Exotic Physics in the Beta Decay of Tritium

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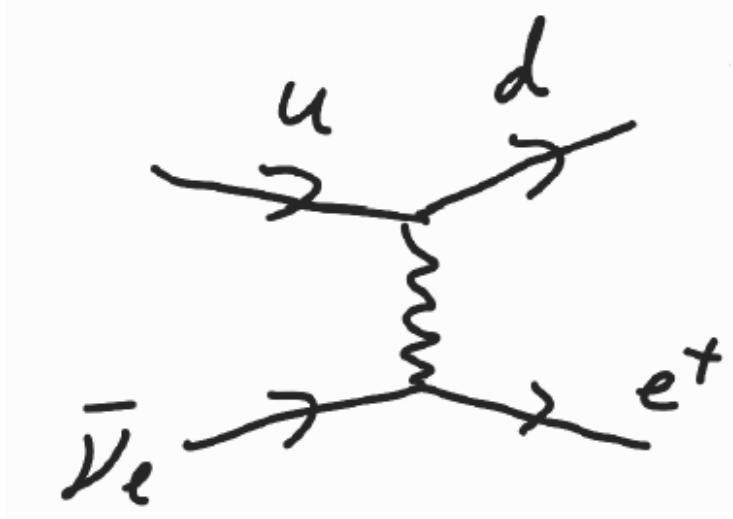
- Beta Decay Calculation
- BSM Physics in Beta Decay

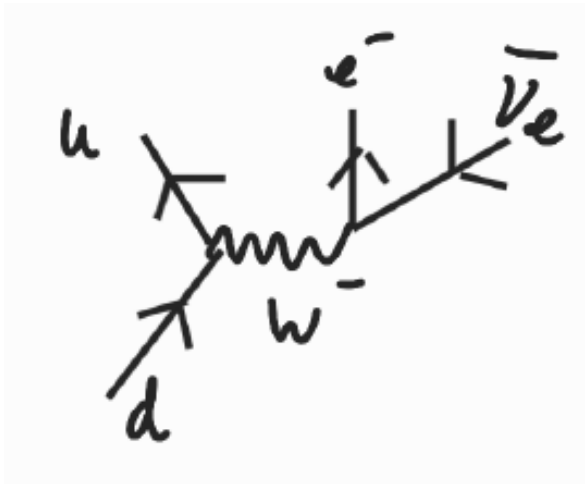
Neutrino Hypothesis and Discovery

1. Weak decay energy conservation
2. Low mass and cross section
3. Discovery using inverse beta decay
4. Neutrino oscillations

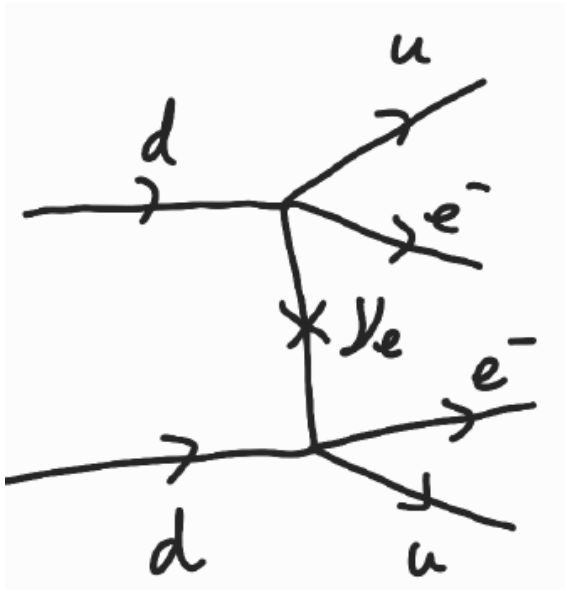


Neutrino Mass Measurement

Single Beta Decay



Double Beta Decay

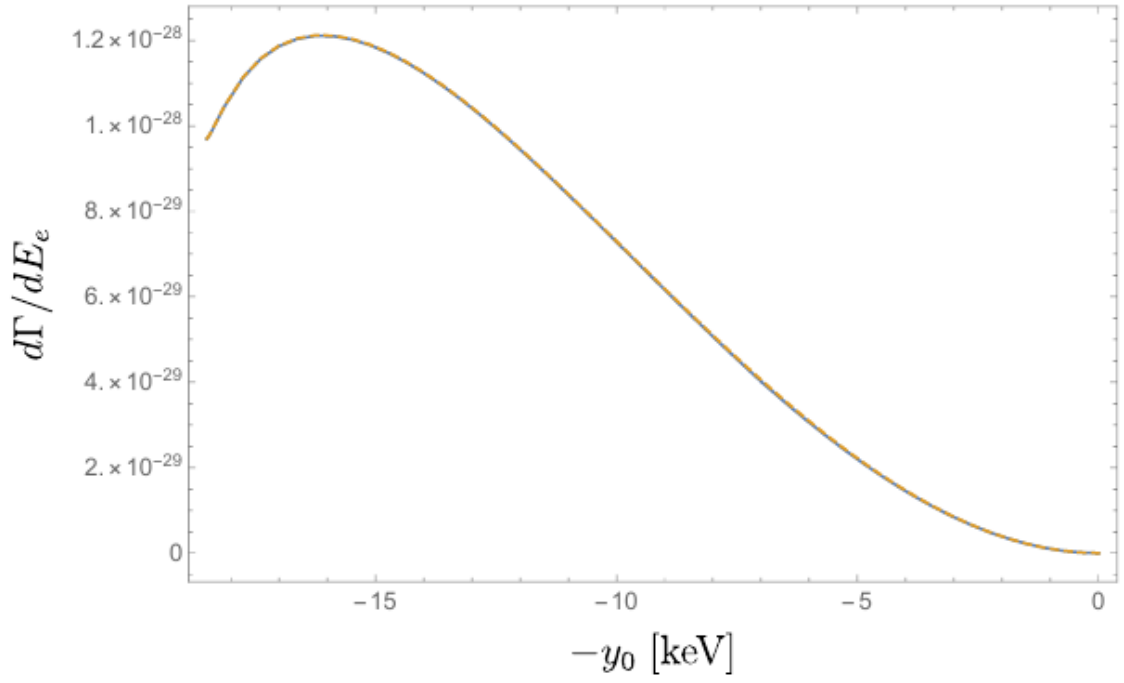


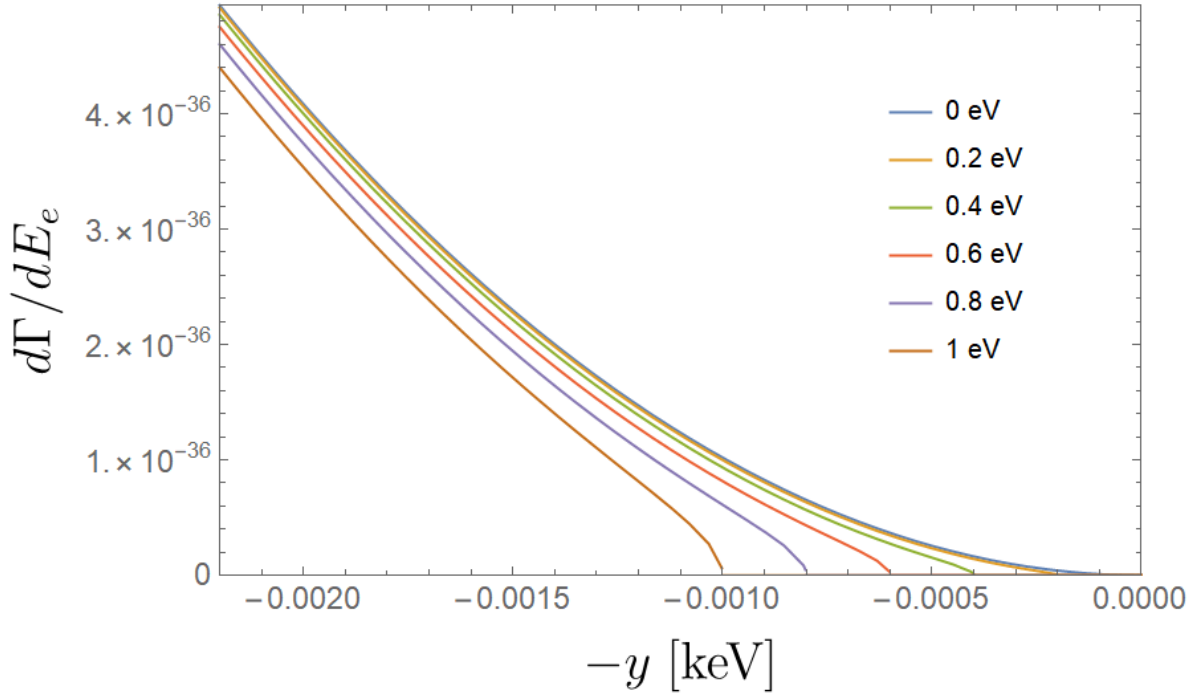
Cosmology

Tritium Beta Decay Spectrum

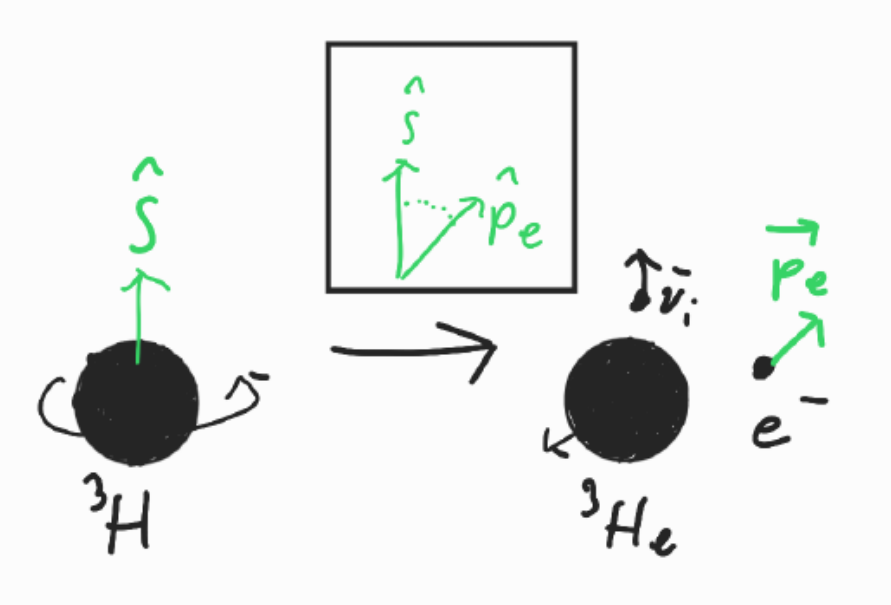
$$\frac{d\Gamma}{dE_e} \approx f(E_e) y_0 \sqrt{y_0^2 - \sum_{i=1}^{3} |U_{ei}|^2 m_i^2},$$

$$y = E_e^{max} - E_e$$

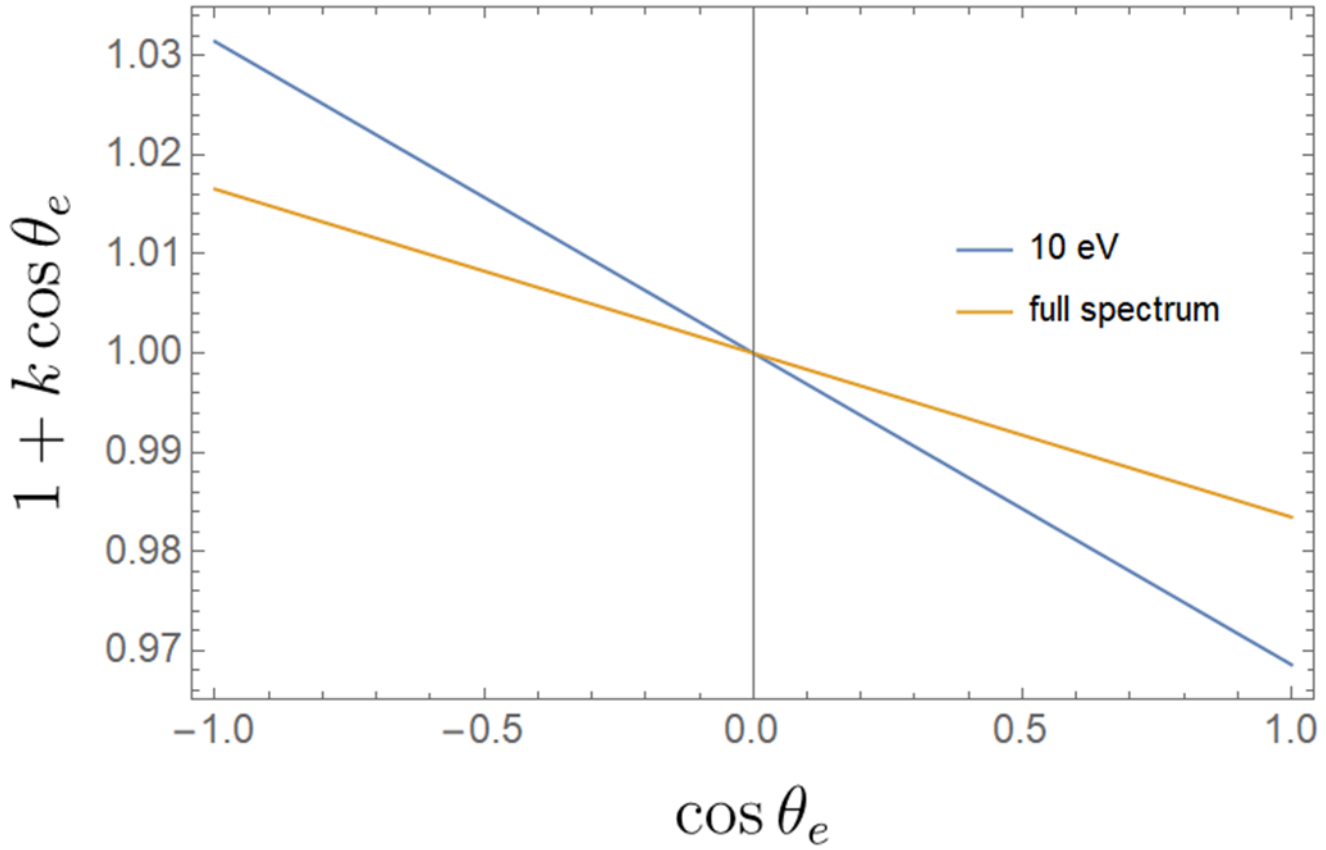




Polarised Tritium



$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_e} = \frac{1}{2}(1 + k\cos\theta_e)$$

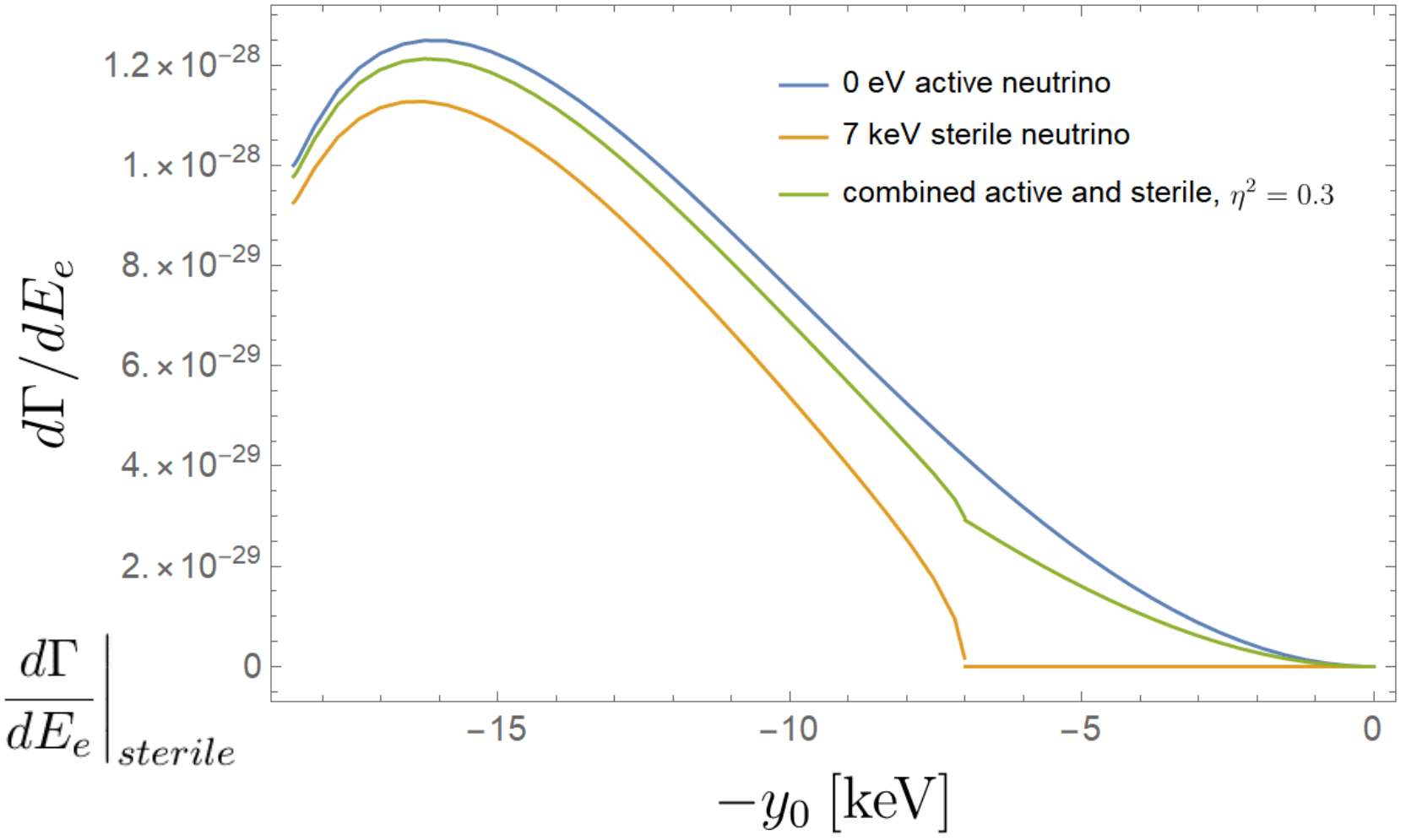


Sterile Neutrino

$$\nu_L = \nu_1 + \eta\nu_2$$

$$N_R = -\eta\nu_1 + \nu_2$$

$$\frac{d\Gamma}{dE_e} = (1-\eta^2)\frac{d\Gamma}{dE_e}\bigg|_{active} + \eta^2 \frac{d\Gamma}{dE_e}\bigg|_{sterile}$$



Right-Handed Currents

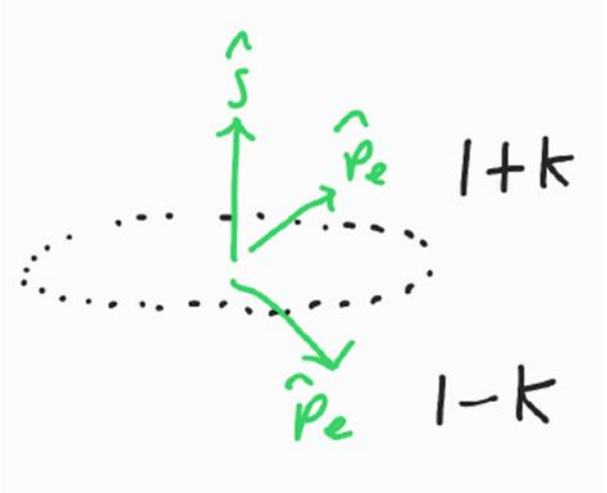
$$\mathcal{L} = \frac{G_F}{\sqrt{2}}(H^{\mu}_{L}(\overline{e}\gamma_{\mu}P_{L}\nu_{e} + \tilde{\epsilon}_{L}\overline{e}\gamma_{\mu}P_{R}N_{R}) + H^{\mu}_{R}(\epsilon_{R}\overline{e}\gamma_{\mu}P_{L}\nu_{e} + \tilde{\epsilon}_{R}\overline{e}\gamma_{\mu}P_{R}N_{R})) + h.c.,$$

	Leptonic LL	Leptonic LR	Leptonic RR
LL	Original case, $\Gamma \propto 3g_A^2 + g_V^2$	Non-negligible only near the endpoint $\sim \frac{m_\nu}{y+m_\nu}\Gamma$, $\propto 3g_A^2 - g_V^2$	$O(10^{-5})$ difference from the original case, $\propto 3g_A^2 + g_V^2$
LR	Negative but comparable to	Non-negligible only near the	Negative but comparable to

Right-Handed Currents and Polarisation

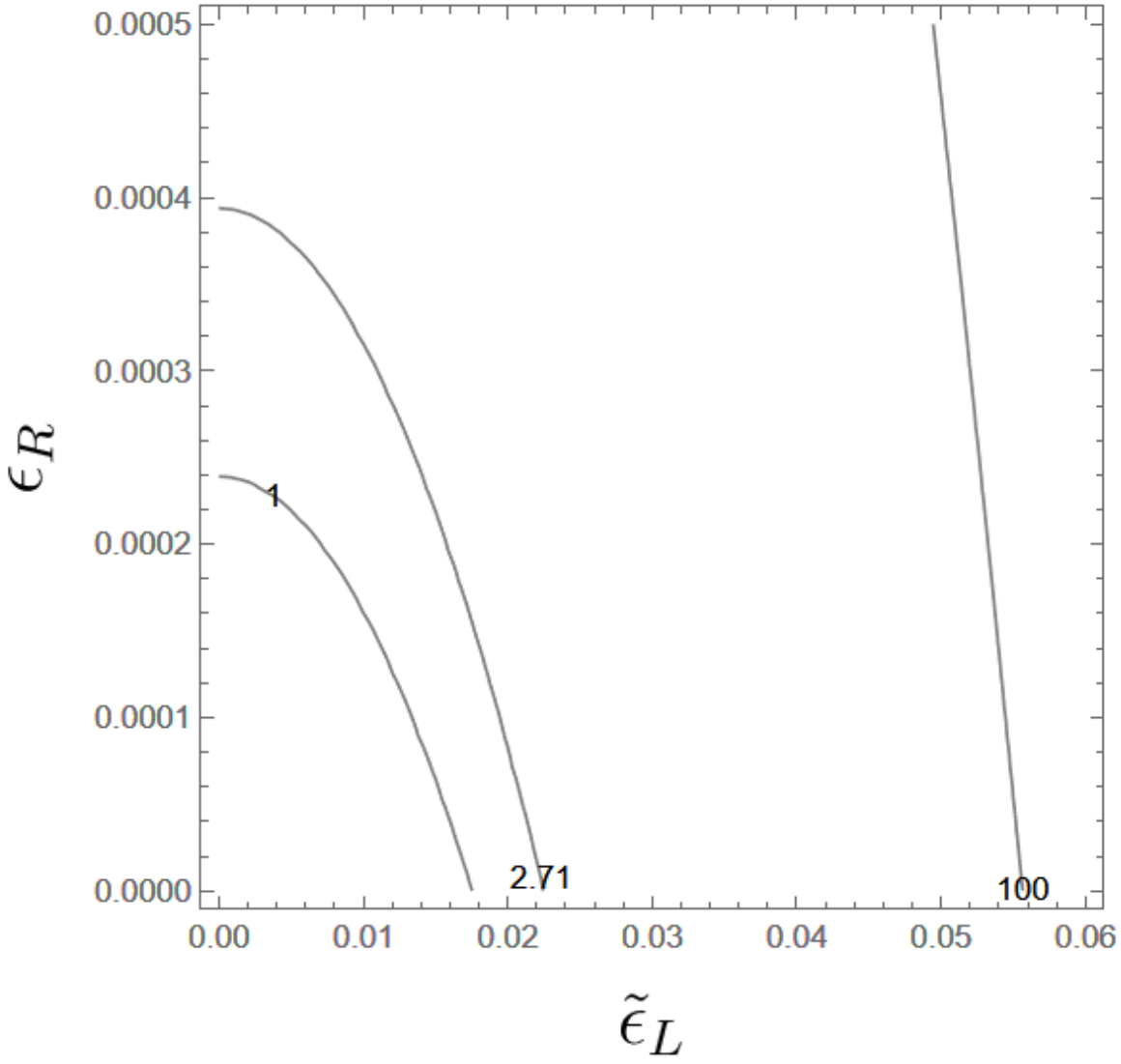
$$\frac{1}{\Gamma}\frac{d\Gamma}{d\cos\theta_e} = \frac{1}{2}(1 + k\cos\theta_e)$$

$$k = k_{LL,LL} + |\tilde{\epsilon}_L|^2 k_{RR,LL} + \ldots$$



	Leptonic LL	Leptonic LR	Leptonic RR
LL	Original case, $\Gamma \propto -2(g_A^2 - g_A g_V)$	Negligible everywhere $\sim \frac{m_e}{M}\frac{m_\nu}{y+m_\nu}\Gamma$	Same shape as the original but positive and enhanced, $\propto 2(g_A^2 + g_A g_V)$
LR	Same shape as the orig	Exactly vanishing, no	Positive and enhanced

χ^2 Calculation



Conclusion and Outlook

- Beta decay leads to the neutrino mass
- Tritium beta decay probes KeV sterile neutrinos
- Right-handed currents seen in the anisotropy of electron emission

- I am working on putting BSM physics in a statistical framework
- I will look for other BSM effects such as additional final-state particles and background fields