

electron
neutrino



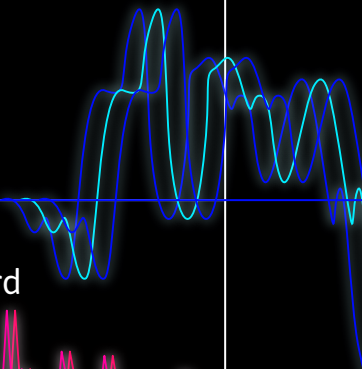
muon
neutrino



tau
neutrino

Group 6: "Neutrinos and Earth-Sized Quantum Devices"

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Mentor: Matheus Hostert



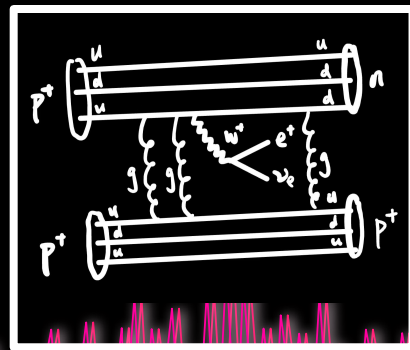
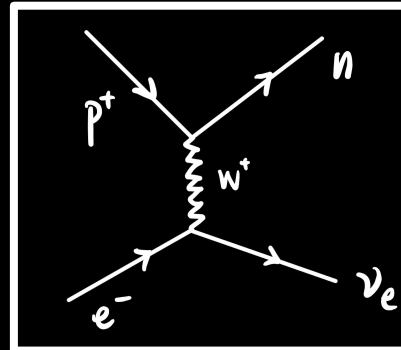
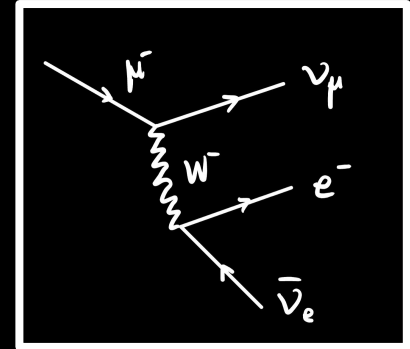
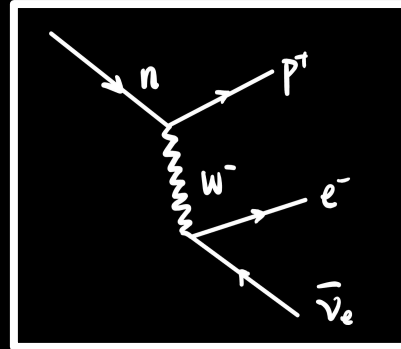
NEUTRINO CREATION

They're here, they're there, they're everywhere
Billions of neutrinos are hitting your hair!

Fusion, fission, supernovas and decay,
Even things like cosmic rays,

Are production processes we can reflect on,
Creating neutrinos for the tau, muon, and
electron.

W bosons are a neutrino's best friend
They mediate the decay and give a neutrino in
the end!



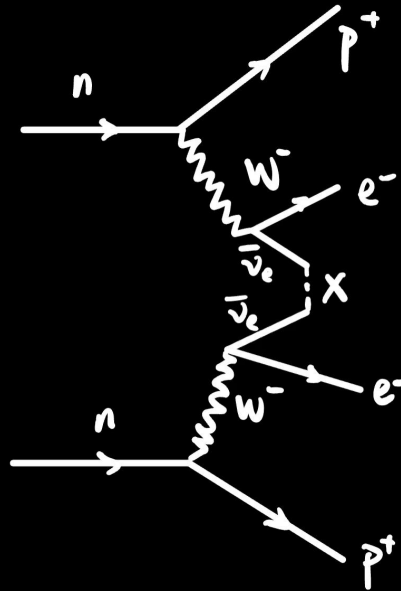
Neutrinoless Double β Decay

Neutrons can decay into protons,
and (amazing) neutrinos and leptons.

And when they decay side by side we find,
A hypothesis to which we're inclined
where neutrinos become their anti-selves,
Causing many new books to be upon shelves.

Because in our universe there exists a rule,
That lepton number conservation is really cool,
And if antineutrinos do decay into
Protons and leptons (it'd be their go-to)
There'd be lepton number variation and
lepton number conservation negation!

To summarize these lines of verse,
and conclude this topic on which we converse:
Neutrinoless double beta decay
could break the laws of physics, okay?



perhaps sth. like
 $\bar{\nu}_e \rightarrow \nu_e$
or perhaps
 $\nu_e \equiv \bar{\nu}_e$

Neutrino Oscillations

Neutrinos, (near) massless as they may be,

Have a quality which is not easy to see,

Upon their travels they slowly change,

Into new forms exotic and strange.

The neutrinos exist in a vector space of mass,

But when they travel, that alters to class,

So they are not pinned down by identity,

But fly and shift, wild and free.

For computing the oscillation,

We use $\langle \text{Bra} | \text{Ket} \rangle$ as the notation,

And the maths may look complicated

but do not fret as they can be replicated

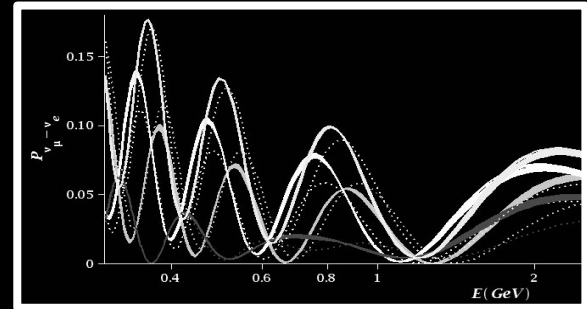
It sounds even simpler to know

that complex numbers are

the star of the show.

But see, the math bears out

And their complexity is in doubt.



$$\begin{aligned} |\nu_e\rangle &= \cos\theta |\nu_1\rangle + \sin\theta |\nu_2\rangle \\ |\nu_\mu\rangle &= -\sin\theta |\nu_1\rangle + \cos\theta |\nu_2\rangle \end{aligned}$$

$$P_{\nu_\mu \rightarrow \nu_e} = |\langle \nu_e | \nu_\mu(t) \rangle|^2 = \sin^2\theta \sin^2\left(\frac{[m_2^2 - m_1^2]L}{4E_\nu}\right)$$

Experiments

Experimentation, from KamLAND to SNO
has been instrumental in letting us know
that when (in a beam) neutrinos are thrown
they change their flavor in the pattern below.
Deep--in laboratory depths--underground
surprising results are found
It is revealed the quantum behave
And those weird plots of waves
are the results from the detection

