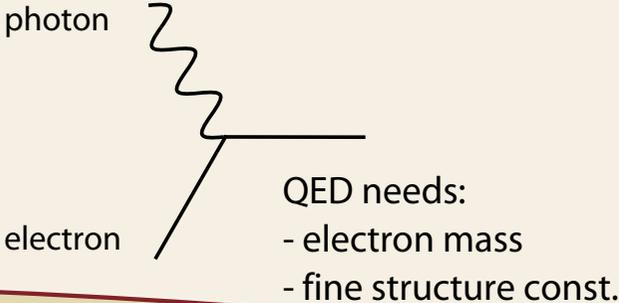


# From Strand Unification To The Fine Structure Constant – And All Colours

A conjecture about the origin of  $\alpha = \frac{e^2}{4\pi\epsilon_0\hbar c} \approx \frac{1}{137.036(1)}$  and of the other fundamental constants of the standard model – and thus of all colours.

**Christoph Schiller**



# Summary

## Strand Conjecture

### ❖ Summary

- ❖ Challenge
- ❖ Fundamental principle
- ❖ Black hole entropy
- ❖ Black hole rotation
- ❖ Everything strands
- ❖ Wave functions
- ❖ Dirac's equation
- ❖ Lepton spin
- ❖ Fermion behaviour
- ❖ Particle spectrum
- ❖ Interactions
- ❖ Gauge groups
- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material

## The Dirac trick at the Planck scale describes nature completely.

In particular, the Dirac trick at the Planck scale implies:

- all known observations and measurements,
- all equations of physics,
  - from general relativity to the standard model of particle physics,
- all mathematical structures, fields and principles used in physics,
- all processes, all Feynman diagrams,
- all gauge interactions, gauge groups and symmetries,
- all observed particles, all quantum numbers,
- all events,
- all motion,
- all fundamental constants, including
  - the fine structure constant and the electron mass.

Equivalently:

**Nature is made of strands. Colours are due to strands.**

# The Challenge

## Strand Conjecture

### ❖ Summary

### ❖ Challenge

- ❖ Fundamental principle
- ❖ Black hole entropy
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- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material

**A complete theory is needed to explain the values  $\alpha = 1/137.035\,999\,206(11)$  of the fine structure constant and of the other 25 fundamental constants of the standard model: the nuclear *couplings*, the elementary particle *masses*, and the *mixing angles*.**

**Complete** means:

‘describing both general relativity (gravitation and curved space) **and** the standard model of particle physics.’

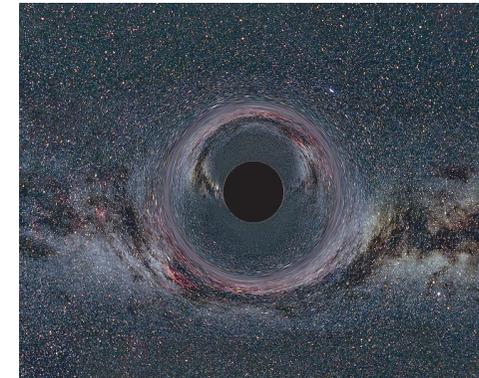
Now, one system can be said to be made either from *curved space* or from *particles*: a **black hole**.

Black holes show effects at **Planck scales**, such as entropy and radiation.

Black holes and particles show effects of **extension** (see later on).

**Conclusion 1:** A correct *Planck-scale* model for a black hole is automatically a candidate model for *curved space* and for *particles*.

**Conclusion 2:** The model must contain *extended*, not point-like constituents – and describe, at the same time, *point* particles and *continuous* space-time.



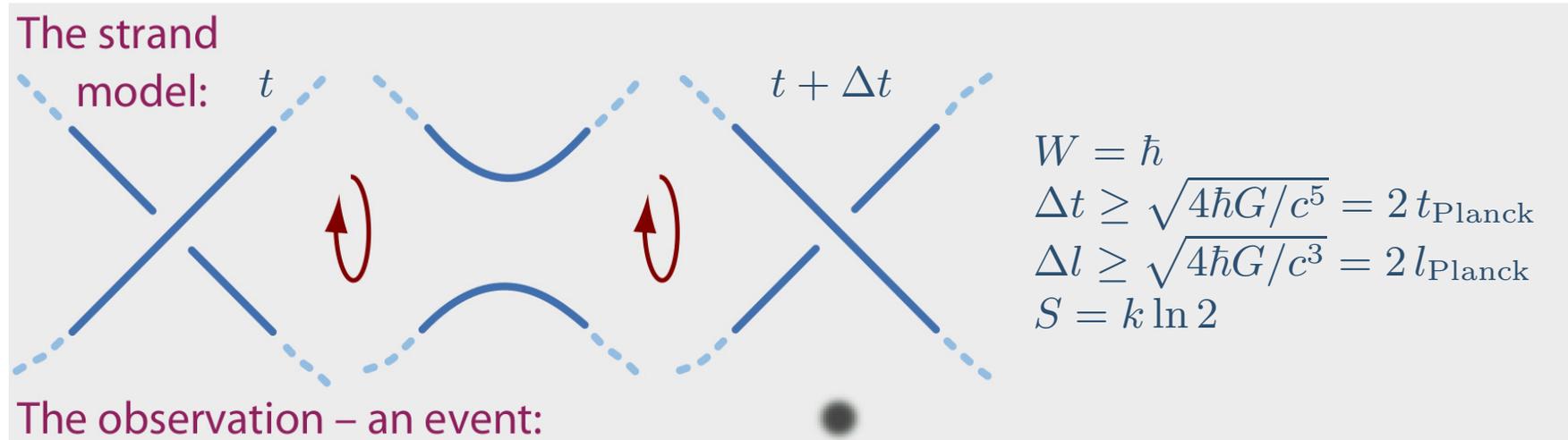
© Ute Kraus

# Maximum Simplicity: Tangled Strands

**Proposal: A black hole is a weave of fluctuating strands.**

Strands are not observable – only crossing switches are.

**Crossing switches of strands define *events* and *Planck units*:**



– Any event is a **crossing switch** and characterized by  $\hbar$ . (A ‘qubit’.)

– Strands are **unobservable**, impenetrable and featureless: no mass, no tension, no branches, no fixed length, no torsion, no ends, no fields.

– A trick: imagine strands with an **effective Planck radius**.

– **All observables** are measured in terms of crossing switches.

**Thesis: This fundamental principle – Dirac’s trick at the Planck scale – implies black hole entropy, general relativity, QFT, U(1) broken SU(2), SU(3) and all particle physics: all of physics.**

## Strand Conjecture

❖ Summary

❖ Challenge

❖ Fundamental principle

❖ Black hole entropy

❖ Black hole rotation

❖ Everything strands

❖ Wave functions

❖ Dirac’s equation

❖ Lepton spin

❖ Fermion behaviour

❖ Particle spectrum

❖ Interactions

❖ Gauge groups

❖ Predictions

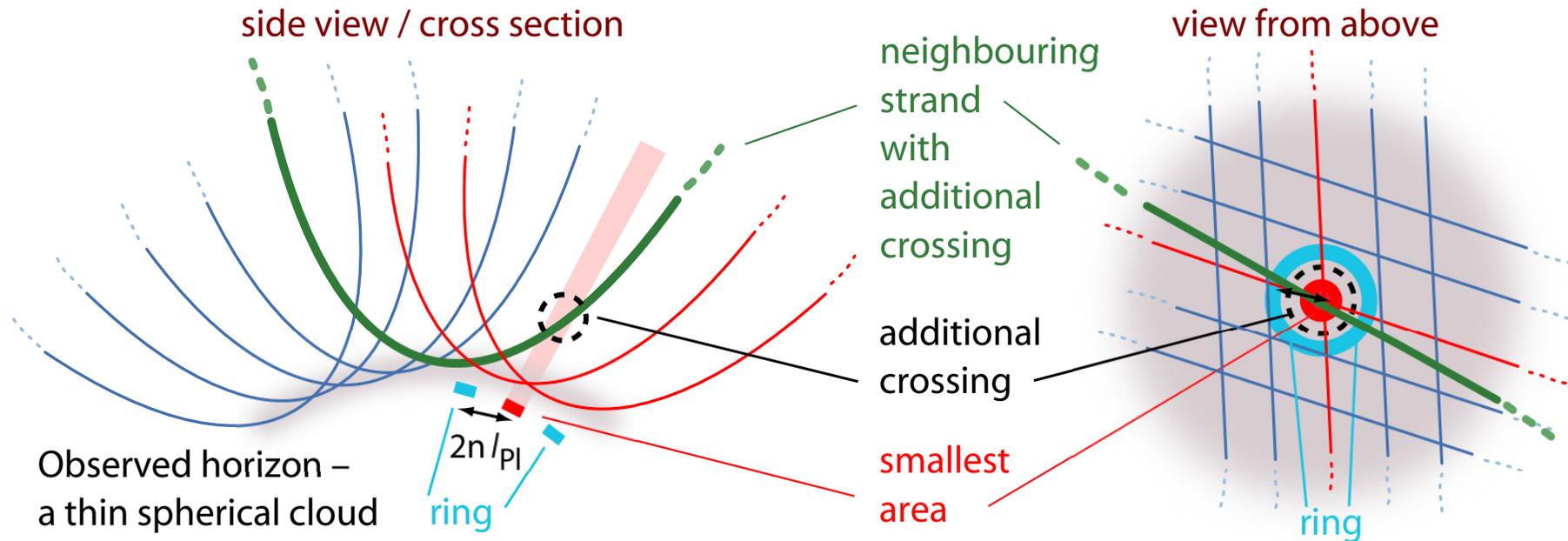
## Coupling Constants

Mass

Conclusion

Bonus Material

# Black hole horizon in the strand conjecture:



Observed horizon – a thin spherical cloud

The effective number  $n$  of possible microstates per smallest area:

$$n = 2 + \frac{1}{2!} + \frac{1}{3!} + \frac{1}{4!} + \frac{1}{5!} + \dots = e = 2.71828\dots$$

yields an entropy value  $S$  that depends on the area  $A$ : (Schiller 2009, 2019)

$$\frac{S}{k} = \frac{A}{4 \hbar G / c^3} - \mathcal{O}\left(\ln \frac{A}{4 \hbar G / c^3}\right)$$

**Conclusion 1:** Strands, through their extension, imply **black hole entropy**, energy, temperature – and evaporation: strands detach.

**Conclusion 2:** Strands thus imply **pure general relativity**. (Jacobson 1995)

**Conclusion 3:** **Power**  $P \leq c^5 / 4G$ , **force**  $F \leq c^4 / 4G$  etc., no singularities, no negative energy regions, no wormholes, no black hole hair, no torsion, no time-like loops, no running of  $G$ , no new observable quantum gravity effects.

## Strand Conjecture

- ❖ Summary
- ❖ Challenge
- ❖ Fundamental principle
- ❖ **Black hole entropy**
- ❖ Black hole rotation
- ❖ Everything strands
- ❖ Wave functions
- ❖ Dirac's equation
- ❖ Lepton spin
- ❖ Fermion behaviour
- ❖ Particle spectrum
- ❖ Interactions
- ❖ Gauge groups
- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material

# *Black Holes Can Rotate*

## Strand Conjecture

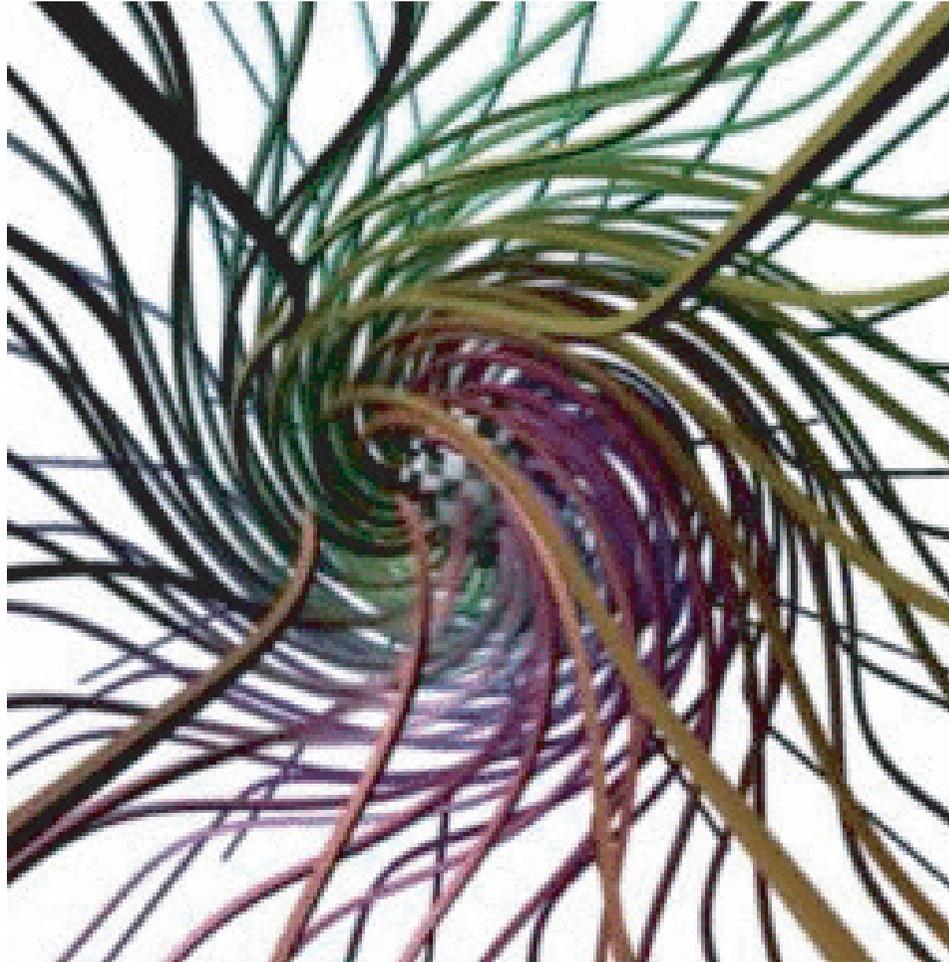
- ❖ Summary
- ❖ Challenge
- ❖ Fundamental principle
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- ❖ **Black hole rotation**
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- ❖ Interactions
- ❖ Gauge groups
- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material



© Jason Hise.

Strands are not observable, only crossing switches are.  
Black holes have a finite moment of inertia; mass is distributed over the horizon.

# A Planck-Scale Model of Almost Everything

**Thesis:** Nature is a wobbly criss-crossing strand woven into the night sky.  
**The universe plays cat's cradle. (Hexensp(i)el/jeu de ficelle/ripiglino)**

## Strand Conjecture

- ❖ Summary
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- ❖ Black hole rotation
- ❖ **Everything strands**
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- ❖ Dirac's equation
- ❖ Lepton spin
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- ❖ Particle spectrum
- ❖ Interactions
- ❖ Gauge groups
- ❖ Predictions

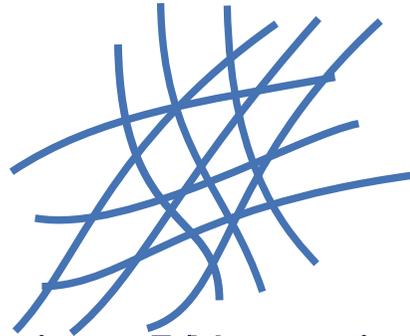
## Coupling Constants

## Mass

## Conclusion

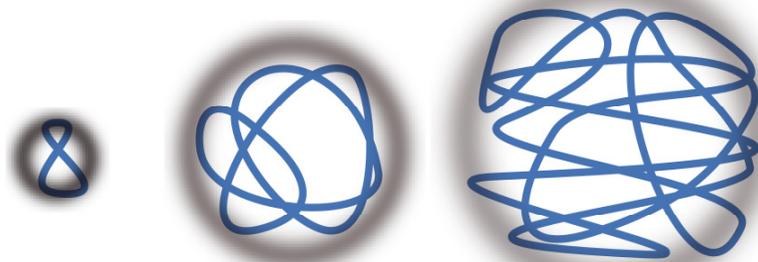
## Bonus Material

### Flat vacuum (not "foam"):



Predictions:  $E/V=0$ , unique, "emergent" and Lorentz-invariant vacuum, 3d.

**Cosmology:** the universe is one loop continuously increasing in complexity:



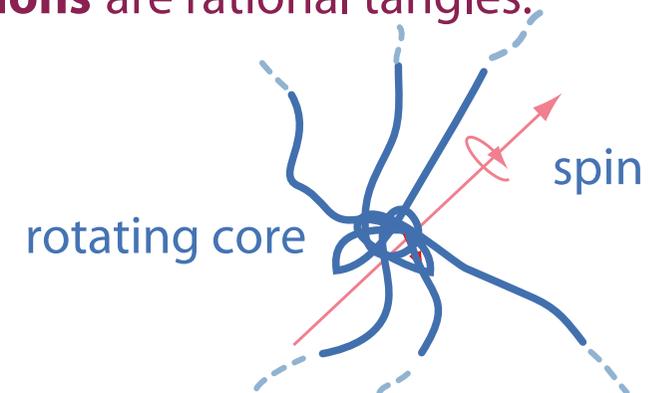
Predicts: horizon, baryon density, no new dark matter, no inflation, more ...

### Curved vacuum:



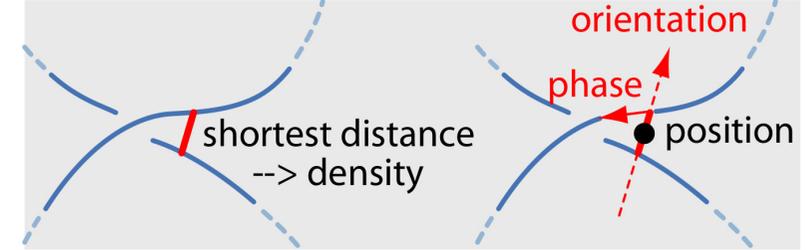
Predictions: pure general relativity, gravitons hard to detect,  $P < c^5/4G$ .

**Fermions** are rational tangles:



Predicts: Dirac equation, least action, particle spectrum, gauge interactions.

# Wave Functions



## Strand Conjecture

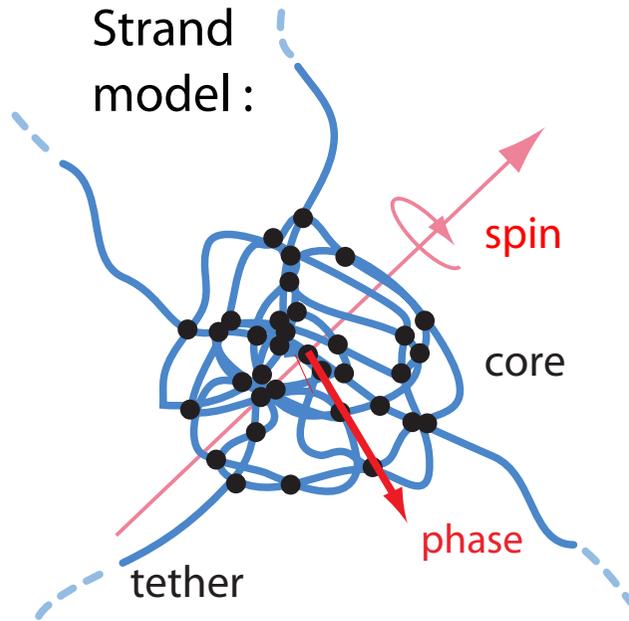
- ❖ Summary
- ❖ Challenge
- ❖ Fundamental principle
- ❖ Black hole entropy
- ❖ Black hole rotation
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- ❖ Dirac's equation
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- ❖ Particle spectrum
- ❖ Interactions
- ❖ Gauge groups
- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

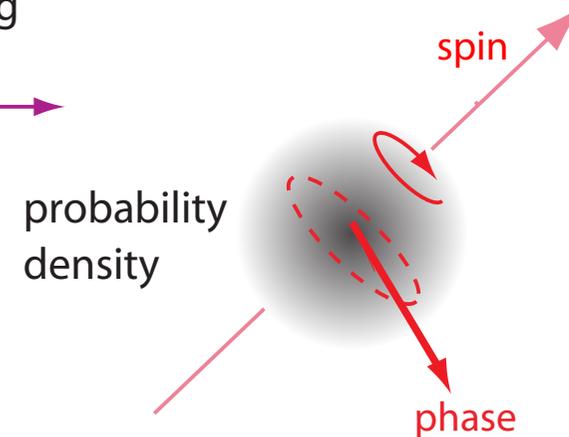
## Bonus Material



time average  
of crossing  
switches



Observation :



**Thesis:** The **wave function** is the averaged **crossing density** of a tangle.

**Free particles are spinning cores, i.e., spinning arrows** (cf. Feynman, *QED*).

The **phase** is the averaged **phase density** of a tangle.

The **spin axis** is the averaged **crossing orientation** of a tangle.

The **probability density** is the averaged **crossing switch density**.

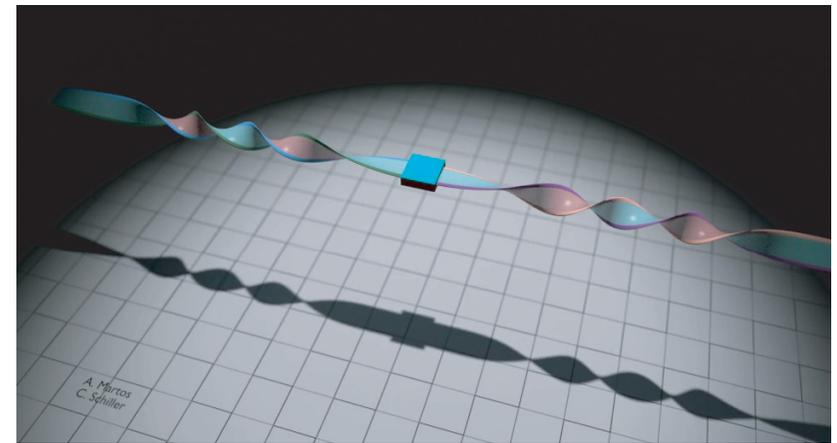
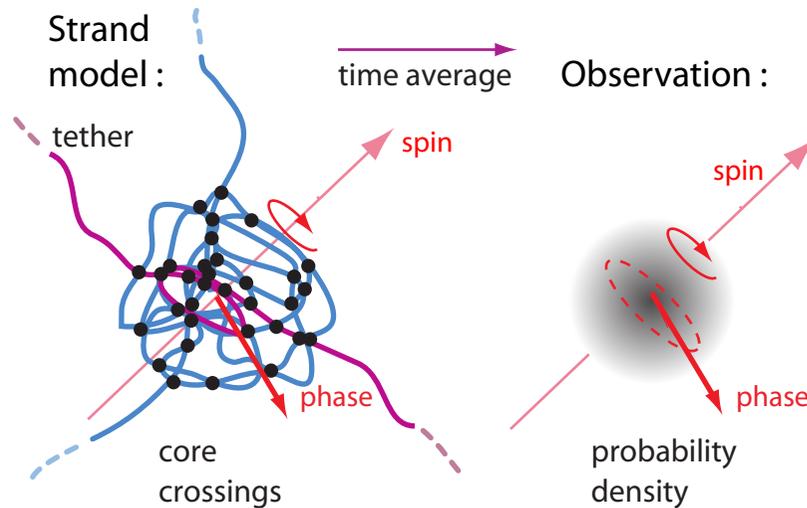
Superpositions, interference, Hilbert spaces and entanglement arise.

**Heisenberg's uncertainty** relations hold.

Localized wave functions spread out over time.

**Decoherence** occurs. There is no hidden variable problem.

# Spin 1/2, the Belt Trick and Dirac's Equation



Free particles (spinors) are (blurred) spinning tangle cores.

**Dirac's belt trick** allows continuous (tethered) rotation (see film © by Antonio Martos).

**Spin** is rotation; spin value is due to strand number and tangle details.

**Antiparticles** are mirror tangles with opposite belt trick.

**Particle momentum and energy** are core wavelength and rotation frequency.

**Quantum phase** is 1/2 of the orientation angle of the tangle core.

The **wave function** is the time-averaged ("blurred") tangle crossing density.

Maximum speed  $c$  and minimum action  $\hbar$  hold.

Strands imply the free **Dirac equation**  $i\hbar\gamma^\mu\partial_\mu\psi = mc\psi$  and its propagator.

(Battey-Pratt and Racey 1980) **Dirac's equation comes from Dirac's trick.**

The **principle of least action** ("cosmic laziness") is the *principle of fewest crossing switches*.

## Strand Conjecture

- ❖ Summary
- ❖ Challenge
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- ❖ Black hole rotation
- ❖ Everything strands
- ❖ Wave functions

## ❖ Dirac's equation

- ❖ Lepton spin
- ❖ Fermion behaviour
- ❖ Particle spectrum
- ❖ Interactions
- ❖ Gauge groups
- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material

# The Spin of Electrons and Other Leptons

## Strand Conjecture

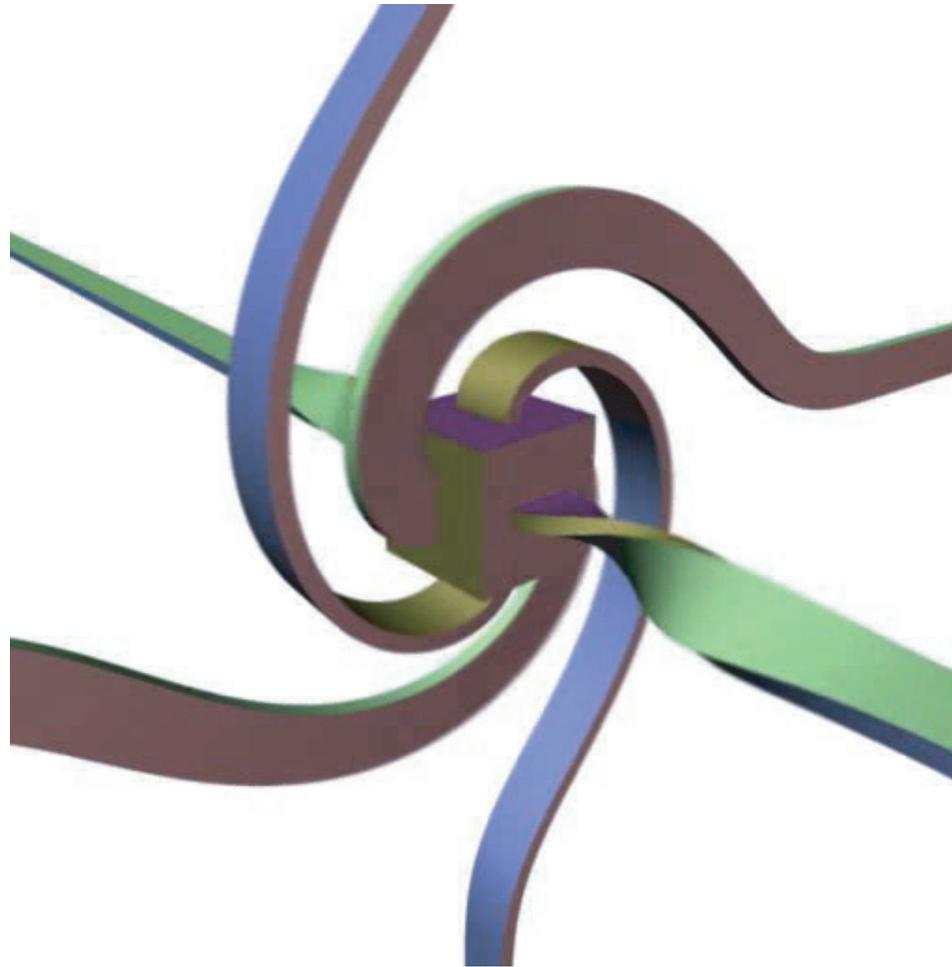
- ❖ Summary
- ❖ Challenge
- ❖ Fundamental principle
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- ❖ Black hole rotation
- ❖ Everything strands
- ❖ Wave functions
- ❖ Dirac's equation
- ❖ **Lepton spin**
- ❖ Fermion behaviour
- ❖ Particle spectrum
- ❖ Interactions
- ❖ Gauge groups
- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material



The cubic belt buckle represents the lepton tangle core.

**In short: A particle is a rotating space defect.**

A particle resembles a rotating piece of space.

© Jason Hise

# Fermion Behaviour – And Spin-Statistics

## Strand Conjecture

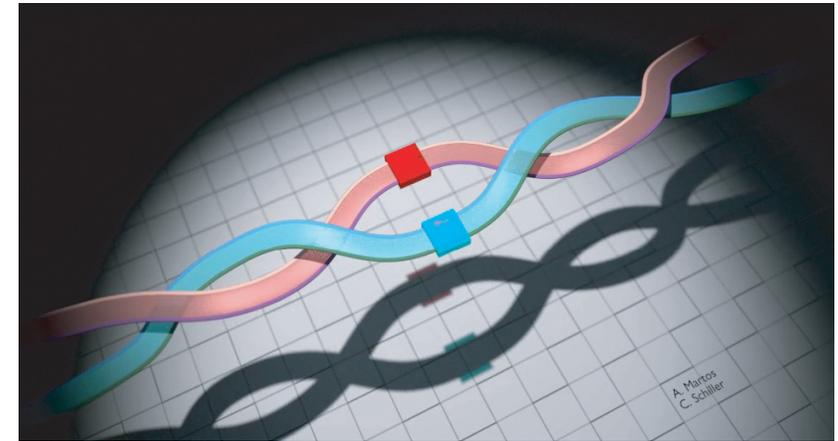
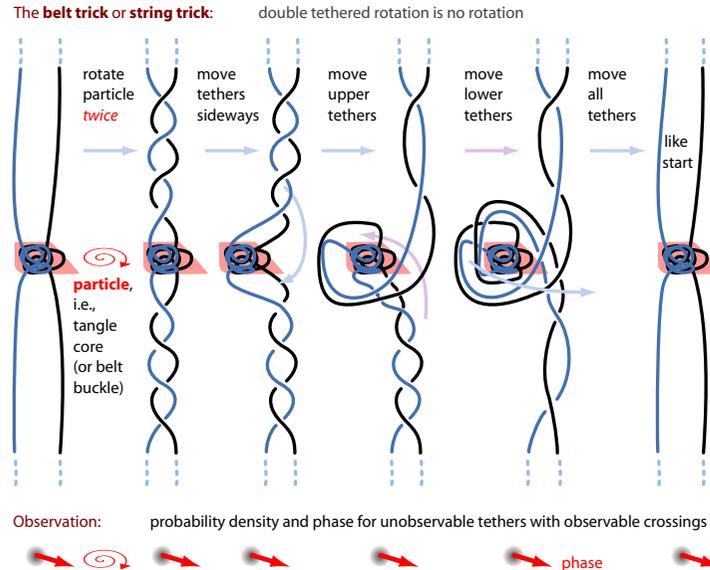
- ❖ Summary
- ❖ Challenge
- ❖ Fundamental principle
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- ❖ Black hole rotation
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- ❖ Dirac's equation
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- ❖ Gauge groups
- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material



Left: Tethered (“extended”) particles behave as *spin 1/2 particles*: double rotation is the same as no rotation.

Right: Tethered (“extended”) particles behave as *fermions*: double exchange is the same as no exchange (film © by Antonio Martos).

## Conclusions about extension:

**It yields all quantum effects & quantum numbers**, masses and mixings.

**Quantum theory and the Dirac equation are valid** up to Planck energy.

**Masses of elementary particles are small:**  $m \ll m_{\text{Pl}}$ .

**Mass is calculable: complex** tangles have **large** mass. A tough problem: we need to estimate the number of crossing switches per belt trick per time.

# Particles Are Rational (Unknotted) Tangles

Elementary particles are tangles made of 1, 2 or 3 strands.

Massive particles are infinite tangle families (add Higgs braids repeatedly):

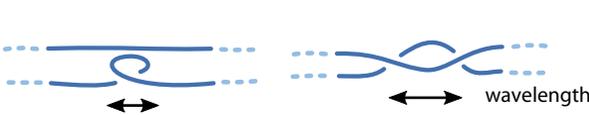
**Photon** (1 strand)



**Gluons** (3 strands)



**W<sub>1</sub>, W<sub>2</sub>, W<sub>3</sub>** (2 strands +1 more from Higgs mech.)



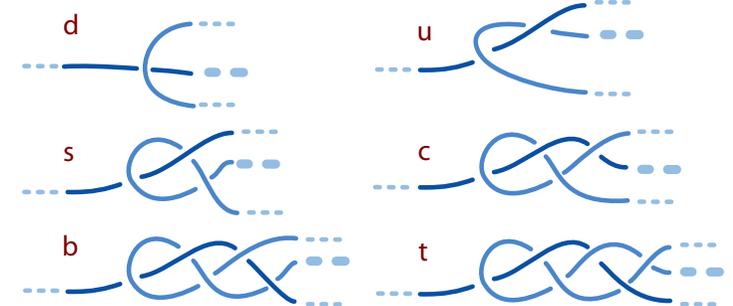
**Higgs boson** (braid of 3 strands)



**Graviton** (2 strands)

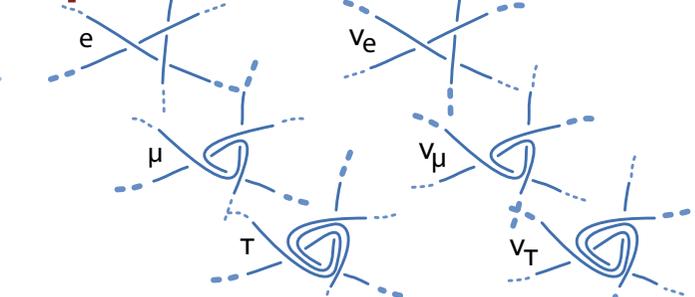


**Quarks** (2 strands, never free)



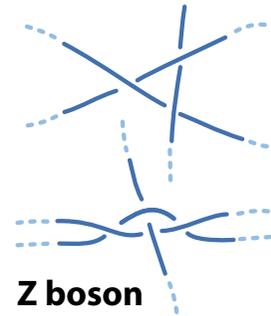
Imply quark model, 3 generations, CP-violating hadrons.

**Leptons** (3 strands)



Imply massive Dirac neutrinos with normal order; tangles tentative.

**W boson**



**Z boson**

(small mistakes possible ...)

**Predictions: No other particles and defects exist.**

Mass ratios (e.g., W/Higgs) and mass value estimates are possible. Crude so far, but compatible with measurements.

## Strand Conjecture

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- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material

# Interactions Are Tangle Core Deformations

## Strand Conjecture

- ❖ Summary
- ❖ Challenge
- ❖ Fundamental principle
- ❖ Black hole entropy
- ❖ Black hole rotation
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- ❖ Wave functions
- ❖ Dirac's equation
- ❖ Lepton spin
- ❖ Fermion behaviour
- ❖ Particle spectrum

## ❖ Interactions

- ❖ Gauge groups
- ❖ Predictions

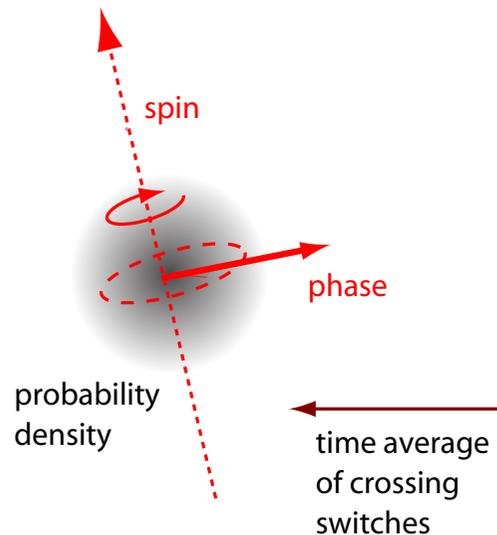
## Coupling Constants

## Mass

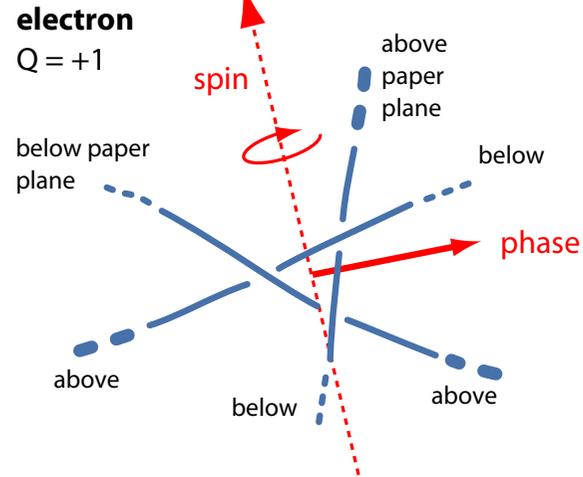
## Conclusion

## Bonus Material

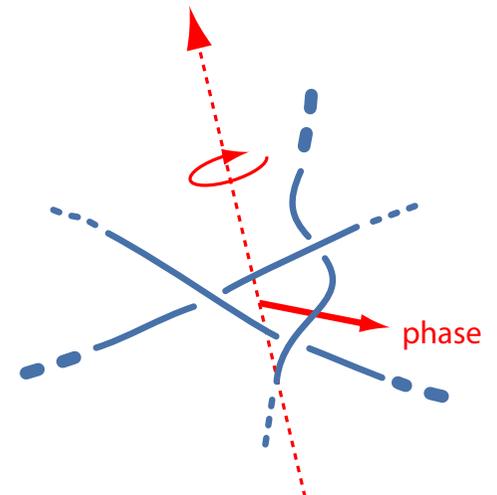
Observation:



Tangle model:



A deformation:



**Free propagating particles are rotating arrows, thus rotating cores:**

Core rotation axis  $\rightarrow$  spin axis

Core orientation  $\rightarrow$  phase of wave function

Tail deformations with rigid core  $\rightarrow$  space-time symmetries

**Interacting fermions are cores being deformed:**

Core deformations change the phase and form gauge groups.

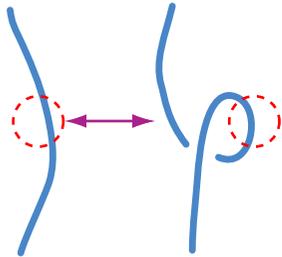
Freedom in the definition of phase  $\rightarrow$  freedom of gauge choice.

**Surprise:** All observable deformations can be built from 3 basic types.

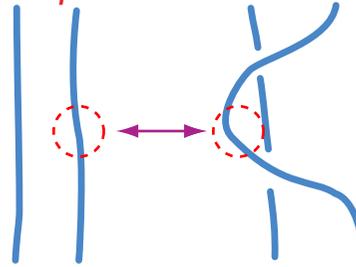
# Reidemeister Moves Yield Gauge Interactions

Every tangle core deformation is built from **three basic types**: (Reidemeister 1926)

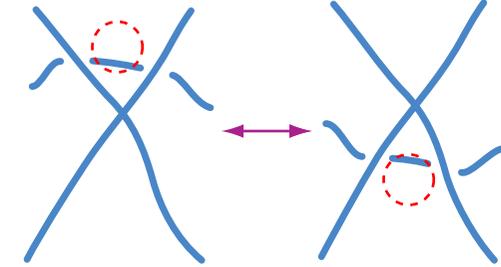
Reidemeister move I  
or *twist*



Reidemeister move II  
or *poke*



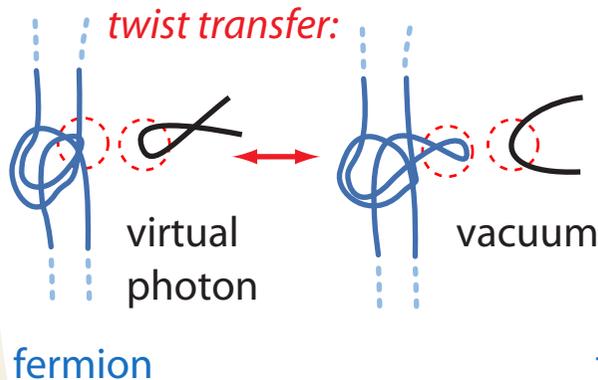
Reidemeister move III  
or *slide*



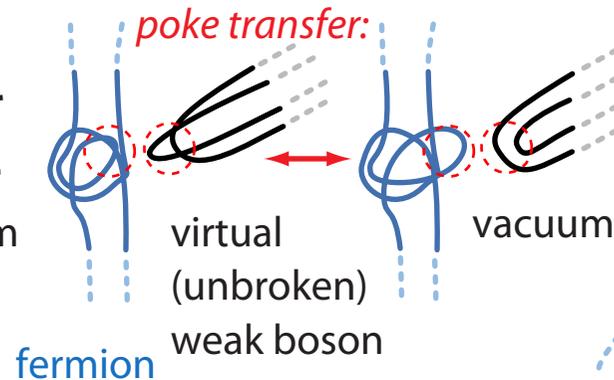
Twist generate **U(1)**, pokes generate **SU(2)**, parity violation and symmetry breaking, while slides generate **SU(3)**. (Schiller 2009, 2019)

**Conclusion: Interactions are (statistical) crossing transfers:**

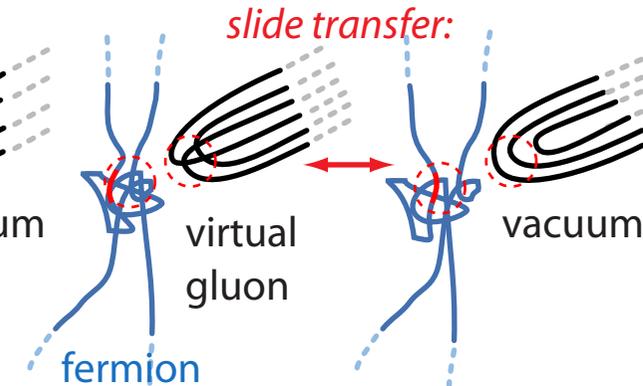
Electromagnetic interaction is



Weak interaction is



Strong interaction is



## Strand Conjecture

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- ❖ Gauge groups
- ❖ Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material

# Predictions – Beyond The Standard Model

## Strand Conjecture

- ❖ Summary
- ❖ Challenge
- ❖ Fundamental principle
- ❖ Black hole entropy
- ❖ Black hole rotation
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- ❖ Gauge groups

## Predictions

## Coupling Constants

## Mass

## Conclusion

## Bonus Material



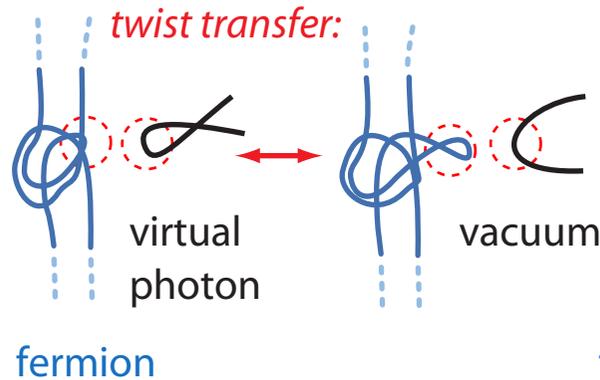
- **3 gauge interactions. Only. They are fundamental. No GUT.**
  - **3 dimensions. No supersymmetry. No non-commutative space.**
  - **3 generations. No new particles. A desert. No unknown dark matter.** No axions, no WIMPS, no sterile neutrinos.
  - **No measurable deviations from the standard model.** Only known Feynman diagrams. Scattering amplitudes, running,  $g - 2$ , and electric dipole moments are as predicted. No proton decay. No baryon number violation. CPT holds. **Dirac neutrinos with normal mass order.**
  - A different view on renormalization and non-perturbative QFT appears.
  - Planck length and Planck time are the smallest measurable intervals. Planck momentum and energy are the highest measurable values for elementary particles.  $c^4/4G$  and  $c^5/4G$  are maximum force and luminosity. Maximum values for electric fields  $E_{\max} = c^4/4Ge \approx 2.4 \cdot 10^{61}$  V/m, magnetic fields  $B_{\max} = c^3/4Ge \approx 8 \cdot 10^{52}$  T, strong and weak fields exist.
  - **No deviation *from* and no physics *beyond* the standard model.**
- And
- **Masses, mixing angles and coupling constants can be calculated.**

# Coupling Constants in the Tangle Model

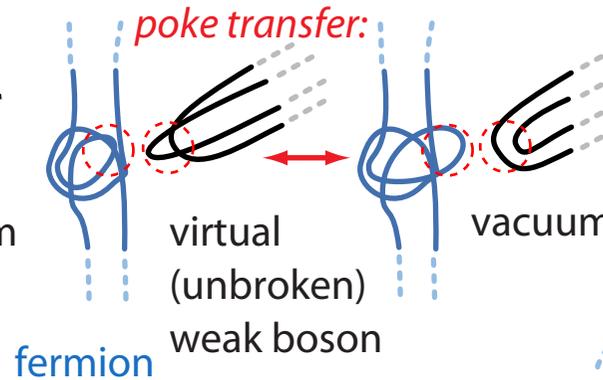
The coupling constants describe the strengths of the interactions: they specify the **average phase change** that a boson induces in a charged particle.

In the tangle model, coupling constants describe the effect of a **boson tangle** on the phase of a **charged tangle core**:

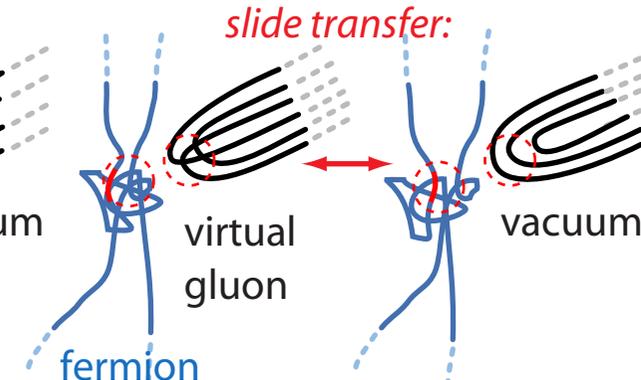
Electromagnetic interaction is



Weak interaction is



Strong interaction is



Consequences:

- QFT is valid, all Feynman diagrams arise, coupling constants **run with energy**.
- The couplings are **not free** parameters, but **fixed** numbers.
- The couplings are **larger than zero** and **smaller than one**. **So is their sum**.
- The couplings are **constant** over time and space.
- The couplings are **equal** for *different* particles with the *same* charge.

**Thesis:** Transfers explain the values of the coupling constants.

Strand Conjecture

Coupling Constants

❖ Strand processes

❖ Electric charge

❖ Spinning electron

❖ Modelling  $\alpha$

❖ Estimating  $\alpha$

Mass

Conclusion

Bonus Material

# The Electric Charge Unit

Strand Conjecture

Coupling Constants

❖ Strand processes

❖ **Electric charge**

❖ Spinning electron

❖ Modelling  $\alpha$

❖ Estimating  $\alpha$

Mass

Conclusion

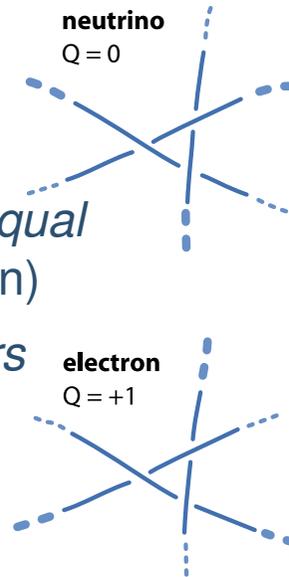
Bonus Material

**A particle is electrically charged if it changes phase in a preferred way when absorbing random photons.**

This yields:

**Neutral particle:** **topologically achiral** tangle core (closed core is *equal* to its mirror image in the minimal crossing projection)

**Charged particle:** **topologically chiral** tangle core (closed core *differs* from its mirror image in the minimal projection)



Consistency check:

- $\nu_e, \nu_\mu, \nu_\tau, Z, \text{Higgs}, \gamma, \text{gluons and graviton}$  are neutral.
- $\text{electron}, \mu, \tau, \text{quarks and } W$  are charged.

**Conclusion 1:** The electric charge unit  $e$  is due to 3 crossings of same sign.

**Conclusion 2:** Quantum electrodynamics is the **rotation of crossings** due to photon (i.e., twist) absorption or emission.

**Conclusion 3:** All measurements are electromagnetic.  
This explains the fundamental principle.

# A Glimpse of a Spinning Electron

## Strand Conjecture

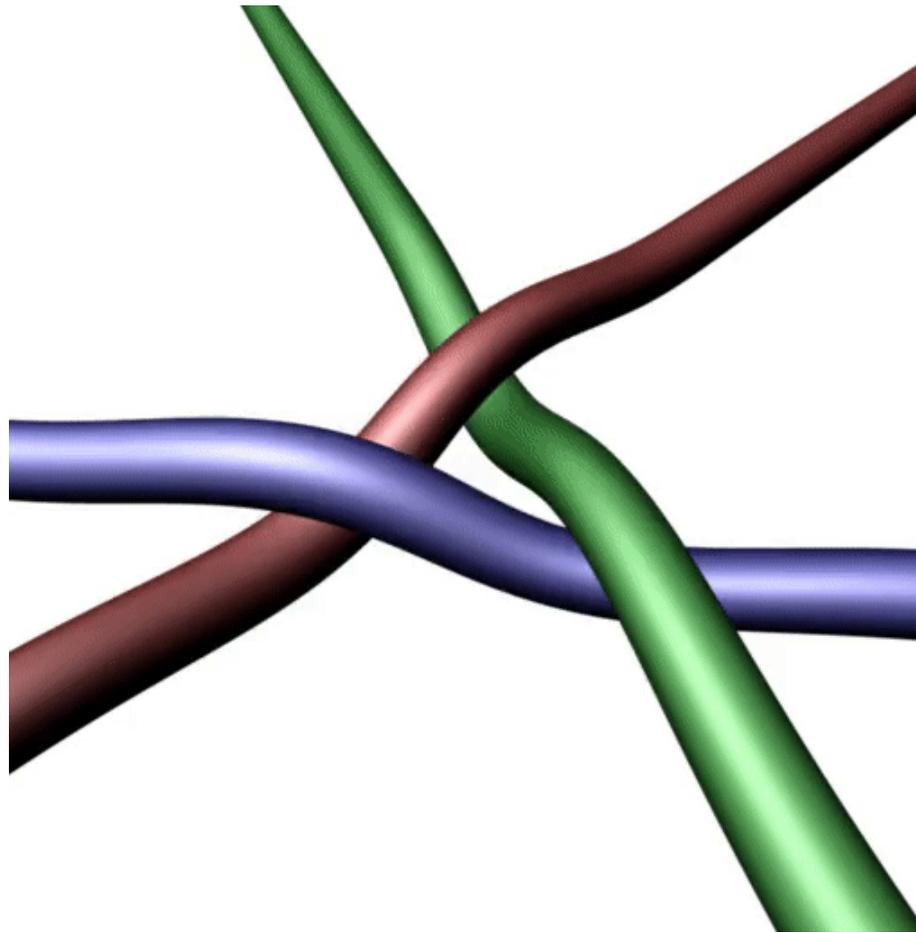
### Coupling Constants

- ❖ Strand processes
- ❖ Electric charge
- ❖ **Spinning electron**
- ❖ Modelling  $\alpha$
- ❖ Estimating  $\alpha$

### Mass

### Conclusion

### Bonus Material



© Jason Hise.

Errors in the animation: missing fluctuations; strand ends should go along the coordinate axes; strands should have constant radius.

# Modelling the Fine Structure Constant

Strand Conjecture

Coupling Constants

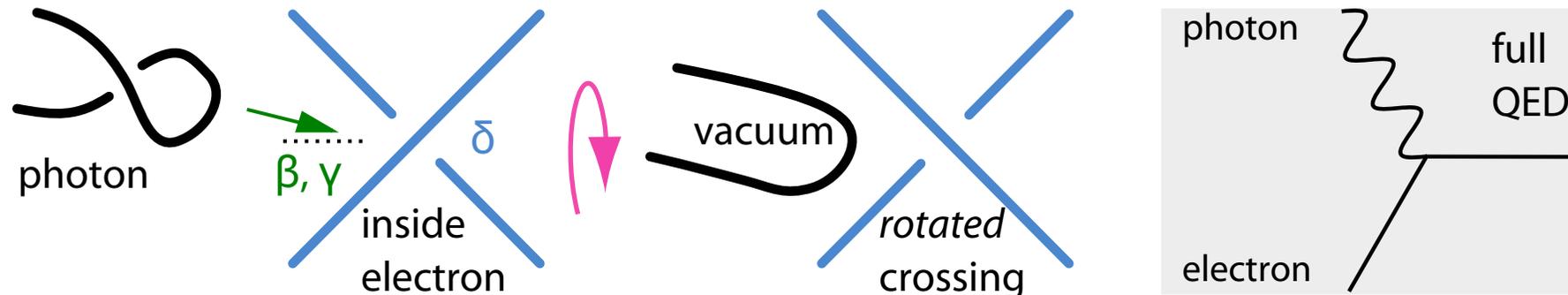
- ❖ Strand processes
- ❖ Electric charge
- ❖ Spinning electron
- ❖ **Modelling  $\alpha$**
- ❖ Estimating  $\alpha$

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**Thesis:** At the Planck scale, **QED** is the rotation of a crossing in a charged fermion by photon absorption (or emission):



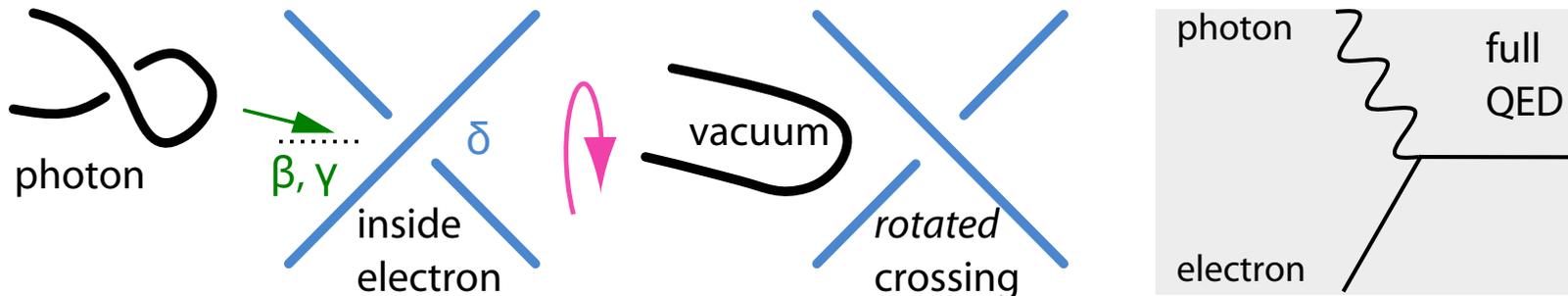
This “QED mechanism” explains the fundamental principle. It explains why only crossing switches are observable. And it allows estimating the fine structure constant  $\alpha$ .

Absorption under **ideal** incidence, polarization, phase and strand configuration:  
a **complete** crossing switch.

Absorption under **non-ideal** configuration:  
a **partial** crossing switch.

The trigonometric approximation:  
the **switching efficiency** is a function of  $\cos \beta$ ,  $\cos \gamma$  and  $\delta$ .

# Estimating the Fine Structure Constant



Using

- Three crossings to model the unit charge  $e$ ,
  - An average over the photon polarization and phase,
  - An average over the two incidence angles  $\beta, \gamma$  of the photon,
  - An average over strand crossing configuration angle  $\delta$ ,
  - A squaring for the two tails and a further squaring for the probability amplitude,
- yields the trigonometric approximation (Schiller 2019)

$$\sqrt{\alpha} \approx \frac{3}{\pi} \int_{\delta=0}^{\pi} \int_{\gamma=-\delta/2}^{\delta/2} \int_{\beta=-\pi/2}^{\pi/2} f(\beta, \gamma, \delta) d\beta d\gamma d\delta \approx 0.1 \pm 0.03 .$$

This is in the range of the experimental value  $\sqrt{1/137.0359992...} \approx 0.085$  at low energy and of the predicted value  $\sqrt{1/109} \approx 0.096$  at Planck energy.

**Summary:** An extremely crude, but an ab initio estimate. (The first?)  
The Planck scale tangle model for QED is promising.

Strand Conjecture

Coupling Constants

❖ Strand processes

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# Particle Masses Are Pure Numbers

At first sight, it seems that elementary particle masses are not pure numbers, but physical quantities with a unit, namely kilogram.

But: There is a natural unit of mass, given by the **Planck mass**

$$m_{\text{Pl}} = \sqrt{\frac{\hbar c}{G}} \approx 21 \mu\text{g} .$$

Now take the ratio between the particle mass and the Planck mass  $m_{\text{Pl}}$ , and you get a pure number that describes the particle mass.

For elementary particles, the mass numbers are small. For the electron, the pure number that describes its mass is of the order of  $10^{-23}$ .

**The strand conjecture explains the *smallness* of the mass numbers by the *low probability of the spontaneous belt trick*.** The conjecture also explains the *equality* of particle and anti-particle mass: mirror tangles have the same mass.

Retrodiction: ***more complex tangles have higher mass***. This agrees with all observations (with one understandable exception).

Prediction: **(heavy) neutrinos are Dirac fermions with normal mass order.**

Strand Conjecture

Coupling Constants

Mass

❖ Mass values

❖ Lepton masses

Conclusion

Bonus Material

# Estimating Lepton Masses

Strand Conjecture

Coupling Constants

Mass

❖ Mass values

❖ **Lepton masses**

Conclusion

Bonus Material

- The **shape** of the core, its three tethers, and
  - The required **tether length** during the belt trick
- yield an estimate for lepton masses (Schiller 2021)

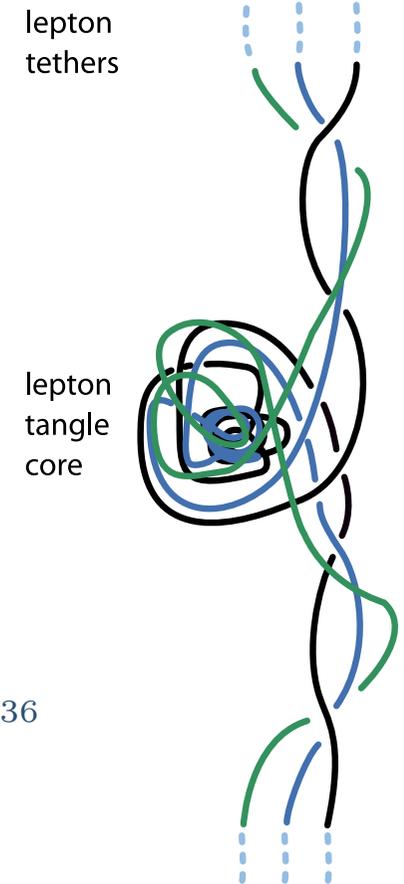
$$(e^{-12})^6 \cdot 2 \cdot 2/100 \lesssim \frac{m_{\text{lepton}}}{\sqrt{\hbar c/4G}} \lesssim (e^{-14})^6 \cdot 2 \cdot 4^{36}$$

or equivalently

$$10 \mu\text{eV} \lesssim m_{\text{lepton}} \lesssim 20 \text{TeV} .$$

The range includes the observed mass values, for neutrinos, the electron, the muon and the tau lepton. A lower limit for the neutrino masses arises.

**Summary:** A disappointing, but an ab initio estimate. (The first?)  
The Planck scale tangle model for QED remains promising.



# Summary and Outlook

Strand Conjecture

Coupling Constants

Mass

Conclusion

**❖ Outlook**

Bonus Material

**Thesis:** Physics and observations are due to fluctuating strands.

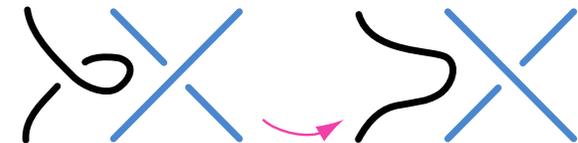
From the fundamental principle that Planck units are due to crossing switches of strands, we seem to get:



**The standard model (forces, particles, Lagrangian) is final.**

**General relativity (Lagrangian) is final.** (At least at sub-galactic scales.)

Approximating quantum electrodynamics using a trigonometric angle dependence,



**Strands imply a value for the fine structure constant that is compatible with experiment.** True also for the two nuclear coupling constants, and for lepton masses. Better estimates (and cosmological predictions) are in work.

**Thank you.**

- Publication and explanations at [www.motionmountain.net/research](http://www.motionmountain.net/research).
- Detailed predictions and a bet at [www.motionmountain.net/bet](http://www.motionmountain.net/bet).
- Thanks to Antonio Martos and Jason Hise for their animations, also available at [www.motionmountain.net/videos](http://www.motionmountain.net/videos).

# Dirac Wrote About His Trick Only Once ...

Strand Conjecture

Coupling Constants

Mass

Conclusion

Bonus Material

❖ Dirac on his trick

❖ Universal gravity

❖ 3 generations

❖ Electrons and positrons

❖ U(1) and SU(2)

❖ SU(3)

❖ Standard model

❖ SM Lagrangian 1

❖ SM Lagrangian 2

❖ Fascination

❖ References

❖ Non-rational tangles

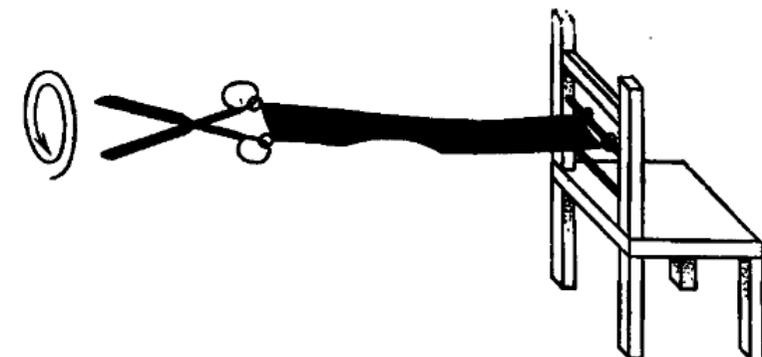
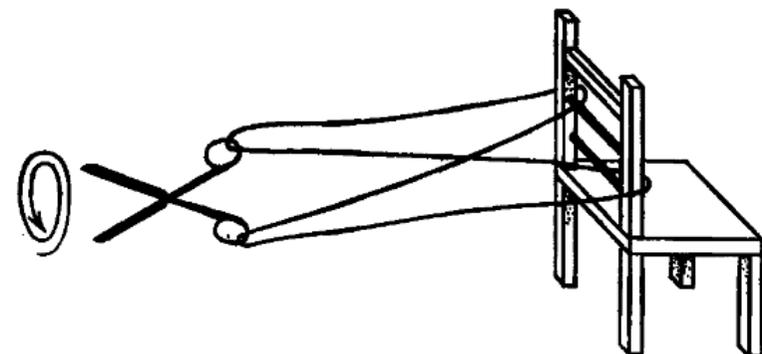
❖ Fun

Dear Mr. Gardner:

I am sorry I was too busy to answer your letter earlier. I first thought of the problem of the strings about 1929. I used it to illustrate a property of rotations, that two rotations of a body about an axis can be continuously deformed, through a set of motions which each end up with the original position, into no motion at all.

It is a consequence of this property of rotations that a spinning body can have half a quantum of angular momentum, but cannot have any other fraction of a quantum.

Yours sincerely  
P.A.M. Dirac



Left: from Martin Gardner, *Riddles of the Sphinx and Other Mathematical Puzzle Tales*, Mathematical Association of America (1987), page 47.

Right: from R. Penrose (one of Dirac's students) and W. Rindler, *Spinors and space-time*, vol. I (1984). See also M.H.A. Newman, *On a String Problem of Dirac*, *Journal of the London Mathematical Society* s1-17(3) (1942) 173–177.

# Universal Gravitation from Gravitons

Strand Conjecture

Coupling Constants

Mass

Conclusion

Bonus Material

❖ Dirac on his trick

❖ **Universal gravity**

❖ 3 generations

❖ Electrons and positrons

❖ U(1) and SU(2)

❖ SU(3)

❖ Standard model

❖ SM Lagrangian 1

❖ SM Lagrangian 2

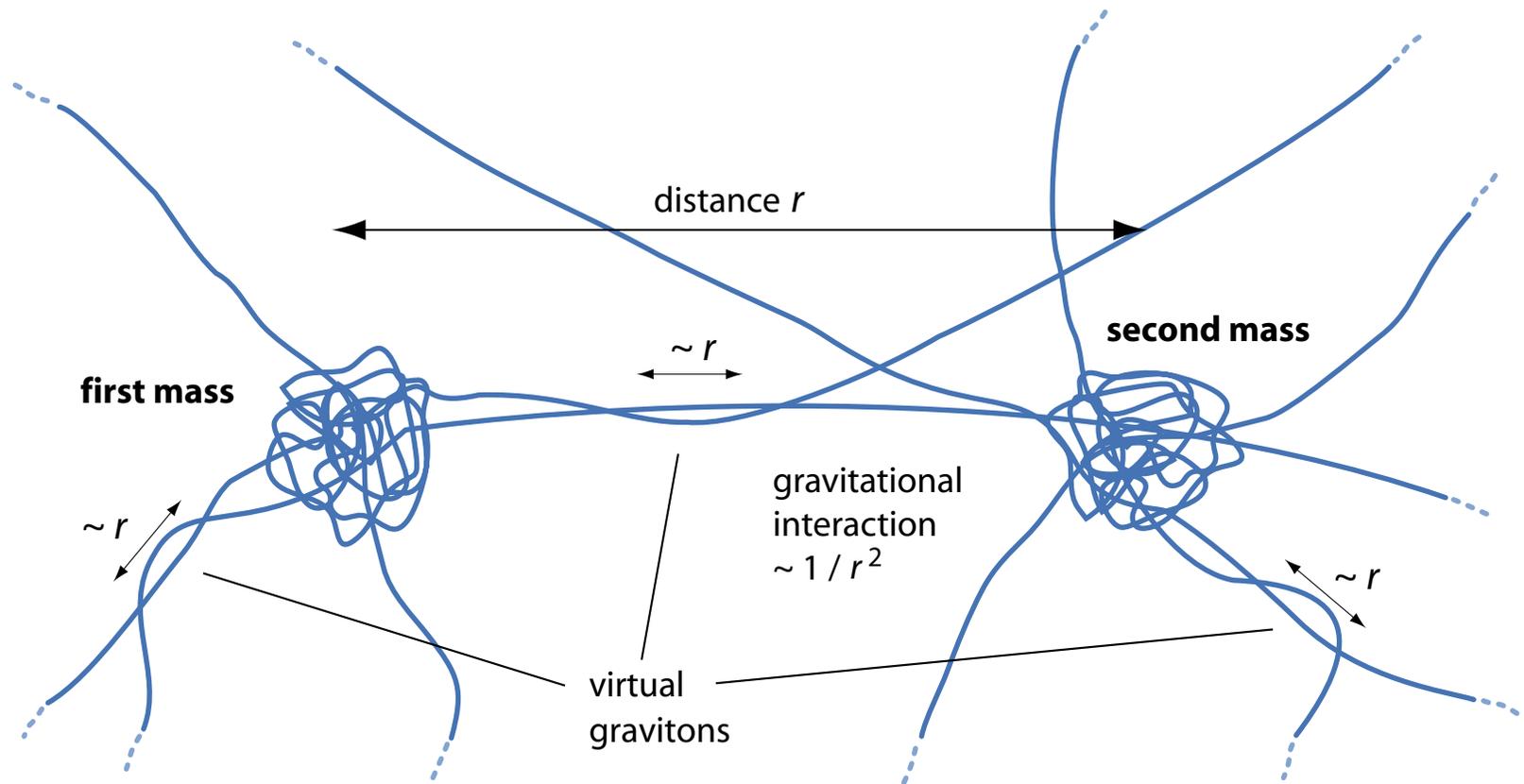
❖ Fascination

❖ References

❖ Non-rational tangles

❖ Fun

The strand conjecture for **universal  $1/r^2$  gravity**



# 6 Quarks

## 3 Generations:

The origin in the case of quarks

Observation:

Strand Conjecture

Coupling Constants

Mass

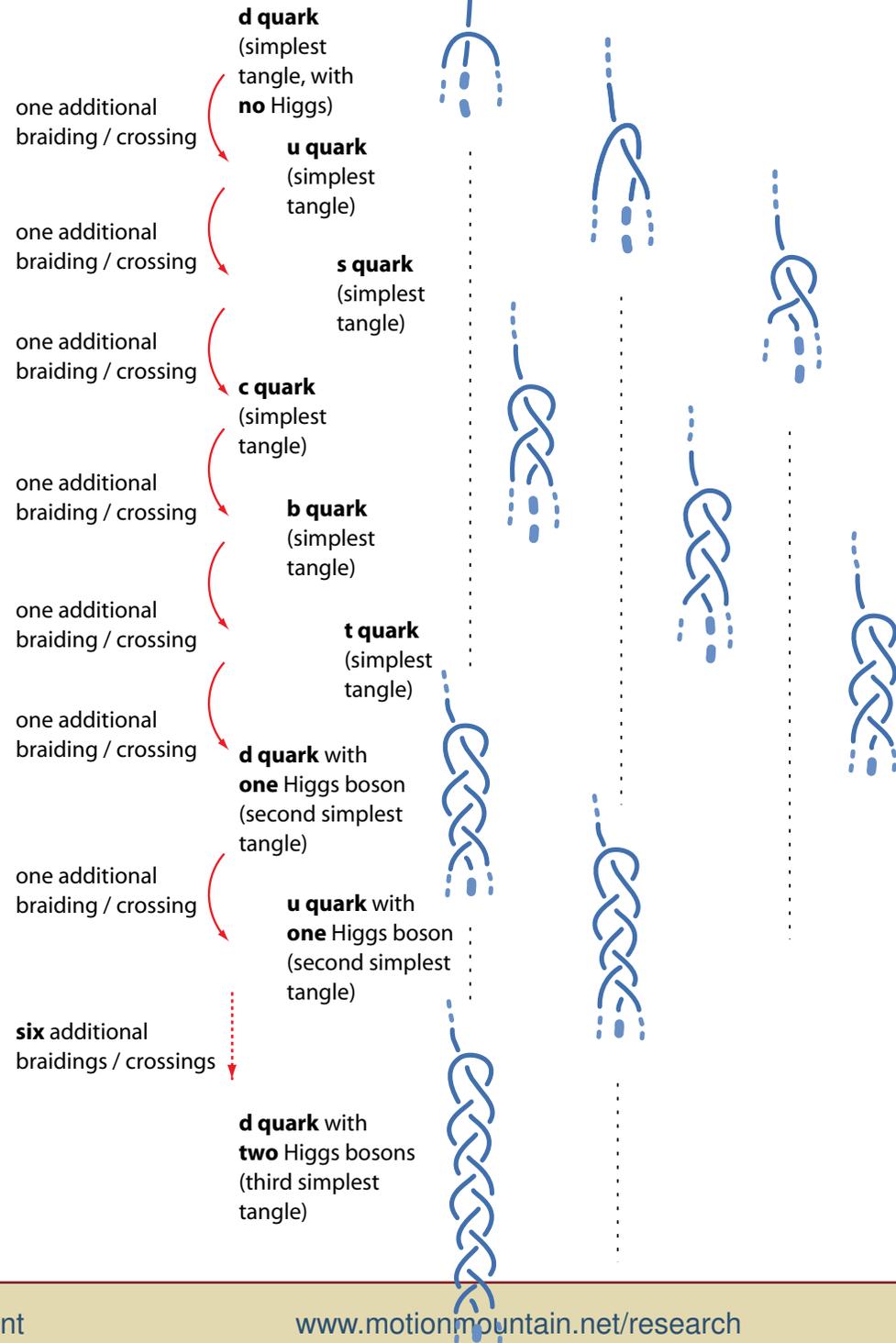
Conclusion

Bonus Material

- ❖ Dirac on his trick
- ❖ Universal gravity

❖ 3 generations

- ❖ Electrons and positrons
- ❖ U(1) and SU(2)
- ❖ SU(3)
- ❖ Standard model
- ❖ SM Lagrangian 1
- ❖ SM Lagrangian 2
- ❖ Fascination
- ❖ References
- ❖ Non-rational tangles
- ❖ Fun



# Electrons and Positrons (Antielectrons)

Strand Conjecture

Coupling Constants

Mass

Conclusion

Bonus Material

- ❖ Dirac on his trick
- ❖ Universal gravity
- ❖ 3 generations
- ❖ **Electrons and positrons**

❖ U(1) and SU(2)

❖ SU(3)

❖ Standard model

❖ SM Lagrangian 1

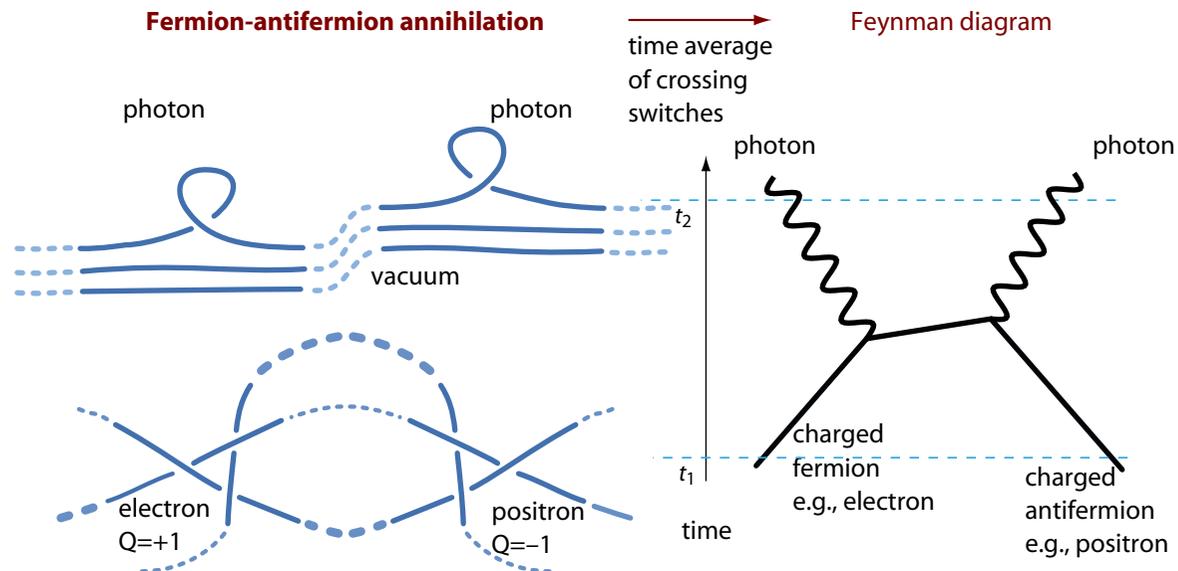
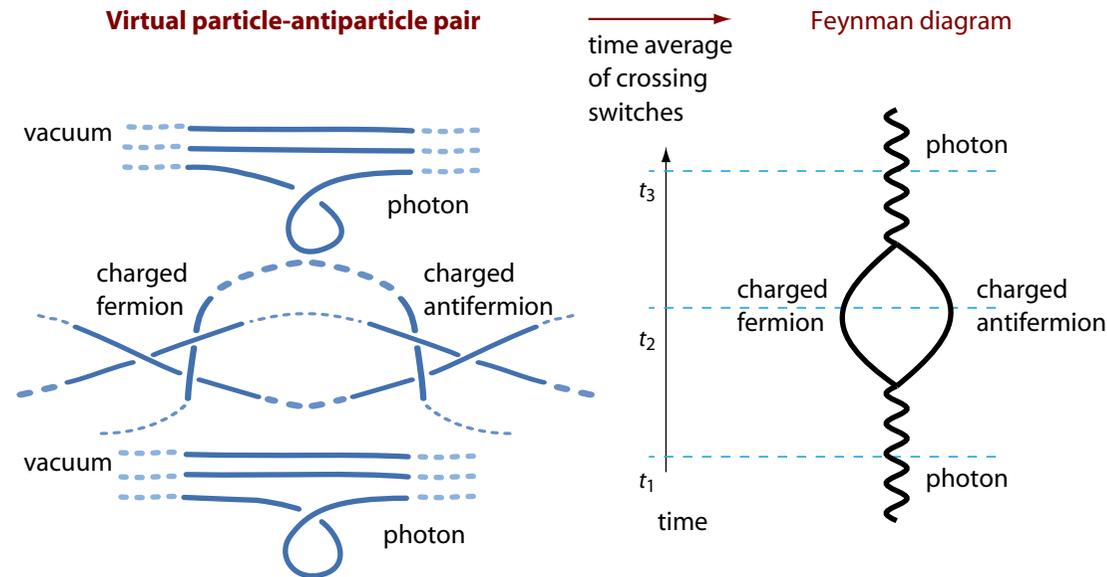
❖ SM Lagrangian 2

❖ Fascination

❖ References

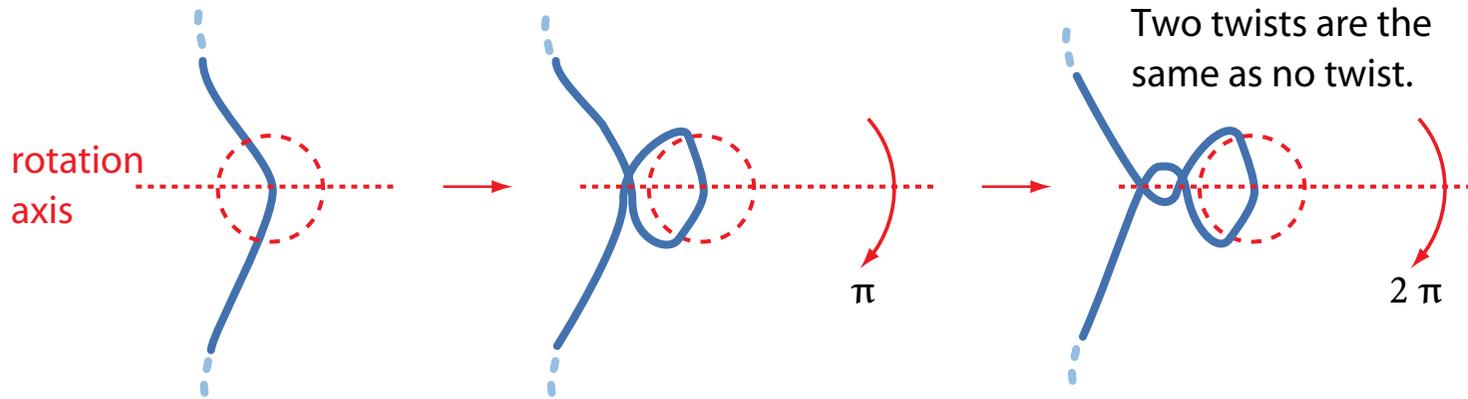
❖ Non-rational tangles

❖ Fun

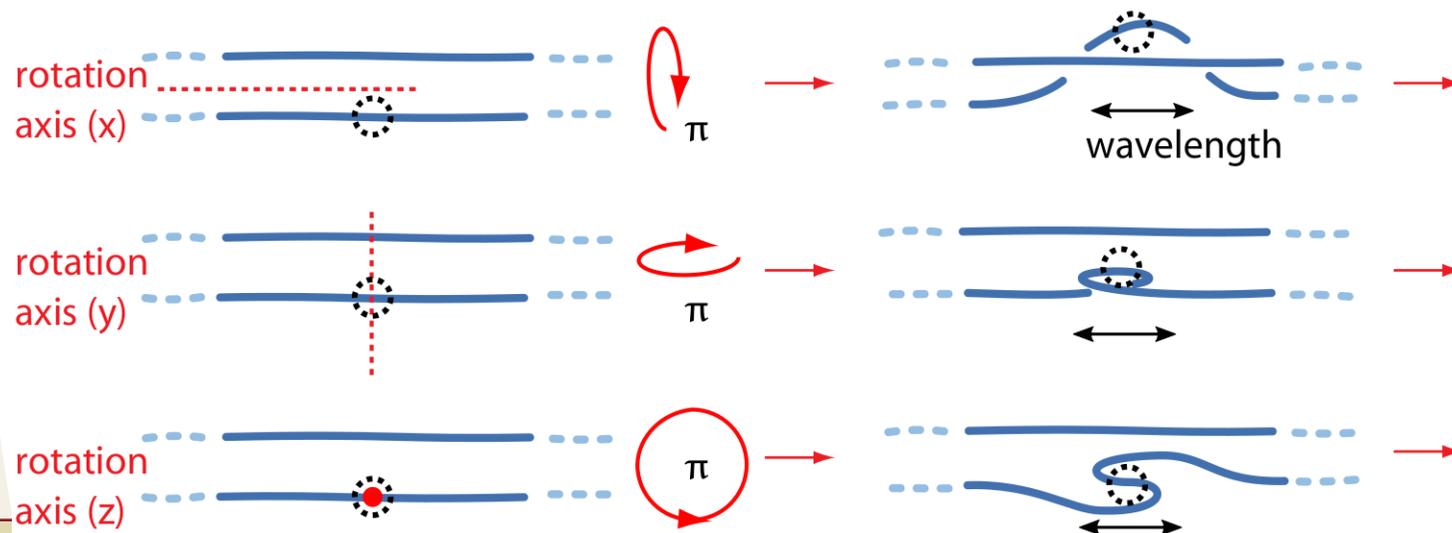


# The Origin of $U(1)$ and $SU(2)$

**Twists**, or first Reidemeister moves, on tangle cores or on single strands form a  **$U(1)$  Lie group**:



**Pokes**, or second Reidemeister moves, on tangle cores or on strands form an  $SU(2)$  Lie group, because the three rotations by  $\pi$  reproduce the  $SU(2)$  algebra of the belt trick:



Strand Conjecture

Coupling Constants

Mass

Conclusion

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- ❖ Dirac on his trick
- ❖ Universal gravity
- ❖ 3 generations
- ❖ Electrons and positrons

❖  **$U(1)$  and  $SU(2)$**

- ❖  $SU(3)$
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- ❖ SM Lagrangian 1
- ❖ SM Lagrangian 2
- ❖ Fascination
- ❖ References
- ❖ Non-rational tangles
- ❖ Fun

# The Origin of $SU(3)$

Strand Conjecture

Coupling Constants

Mass

Conclusion

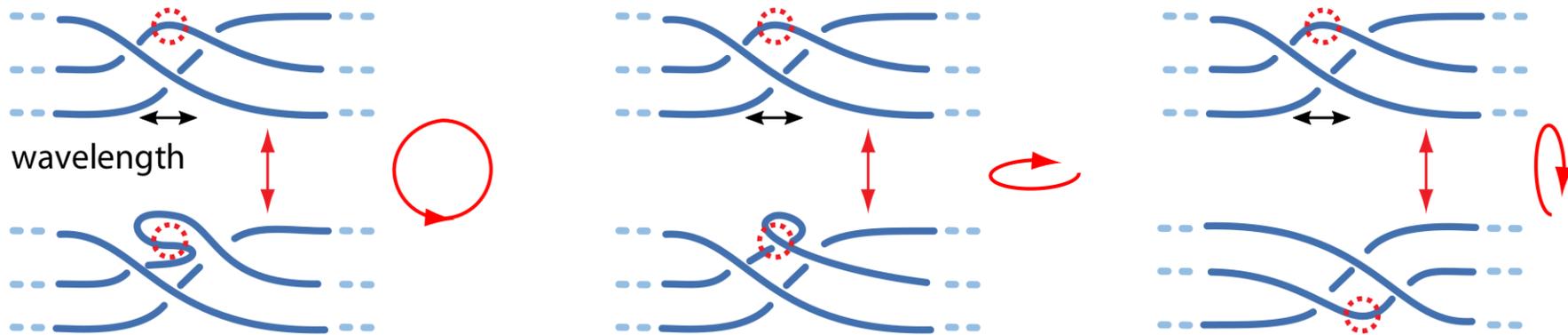
Bonus Material

- ❖ Dirac on his trick
- ❖ Universal gravity
- ❖ 3 generations
- ❖ Electrons and positrons
- ❖  $U(1)$  and  $SU(2)$

❖  **$SU(3)$**

- ❖ Standard model
- ❖ SM Lagrangian 1
- ❖ SM Lagrangian 2
- ❖ Fascination
- ❖ References
- ❖ Non-rational tangles
- ❖ Fun

**Slides**, or third Reidemeister moves, on tangle cores or on strands form a  $SU(3)$  Lie group. Here is one of its three  $SU(2)$  subgroups:



Of the nine rotations, only eight are linearly independent.

$SU(3)$  has three linear independent  $SU(2)$  subgroups.

Exploring the eight generators yields  $SU(3)$ . (Schiller 2009, 2019)

# Feynman Diagrams of the Standard Model

Strand Conjecture

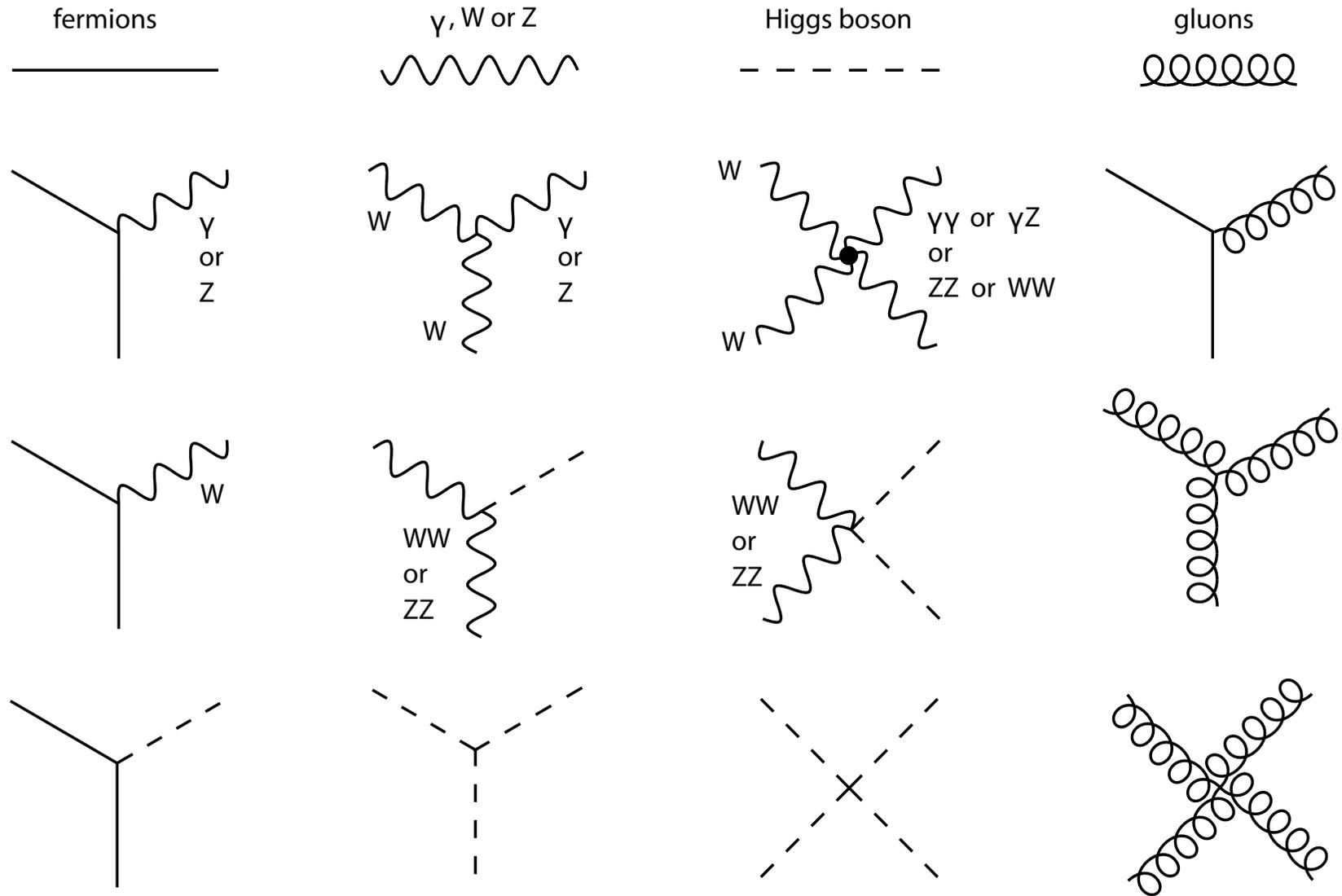
Coupling Constants

Mass

Conclusion

Bonus Material

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- ❖ SU(3)
- ❖ **Standard model**
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- ❖ SM Lagrangian 2
- ❖ Fascination
- ❖ References
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- ❖ Fun



# Lagr. 1

Strand Conjecture

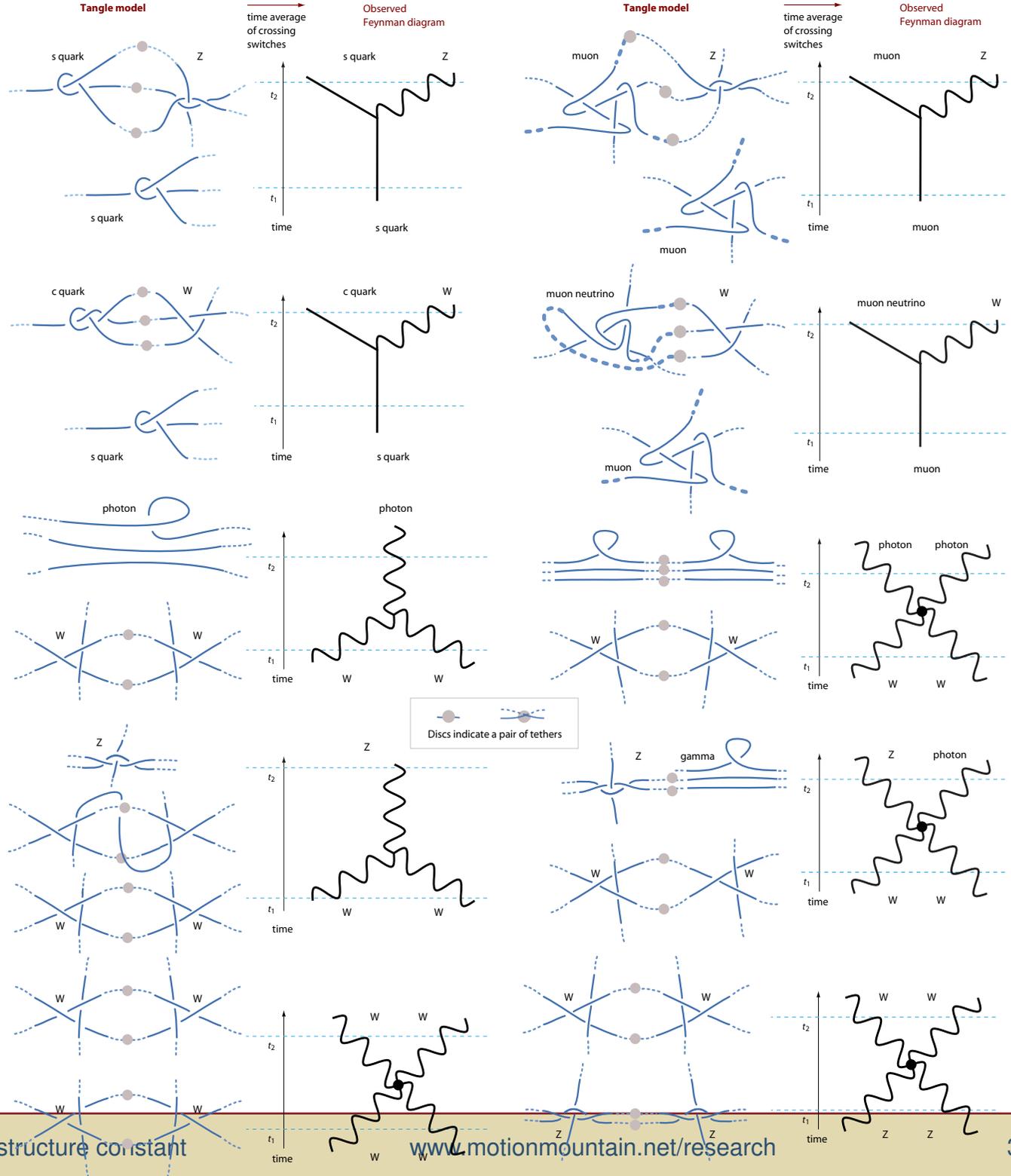
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Mass

Conclusion

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- ❖ Electrons and positrons
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- ❖ SU(3)
- ❖ Standard model
- ❖ SM Lagrangian 1
- ❖ SM Lagrangian 2
- ❖ Fascination
- ❖ References
- ❖ Non-rational tangles
- ❖ Fun



# Lagr. 2

Strand Conjecture

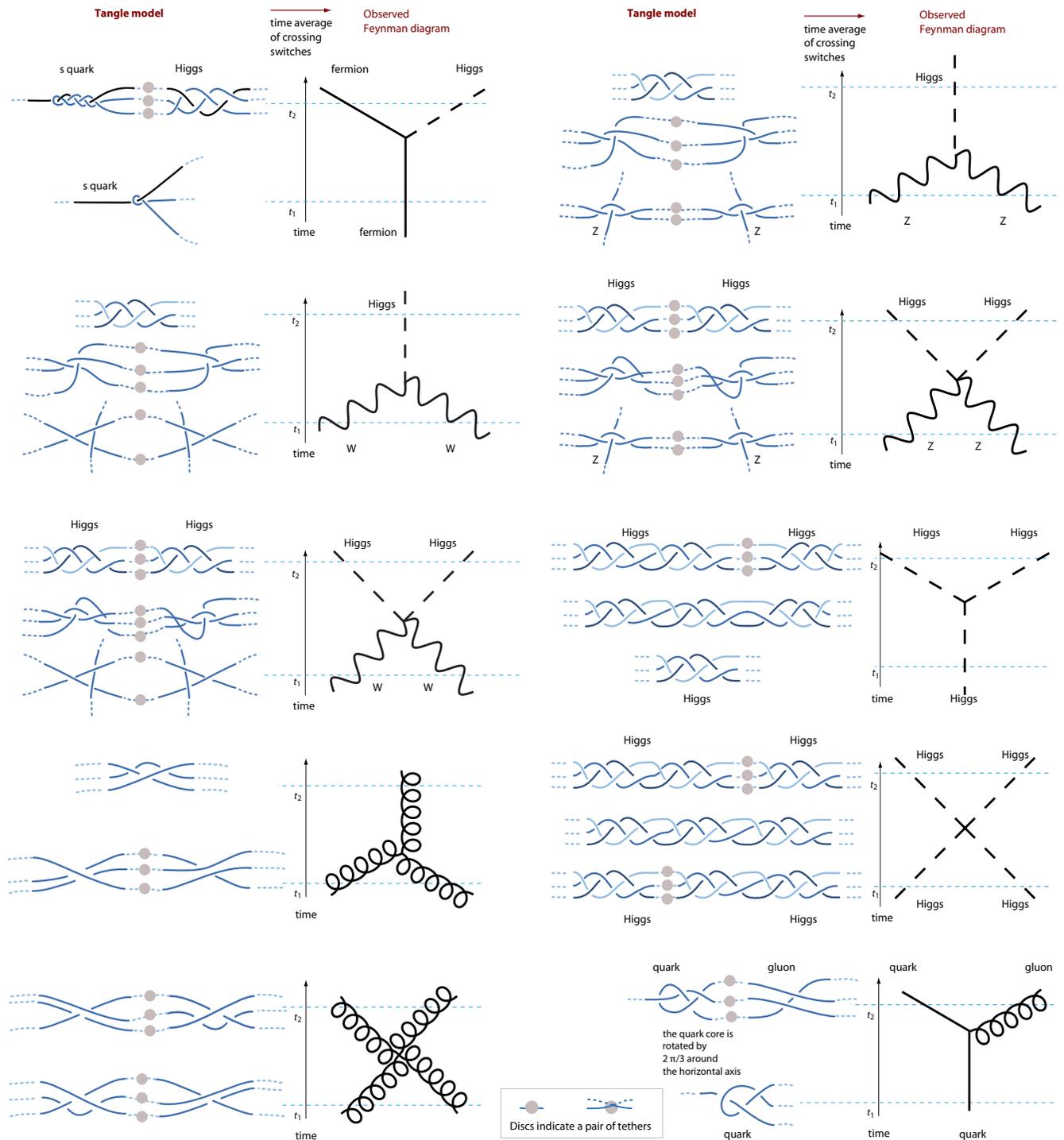
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- ❖ 3 generations
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- ❖ U(1) and SU(2)
- ❖ SU(3)
- ❖ Standard model
- ❖ SM Lagrangian 1
- ❖ SM Lagrangian 2
- ❖ Fascination
- ❖ References
- ❖ Non-rational tangles
- ❖ Fun



# Why Strands Are Fascinating

Strand Conjecture

Coupling Constants

Mass

Conclusion

Bonus Material

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- ❖ SU(3)
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- ❖ SM Lagrangian 2
- ❖ **Fascination**
- ❖ References
- ❖ Non-rational tangles
- ❖ Fun

- Full agreement with experiment – also of its predictions, since many years.
- The first and so far the only explanation for:
  - the number of the elementary particles and all their properties,
  - the number of the interactions and all their properties,
  - the values of the fundamental constants,
  - everything observed in fundamental physics.
- A simple principle.
- No way to modify the conjecture – and its predictions.

# References and Links

[Strand Conjecture](#)

[Coupling Constants](#)

[Mass](#)

[Conclusion](#)

[Bonus Material](#)

- ❖ Dirac on his trick
- ❖ Universal gravity
- ❖ 3 generations
- ❖ Electrons and positrons
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- ❖ SU(3)
- ❖ Standard model
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- ❖ SM Lagrangian 2
- ❖ Fascination
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C. Schiller, *Testing a conjecture on the origin of the standard model*, European Physical Journal Plus 136 (2021) 79. [dx.doi.org/10.1140/epjp/s13360-020-01046-8](https://doi.org/10.1140/epjp/s13360-020-01046-8). Read it online for free at [www.rdcu.be/cdwSI](http://www.rdcu.be/cdwSI).

C. Schiller, *A conjecture on deducing general relativity and the standard model with its fundamental constants from rational tangles of strands*, Physics of Particles and Nuclei 50 (2019) 259–299. [dx.doi.org/10.1134/S1063779619030055](https://doi.org/10.1134/S1063779619030055). Read it online for free at [www.rdcu.be/cdCK7](http://www.rdcu.be/cdCK7).

C. Schiller, *Simple derivation of minimum length, minimum dipole moment and lack of space-time continuity*, International Journal of Theoretical Physics 45 (2006) 213–227, [dx.doi.org/10.1007/s10773-005-9018-7](https://doi.org/10.1007/s10773-005-9018-7). Read it online for free at [www.rdcu.be/cdG3E](http://www.rdcu.be/cdG3E).

C. Schiller, *General relativity and cosmology derived from principle of maximum power or force*, International Journal of Theoretical Physics 44 (2005) 1629–1647, [dx.doi.org/10.1007/s10773-005-4835-2](https://doi.org/10.1007/s10773-005-4835-2). Read it online for free at [www.rdcu.be/cdG3C](http://www.rdcu.be/cdG3C).

Additional preprints at [www.motionmountain.net/research](http://www.motionmountain.net/research).

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# Most Tangles Are Not Rational, but Prime or Locally Knotted

Strand Conjecture

Coupling Constants

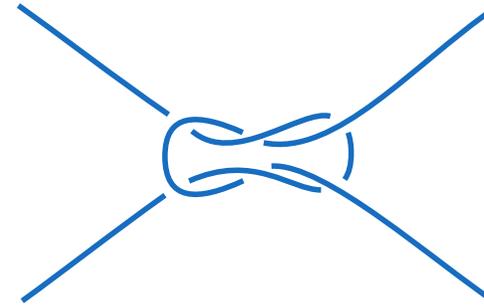
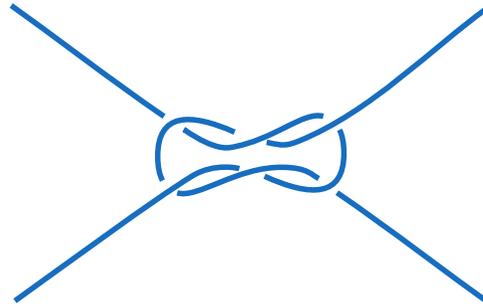
Mass

Conclusion

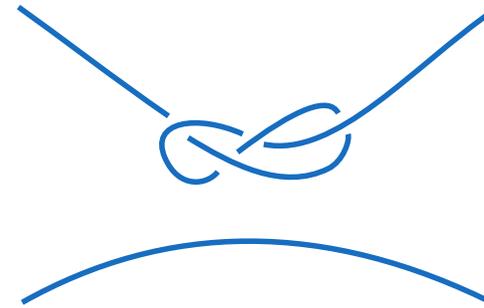
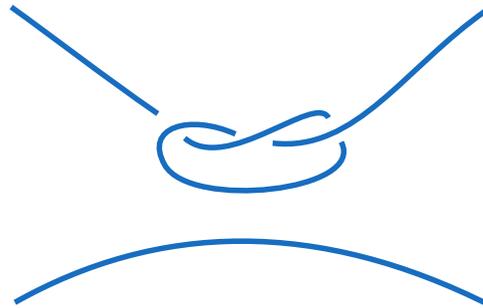
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- ❖ Electrons and positrons
- ❖ U(1) and SU(2)
- ❖ SU(3)
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- ❖ SM Lagrangian 1
- ❖ SM Lagrangian 2
- ❖ Fascination
- ❖ References
- ❖ Non-rational tangles
- ❖ Fun

**Prime** tangles



**Locally knotted** tangles



Such tangles are not rational, and cannot occur in the strand conjecture, because tethered strands do not allow to form them.

# Strings vs Strands

Strand Conjecture

Coupling Constant

Mass

Conclusion

Bonus Material

❖ Dirac on his theory

❖ Universal gravitation

❖ 3 generations of fermions

❖ Electrons and positrons

❖ U(1) and SU(2)

❖ SU(3)

❖ Standard model

❖ SM Lagrangian

❖ SM Lagrangian

❖ Fascination

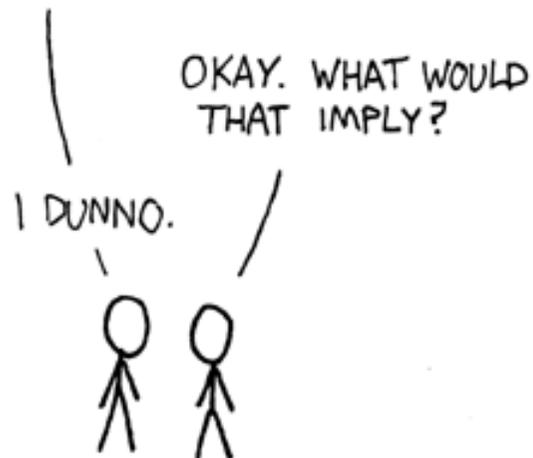
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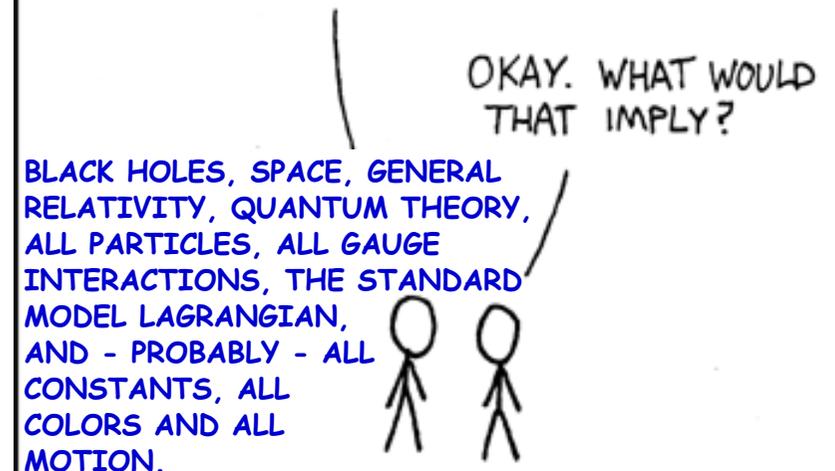
## STRING THEORY SUMMARIZED:

I JUST HAD AN AWESOME IDEA.  
SUPPOSE ALL MATTER AND ENERGY  
IS MADE OF TINY, VIBRATING "STRINGS."



## STRAND MODEL SUMMARIZED:

I JUST HAD AN AWESOME IDEA.  
SUPPOSE ALL MATTER AND ENERGY  
IS MADE OF TINY, FLUCTUATING "TANGLES".



12 dimensions vs 3d. Tension vs none. Supersymmetry & GUT vs none.

Based on [www.xkcd.com/171](http://www.xkcd.com/171), used with permission.