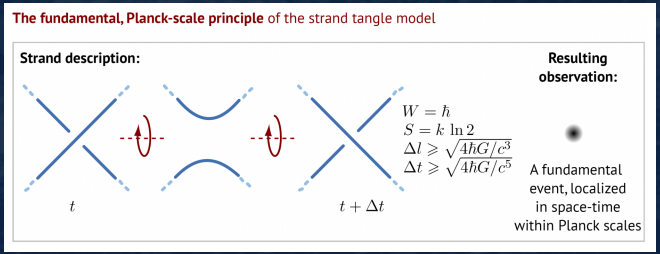
Boson motion implies a *mass for the W boson* between $32\,\mathrm{GeV}/c^2$ and $8.4\,\mathrm{TeV}/c^2$.

Tether motion imply a *mass for the Higgs* between $96\,\mathrm{GeV}/c^2$ and $3.9\,\mathrm{TeV}/c^2$.

Not precise, but ab initio – and strands solve the mass hierarchy problem.

Predictions: no deviation from the standard model with massive neutrinos will ever be observed; no other model derives elementary particle mass values ab initio.

Summary: *only* strands deduce physics from a single principle



• The fundamental principle deduces the Lagrangian of the standard model of particle physics with massive neutrinos.

• The fundamental principle deduces the Hilbert Lagrangian of general relativity.

• So far, all consequences of the fundamental principle agree with all observations.

• Predictions: no observation will ever contradict the two Lagrangians; no unified equations are possible; no other unified model is possible; more precise estimates of the masses, couplings and mixing angles are possible.

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