Title: Bonnie's Group

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Abstract:

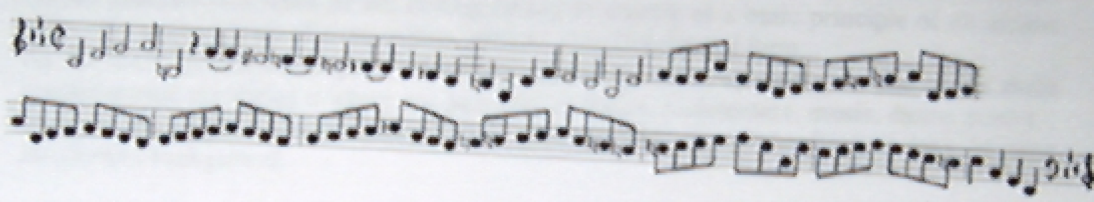
SYMMETRY

·BONNIE EDWARDS·

Saidi	(introduction)
Francesco	(music and art)
Dina	(Arrows of time)
Sarah	(supersymmetry)

Art and symmetry: one the expression of human feeling, the other the expression of human rationality, how can they be related?

Many musical compositions show symmetry in their structure. In many musical forms a theme (short melody) is repeated many times, often with small changes, throughout the piece. When the theme is repeated it may simply start later than the original (a slide or translation) or it may be played backwards (a flip or reflection), or played upside-down (another type of reflection). The theme may be stretched so that it goes twice as slowly or shrunk so that it goes twice as fast.



The connection between art and symmetry becomes even more evident in the field of poetry. The human aesthetic is strongly rooted in pattern and repetition; we seek symmetry in form in most arts, as well as in science.
The artist or poet seeks a similar symmetry in many ways; the metre of poetry is a subtle counting, and the words chosen are a concise reflection of the experience of the poet. He seeks to give his poem a contained, elegant form, with verses and stanzas showing the inner symmetry of thought.
The mathematics we choose to hate in school is not the mathematics which, being a part of our soul, we will always love. As Leibniz said, "Music is the pleasure the human soul experiences from counting without being aware that it is counting." It is true of all arts, for symmetry and pattern are the manifestations of mathematics.

$E = MC^2$

Morris Bishop

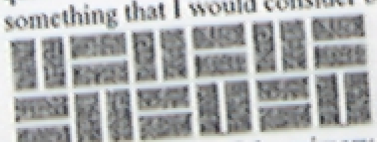
What was our trust, we trust not,
  What was our faith, we doubt;
Whether we must or not
  We may debate about.
The soul, perhaps, is a gust of gas
  And wrong is a form of right-
But we know that Energy equals Mass
  By the Square of the Speed of Light.

Come, little lad; come, little lass,
Your docile creed recite:
"We know that Energy equals Mass
By the Square of the Speed of Light."

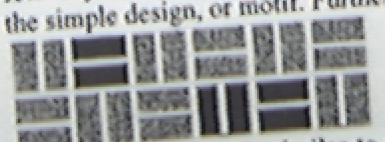
Another important, although apparently restricted area of the theory of symmetry is the field of the theory of symmetry and ornamental art.
There are also examples of direct cooperation between artists and scientists.
The fundamental role of symmetry in the art is not exhausted by its connection with ornament or geometric abstraction. Art historians often used symmetry to characterize the formal qualities of a work of art, distinguishing symmetry as a basic principle of all artistic rules - the canons, laws of composition, criteria of well-balanced form...
As the most significant property of harmony and regularity, symmetry is one of the main organizational principles in every art: painting, sculpture, architecture, music, dance, poetry...
Even in the most extreme modern art - conceptualism or minimalism, it lays in their intellectual background.

A motif can have its own symmetry beyond that of the overall design. In the example below, although the overall pattern exhibits Rotation symmetry, the motif itself has a design with Reflection symmetry:

Symmetrical operations certainly add some elegance to an otherwise drab design. You can quite easily, however, have too much of a good thing. The following design, for example, is something that I would consider boring:



Too many repeats of the primary simple design bores us. What constitutes "too many" or "too few" repeats is a matter of taste and personal opinion. It also has to do with the complexity of the simple design, or motif. Furthermore, it might be affected by the symmetry operation:



The above example is similar to the boring example with too many repeats, however since the symmetrical operation is a Glide Rotation instead of a Translation, it is considerably more interesting.

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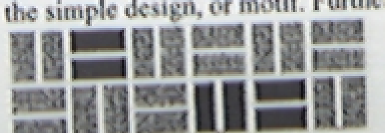

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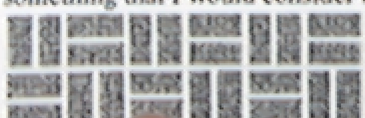

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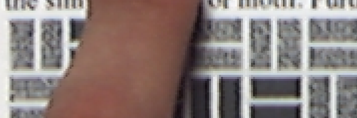

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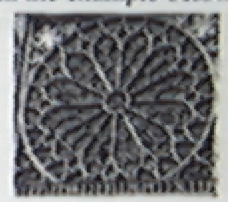

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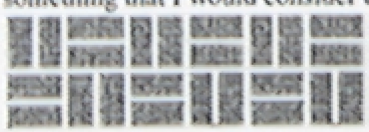

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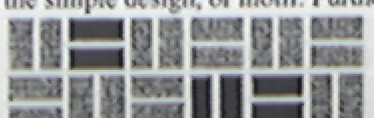

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Now I have to ask a big question: could a computer generate an entire symphony or write a

The answer I provide is the following:
The math is in the symmetry. The art is in choosing the best option for your melody.

Now the last question, I promise!

Did I talk about the symmetry of art or the art of symmetry??

SYMMETRY

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CPT Invariance / Symmetry

A **symmetry** in a physical experiment suggests that something is **conserved** (invariance).

Charge conjugation: inversion of charge (replace matter with antimatter, or vice versa)
Parity: inversion of space coordinates (mirror symmetry)
Time reversal: inversion of order of events, this also reverses time derivatives like momentum and angular momentum.

* applies to all physical laws

- **No time symmetry in the collective behavior of many particles because of probability** (entropy).

- **The weak force occasionally violates CP conservation.** This may explain why there is **more matter than antimatter** in our universe.

- Connection of C and PT suggests a meaningful relationship between spacetime and the structure of particles.

$CPT\,\psi = \psi$

$\psi(x,t) = e^{i2\pi\left(\frac{x}{\lambda} - \frac{t}{T}\right)}$

$\psi(x,-t) = e^{i2\pi\left(\frac{x}{\lambda} + \frac{t}{T}\right)}$

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Arrows of Time

There are various proposed arrows of time:

Subjective	Radiation
Electromagnetic	Quantum-mechanical
Black Hole	Neutral Kaon ***CP violation**
Universe Entropy	Biological aging

Cause precedes effect (finite transmission time)

Three major ones:

Subjective arrow of time: how we perceive time (remember past, not future)

Thermodynamic arrow: direction in which entropy increases

Cosmological arrow: direction of expansion of the universe

Subjective arrow of time depends on thermodynamic one (recording information releases energy, life processes convert orderly forms of energy into less orderly ones).

To understand the cosmological and thermodynamic arrows of time, early universe must be understood. Thus, **a connection to the major questions of cosmology**.

- if we assume the "no boundary" condition, the cosmological arrow may reverse, but the entropy will always increase and human life would only be possible during the expanding stage

Some websites:

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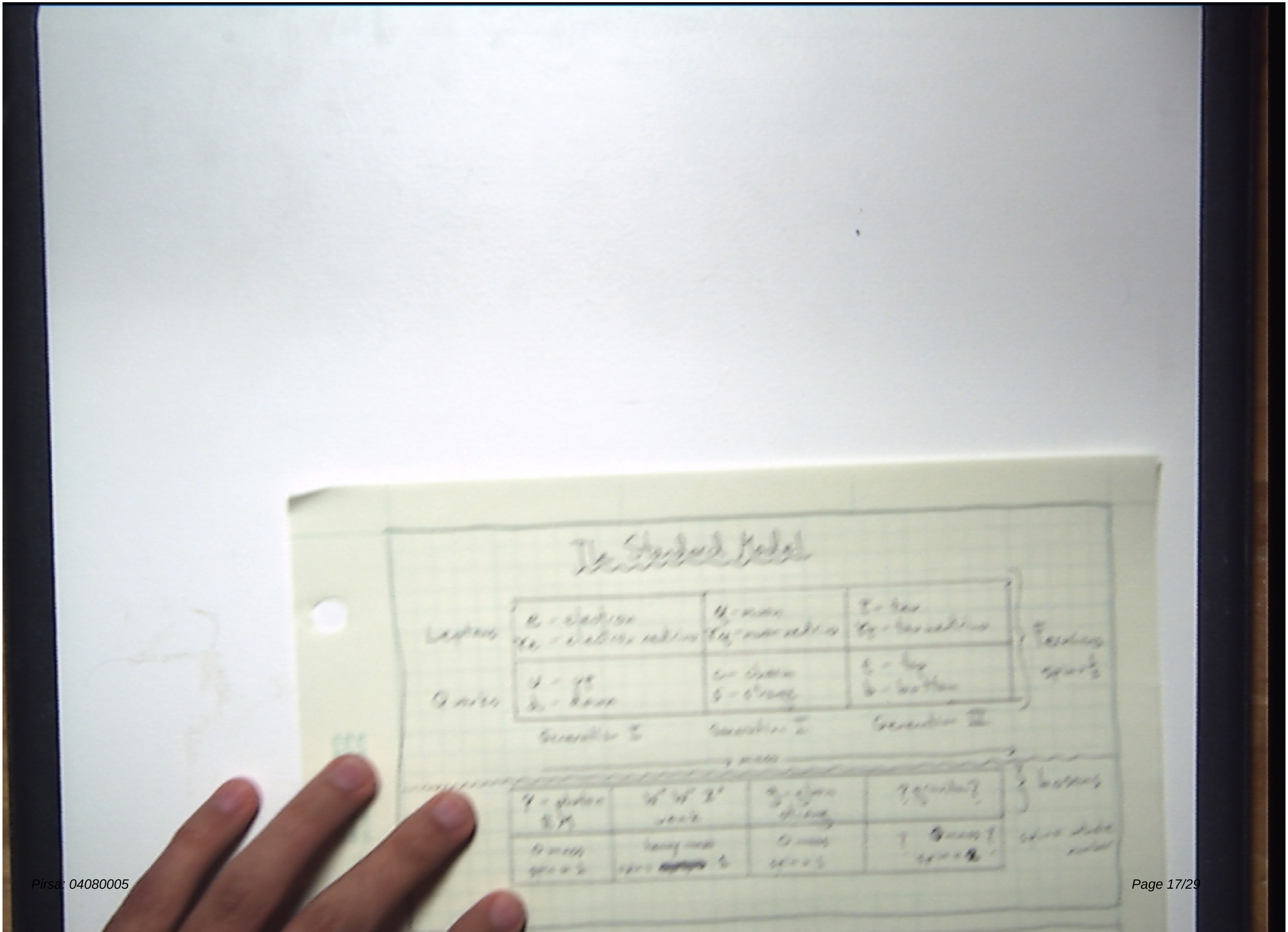
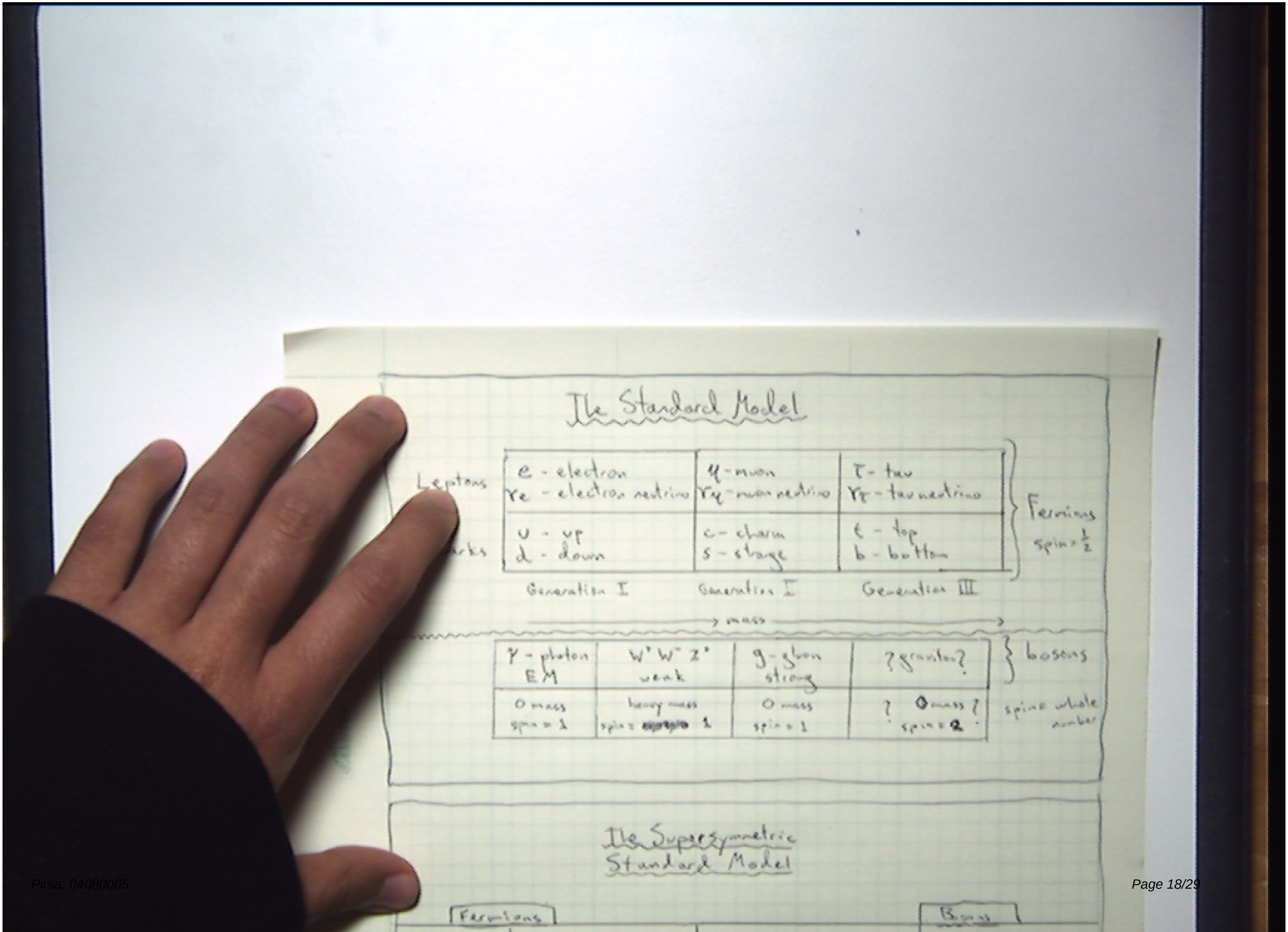
http://www.lbl.gov/abc/wallchart/chapters/05/0.html#toc

http://www2.slac.stanford.edu/vvc/theory/timereversal.html

http://physicsweb.org/article/news/8/8/1


The Standard Model
Leptons
Quarks
Generation I
Generation II
Generation III
bosons


The Standard Model
Leptons
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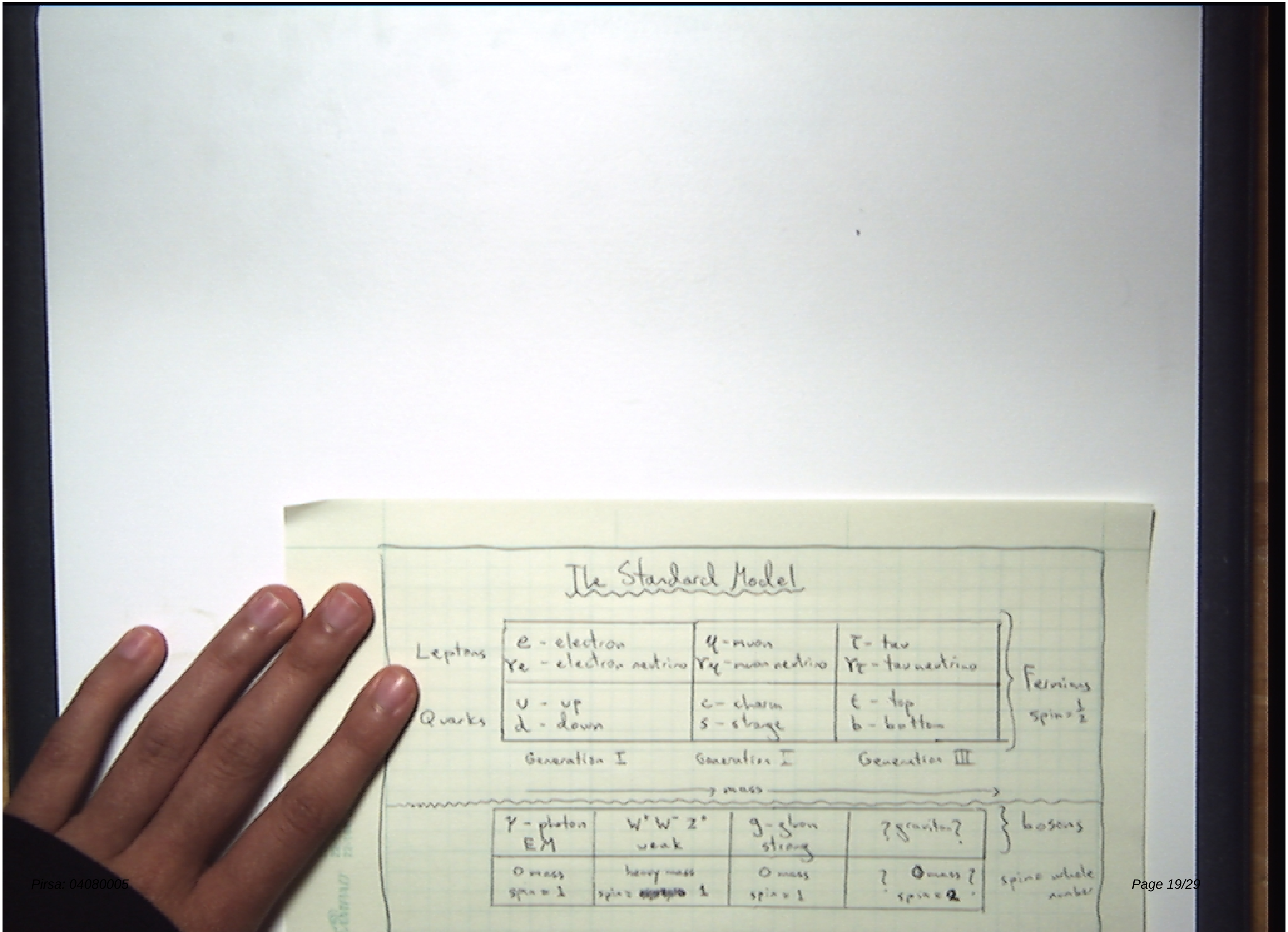
νe - electron neutrino
μ - muon
νμ - muon neutrino
τ - tau
ντ - tau neutrino
u - up
d - down
c - charm
s - strange
t - top
b - bottom
Fermions
spin = 1/2
Generation I
Generation II
Generation III
mass
γ - photon
EM
W+ W- Z0
weak
g - gluon
strong
? graviton ?
bosons
0 mass
spin = 1
heavy mass
spin = 1
0 mass
spin = 1
? 0 mass ?
spin = 2
spin = whole number
The Supersymmetric Standard Model
Fermions
Bosons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The Standard Model

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Quarks	u - up d - down	c - charm s - strange	t - top b - bottom	

→ mass →

γ - photon EM	$W^+ W^- Z^0$ weak	g - gluon strong	? graviton ?	bosons
0 mass spin = 1	heavy mass spin = 1	0 mass spin = 1	? 0 mass ? spin = 2 ?	spin = whole number

The Supersymmetric Standard Model

Fermions

Bosons

Leptons	e - electron	$\tilde{e}$ - selectron $\tilde{\nu}$ - selectron sneutrino	Sleptons spin = 1

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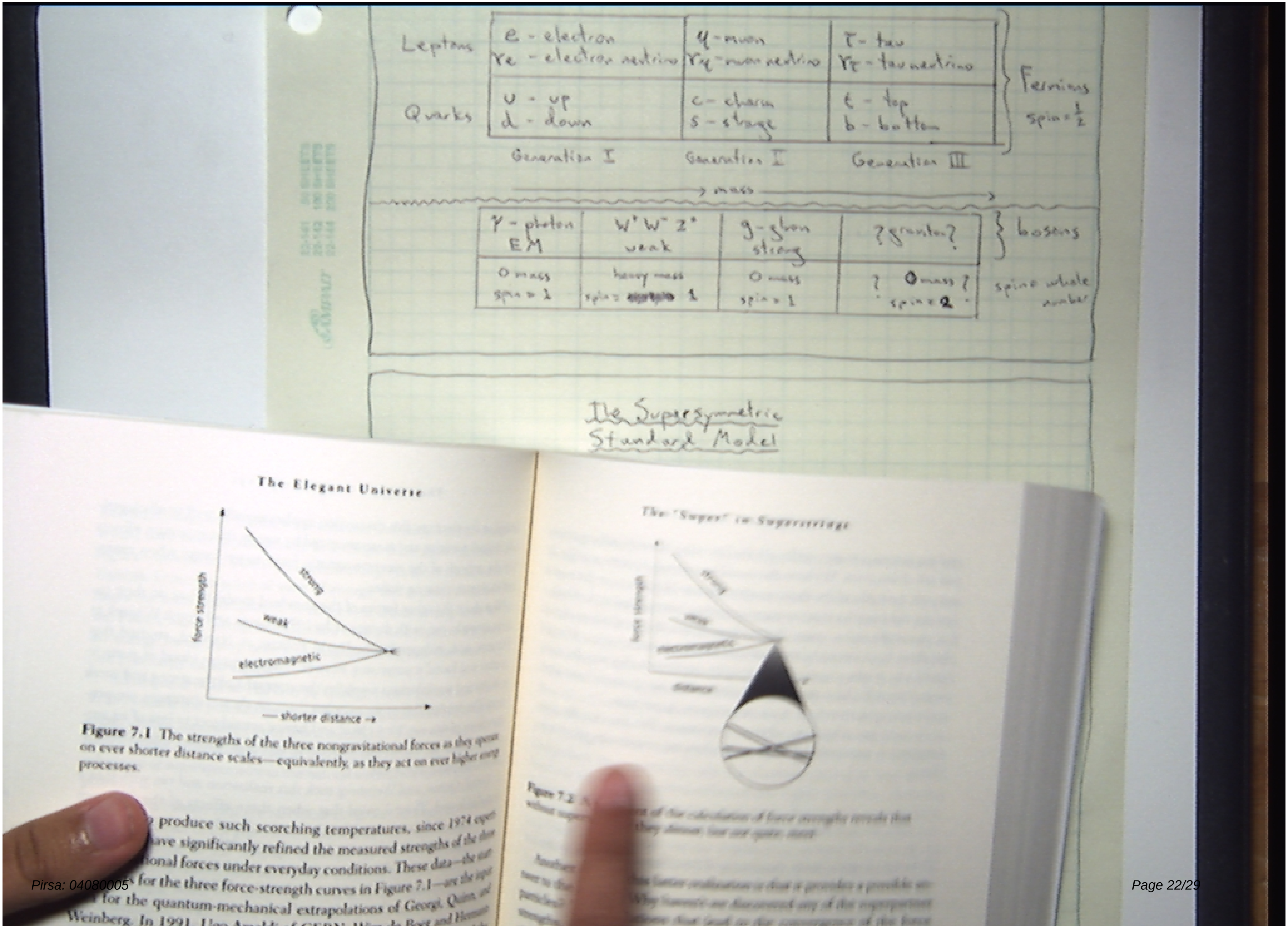
The Supersymmetric Standard Model

Fermions			Bosons
Leptons spin = $\frac{1}{2}$	e - electron ν_e - electron neutrino μ - muon ν_μ - muon neutrino τ - tau ν_τ - tau neutrino	$\tilde{e}$ - selectron $\tilde{\nu}_e$ - selectron sneutrino $\tilde{\mu}$ - smuon $\tilde{\nu}_\mu$ - smuon sneutrino $\tilde{\tau}$ - stau $\tilde{\nu}_\tau$ - stau sneutrino	Sleptons spin = 1 mass = heavy
quarks spin = $\frac{1}{2}$	u - up d - down c - charm s - strange t - top b - bottom	$\tilde{u}$ - sup $\tilde{d}$ - sdown $\tilde{c}$ - scharm $\tilde{s}$ - strange boson $\tilde{t}$ - stop $\tilde{b}$ - sbottom	Squarks spin = 1 mass = heavy
spin = $\frac{1}{2}$ mass = heavy	$\tilde{\gamma}$ - photino $\tilde{W}$ - wino $\tilde{g}$ - gluino	γ - photon W^+, W^- bosons g - gluon	spin = 1
?	? gravitino ? ? heavy mass ? spin = $\frac{3}{2}$?	? graviton ? 0 mass spin = 2 ? ? ?	?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The Supersymmetric Standard Model
The Elegant Universe
force strength
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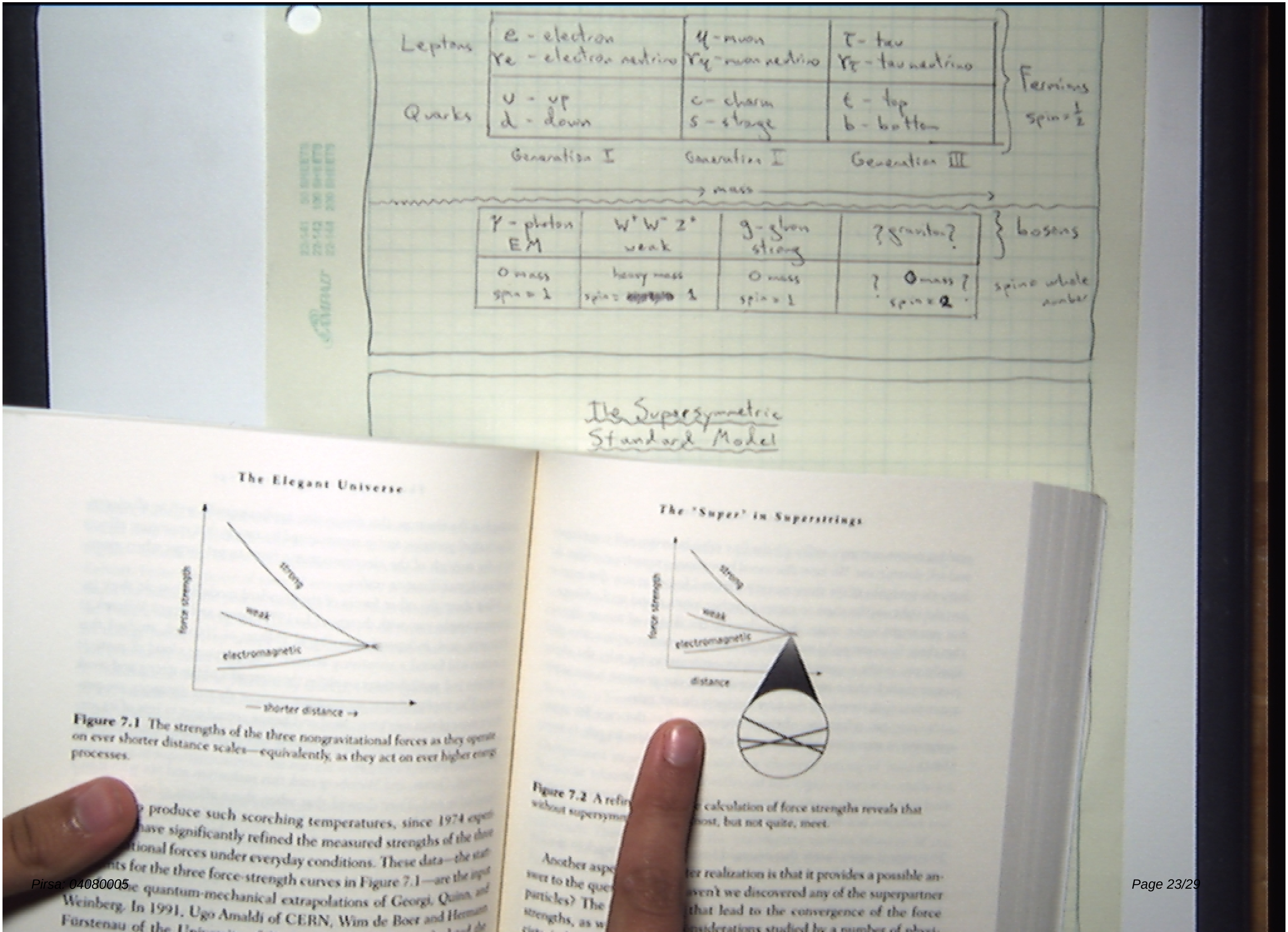
shorter distance →
Figure 7.1 The strengths of the three nongravitational forces as they operate on ever shorter distance scales—equivalently, as they act on ever higher energy processes.
The "Super" in Superstrings



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The Supersymmetric Standard Model

The Elegant Universe

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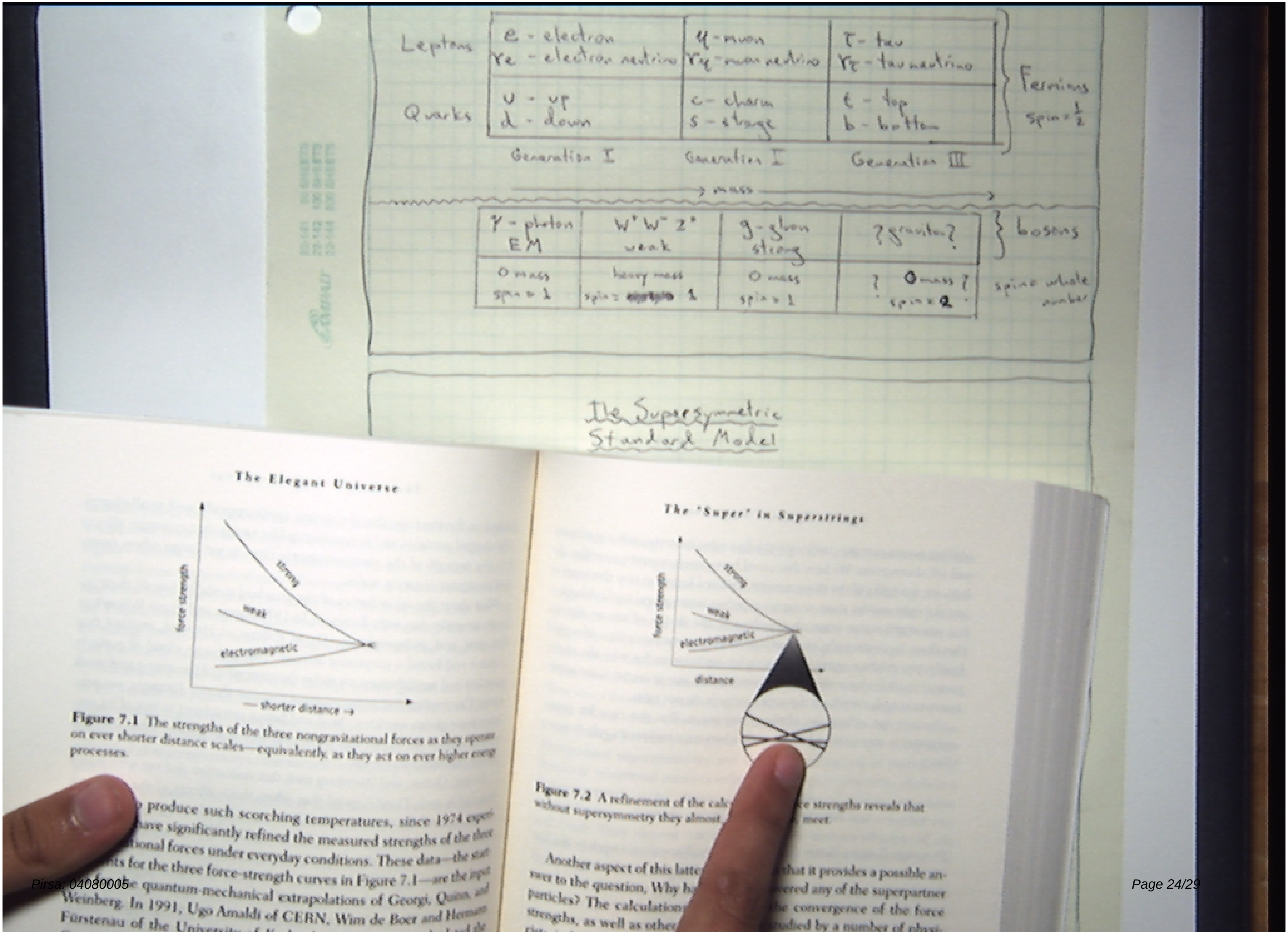
...produce such scorching temperatures, since 1974 expe... have significantly refined the measured strengths of the three ...tional forces under everyday conditions. These data—the star... ...nts for the three force-strength curves in Figure 7.1—are the input ...e quantum-mechanical extrapolations of Georgi, Quinn, and Weinberg. In 1991, Ugo Amaldi of CERN, Wim de Boer and Hermann Fürstenau of the Univ...

The "Super" in Superstrings

Figure 7.2 A refin... calculation of force strengths reveals that without supersymm... ...most, but not quite, meet.

Another aspe... ...er realization is that it provides a possible answer to the que... ...aven't we discovered any of the superpartner particles? The ... that lead to the convergence of the force strengths, as w... ...nsiderations studied by a number of physi...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The Supersymmetric
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The Elegant Universe
force strength
strong
weak
electromagnetic
shorter distance
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weak
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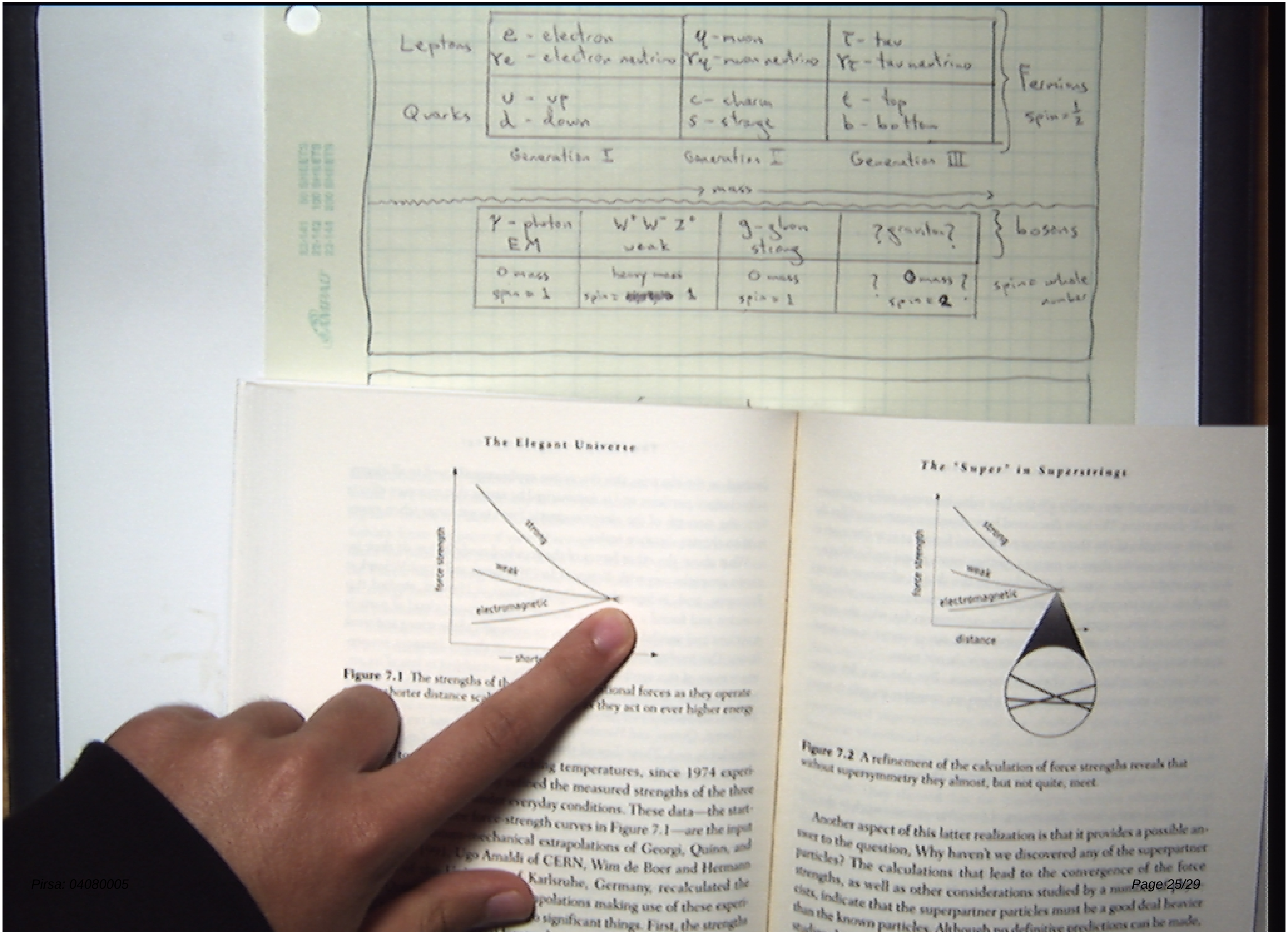
distance
Figure 7.2 A refinement of the calc… strengths reveals that without supersymmetry they almost … meet.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spin = whole number
The Elegant Universe
force strength
strong
weak
electromagnetic
The "Super" in Superstrings
force strength
strong
weak
electromagnetic
distance
Figure 7.2 A refinement of the calculation of force strengths reveals that without supersymmetry they almost, but not quite, meet.
Another aspect of this latter realization is that it provides a possible answer to the question, Why haven't we discovered any of the superpartner particles? The calculations that lead to the convergence of the force strengths, as well as other considerations studied by a number of physicists, indicate that the superpartner particles must be a good deal heavier than the known particles.

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→ mass →

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0 mass spin = 1	heavy mass spin = 1	0 mass spin = 1	? 0 mass ? spin = 2	spin = whole number

The Supersymmetric Standard Model

Fermions			Bosons
Leptons spin = $\frac{1}{2}$	e - electron ν_e - electron neutrino μ - muon ν_μ - muon neutrino τ - tau ν_τ - tau neutrino	$\tilde{e}$ - selectron $\tilde{\nu}_e$ - selectron sneutrino $\tilde{\mu}$ - smuon $\tilde{\nu}_\mu$ - smuon sneutrino $\tilde{\tau}$ - stau $\tilde{\nu}_\tau$ - stau sneutrino	Sleptons spin = 1 mass = heavy
quarks spin = $\frac{1}{2}$	u - up d - down c - charm s - strange t - top b - bottom	$\tilde{u}$ - sup $\tilde{d}$ - sdown $\tilde{c}$ - scharm $\tilde{s}$ - strange boson $\tilde{t}$ - stop $\tilde{b}$ - sbottom	squarks spin = 1 mass = heavy
spin = $\frac{1}{2}$ mass = heavy	$\tilde{\gamma}$ - photino $\tilde{W}$ - wino $\tilde{g}$ - gluino	γ - photon W^+, W^- bosons g - gluon	spin = 1
?	? ? graviton ? ? ? heavy mass ? spin = $\frac{3}{2}$?	? graviton ? 0 mass ? ? ? spin = 2	?

② As of yet, nothing shows that SUSY is true but there are more discrepancies resolved when it is [redacted] included.
In GUT → the three forces gain equal strength at very high energies, but they are not equal → with SUSY included → the mathematics result in a concise merging point → all forces have = strength @ 10^{16} Gev

③ Superstring Theory.

– recall Alex Buchel – remember that early string theory postulated the existence of the negative energy particle – the tachyon – associated with E=0 → ground state energy → lowest quantum excitation of the string. The tachyon would also have negative mass so momentum greater than c → dashes everything, etc. etc.

→ To rid the tachyon → string theory was expanded not only to describe bosonic vibration patterns (originally arising from a way to describe gravity if you recall) but fermionic ones also

– It was discovered that for each fermionic pattern there was also a corresponding bosonic pattern! – The new string theory predicts supersymmetry and is in fact unable to be described without it. SUSY is essential to string theory.

④ Conclusion.

- As you can see → superstring theory is one of the top candidates as a potential theory of everything in the far future as it unifies QM and grav.
- SUSY plays an essential role and also solves other problems like GUT and Higgs.
- Symmetry is found all around us + is the best tool to accomplish the prime goal of the physicist – simplificat...
- whatever the master theory of the u... that de... everything is... if it does exist → will have sy... as a ... principle.

Pictures

① → Standard Model and Sup...

② → Unification graphs with... ...

② As of yet, nothing shows that SUSY is true but there are more discrepancies resolved when it is ~~[illegible]~~, included.
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[illegible]tures
① → Standard Model and Supersy[illegible] st[illegible]
② → Unification graphs with [illegible]t

The Standard Model

	Generation I	Generation II	Generation III
Leptons	e - electron ν_e - electron neutrino	μ - muon ν_μ - muon neutrino	τ - tau ν_τ - tau neutrino
Quarks	u - up d - down	c - charm s - strange	t - top b - bottom

} Fermions, spin = $\frac{1}{2}$

→ mass →

γ - photon EM	$W^+ W^- Z^0$ weak	g - gluon strong	? graviton ?
0 mass spin = 1	heavy mass spin = 1	0 mass spin = 1	? 0 mass ? spin = 2

} bosons, spin = whole number

The Supersymmetric Standard Model

Fermions			Bosons
Leptons spin = $\frac{1}{2}$	e - electron ν_e - electron neutrino μ - muon ν_μ - muon neutrino τ - tau ν_τ - tau neutrino	$\tilde{e}$ - selectron $\tilde{\nu}_e$ - selectron sneutrino $\tilde{\mu}$ - smuon $\tilde{\nu}_\mu$ - smuon sneutrino $\tilde{\tau}$ - stau $\tilde{\nu}_\tau$ - stau sneutrino	Sleptons spin = 1 mass = heavy
quarks spin = $\frac{1}{2}$	u - up d - down c - charm s - strange t - top b - bottom	$\tilde{u}$ - sup $\tilde{d}$ - sdown $\tilde{c}$ - scharm $\tilde{s}$ - strange boson $\tilde{t}$ - stop $\tilde{b}$ - sbottom	Squarks spin = 1 mass = heavy