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Seesaw Model of Neutrino Mass Estimation with a Dirac Mass of 585 GeV Electroweak Fermion and the Unified Stoney Mass

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Abstract

In this work, we propose a novel approach to estimate neutrino masses using a Dirac seesaw mechanism grounded in our 4G model of final unification. The framework utilizes a Dirac mass of 585 GeV, an assumed electroweak fermion having its existence connected with nuclear structure and the unified Stoney mass of 1.859e-9 kg. Neutrino mass hierarchies are constructed using integer scaling parameters 1,2 and 3 connected with the lepton series and square roots of charged lepton mass ratios associated with electron. Estimated rest masses of the three neutrinos are 0.289 meV/c², 8.297 meV/c² and 51.03 meV/c² respectively, yielding a total neutrino mass sum of 59.63 meV/c². Including antineutrinos, the combined mass sum is 0.12 eV/c², consistent with cosmological constraints and the Dirac neutrino hypothesis. For data fitting, we consider a coefficient of 0.88. This coefficient may be refined with future observations and theoretical developments.

Keywords: neutrinos; Seesaw method; Dirac mass; electroweak fermion of 585 GeV; GUT scale; Stoney mass

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1. Introduction

The origin and absolute scale of neutrino masses remain one of the central mysteries in particle physics. We approach this problem through a Dirac seesaw framework [1–8] inspired by our proposed 4G model of final unification having four different gravitational constants and an electroweak fermion of rest energy 585 GeV [9–11]. Within this model, we derive neutrino masses based on a high-scale Dirac mass term of 585 GeV and a unified gravitational mass associated with the Stoney scale [12,13]. To better match the mass observations, a fitting coefficient of 0.88 is applied. It can have a range of (0.85 to 0.9).

2. Modified Seesaw Mass Formula

Based on the Seesaw model, we adopt a modified formula in the following way. It needs a critical review at fundamental level. For the time being it can be considered as a reference mass formula.

$$m_{l\nu} \cong k * n * \sqrt{\frac{m_{lepton}}{m_e}} \left(\frac{M_D^2}{M_{GUT}} \right) \cong 0.88 * n * \sqrt{\frac{m_{lepton}}{m_e}} \left(\frac{M_{wf}^2}{M_{Stoney}} \right) \quad (1)$$

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where,
$m_{l\nu} \cong$ Mass of lepton neutrino
$k \cong$ A coefficient needs attention and review $\cong 0.88$
$n = 1,2,3$ for electron, muon and tau respectively.
$\frac{m_{lepton}}{m_e} \cong \frac{\text{Mass of electron or Muon or Tau}}{\text{Mass of electron}}$
$M_D \cong$ Dirac mass $\cong M_{wf} \cong 584.725\ \text{GeV}/c^2$
$\cong$ Proposed electroweak fermion of our 4G model of final unification [9,10,11]
$M_{Gut} \cong$ Grand Unified mass unit
$\cong M_{Stoney} \cong \sqrt{\frac{e^2}{4\pi\varepsilon_0 G_N}} \cong 1.85921\times10^{-9}$ kg $\cong$ Stoney mass [12,13]
$G_N \cong$ Newtonian gravitational constant

The factor 0.88 is included as a phenomenological correction factor, likely tied to radiative or cosmological damping effects. These values suggest a hierarchical pattern among neutrino masses, with the electron neutrino being the lightest and tau neutrino the heaviest. This mass distribution is a natural outcome of the formula used and reflects the scaling with lepton mass and generation index. In terms of gravitational and electromagnetic force ratio associated with M_{wf} having a charge e can be expressed as,

$$m_{l\nu} \cong 0.88 * n * \sqrt{\frac{4\pi\varepsilon_0 G_N M_{wf}^2}{e^2}} \sqrt{\frac{m_{lepton}}{m_e}} \left(M_{wf}\right) \tag{2}$$

3. Calculated Neutrino Masses and the Cosmological Observations

At n=1, Electron neutrino mass is $m_{e\nu} \cong 0.289\ \text{meV}/c^2$
At n=2, Muon neutrino mass is $m_{\mu\nu} \cong 8.297\ \text{meV}/c^2$
At n=3, Tau neutrino mass is $m_{\tau\nu} \cong 51.03\ \text{meV}/c^2$
Sum of the three neutrino rest masses can be expressed as,

$$\sum m_\nu c^2 \cong (0.289)+(8.297)+(51.03) \cong 59.63\ \text{meV} \tag{3}$$

Sum of the three anti neutrino rest masses can also be expressed as,

$$\sum \overline{m_\nu} c^2 \cong (0.289)+(8.3)+(51.0) \cong 59.63\ \text{meV} \tag{4}$$

$$\sum m_\nu c^2 + \sum \overline{m_\nu} c^2 \cong 2 * 59.63 \cong 119.26\ \text{meV} \tag{5}$$

This value is consistent with cosmological observations (Planck 2018, DESI 2024) [17,18].

4. Mass Splitting of the Estimated Neutrinos Using the Squared Mass Differences

For the above estimated neutrino masses,

$$\left(m_{\tau\nu}^2 - m_{\mu\nu}^2\right)c^4 \cong 2.54\times10^{-3}\ \text{eV}^2 \tag{6}$$

$$\left(m_{\mu\nu}^2 - m_{e\nu}^2\right)c^4 \cong 6.875\times10^{-5}\ \text{eV}^2 \tag{7}$$

These values are well-aligned with experimental data from solar and atmospheric neutrino oscillations [19,20]. The mass-squared differences are key observables in neutrino physics. Their compatibility with experimental results provides support for the proposed mass model and helps validate the scaling relations applied [14–18].

5. To Replace the Stoney Scale and the Planck Scale

The Stoney scale [11,12], introduced by George Stoney before the advent of quantum theory, is based on the elementary constants e, G_N and c and defines a natural gravitational-electromagnetic mass scale. It is given by,

$$M_{Stoney} \cong \sqrt{\frac{e^2}{4\pi\varepsilon_0 G_N}} \cong 1.85921\times10^{-9} \text{ kg} \quad (8)$$

Using the definition of the fine-structure constant,

$$\alpha \cong \frac{e^2}{4\pi\varepsilon_0 \hbar c} \quad (9)$$

We obtain the relation,

$$M_{Stoney} \cong \sqrt{\alpha}\left(\sqrt{\frac{\hbar c}{G_N}}\right) \cong \sqrt{\alpha}\left(M_{Planck}\right) \quad (10)$$

This shows that the Stoney mass is naturally suppressed compared to the Planck mass by a factor of $\sqrt{\alpha} \cong \frac{1}{11.7}$. In this context, the Stoney mass may be viewed as an intermediate scale connecting gravity and electromagnetism, and its appearance in our seesaw formulation highlights a possible coupling between charged lepton mass ratios and unified gravitational effects. Thus, our proposed seesaw relation can be expressed as,

$$m_{l\upsilon} \cong \frac{k*n}{\sqrt{\alpha}} * \sqrt{\frac{m_{lepton}}{m_e}}\left(\frac{M_{wf}^2}{M_{Planck}}\right) \quad (11)$$

where $k \cong (0.85 \text{ to } 0.9) \cong 0.88$

Following this relation, quantitatively, in a trial-error method, we have noticed that,

$$\frac{k}{\sqrt{\alpha}} \cong \ln\left(\frac{M_{wf}}{\sqrt{m_p m_e}}\right) \cong 10.193$$
$$\rightarrow k \cong \sqrt{\alpha} \times \ln\left(\frac{M_{wf}}{\sqrt{m_p m_e}}\right) \cong 0.871 \quad (12)$$

Now $\frac{k*n}{\sqrt{\alpha}}$ can be expressed as,

$$\frac{k*n}{\sqrt{\alpha}} \cong n*\ln\left(\frac{M_{wf}}{\sqrt{m_p m_e}}\right) \cong \ln\left(\frac{M_{wf}}{\sqrt{m_p m_e}}\right)^n \quad (13)$$

Thus,

$$m_{l\upsilon} \cong \ln\left(\frac{M_{wf}}{\sqrt{m_p m_e}}\right)^n * \sqrt{\frac{m_{lepton}}{m_e}}\left(\frac{M_{wf}^2}{M_{Planck}}\right) \quad (14)$$

6. General Discussion

Our approach assumes Dirac neutrinos, supported by the absence of neutrino less double beta decay and lepton number violation. This contrasts with conventional Type-I seesaw models which

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typically favour Majorana neutrinos due to lepton number violation considerations. The model's consistency with cosmological bounds (total mass < 0.12 eV) strengthens its viability. The introduction of the 0.88 coefficient seems to direct towards a deeper unification of physics or understated suppression effects inherent in cosmic evolution.

The use of a Dirac framework suggests that neutrinos have distinct antiparticles and conserve lepton number. This choice is not only conceptually economical but also observationally motivated. Furthermore, the cosmological data from Planck and DESI provides strong upper limits on the neutrino mass sum, and our results satisfy these bounds comfortably.

Currently, there is limited clarity on the cosmological distinction between neutrinos and antineutrinos-particularly regarding their thermal histories, possible annihilation, and relic asymmetries. Further theoretical and observational studies are required to explore these aspects, especially in the context of Dirac neutrino models where lepton number conservation plays a crucial role.

Although neutrinos and antineutrinos can, in principle, annihilate via weak interactions, such annihilations become highly suppressed after thermal decoupling in the early universe. In the context of Dirac neutrinos, where lepton number is conserved and neutrinos are distinct from antineutrinos, it remains unclear whether any relic asymmetry could have influenced their annihilation history. This issue merits deeper theoretical investigation.

7. Applications and Significance of the 585 GeV Electroweak (Dirac) Fermion

The 585 GeV electroweak Dirac fermion posited in our 4G unification model is supported by multiple independent lines of evidence spanning nuclear physics and astrophysical observations [9–11]. Nuclear structural analyses suggest signatures consistent with the physical existence of such a heavy fermion, offering new insight into the interplay between nuclear phenomena and electroweak scale physics.

From an astrophysical perspective [9], the presence of unexplained TeV-scale gamma rays observed in galactic and extragalactic sources can be naturally accounted for by particle processes involving this 585 GeV fermion (in place of electron or proton), including annihilation and inverse Compton scattering, thereby bridging particle physics and high-energy astrophysics in a unified framework.

A key phenomenological scaling factor appearing in our model is the ratio of the geometric mean of the charged and neutral pion masses (~137.26 MeV) to that of the weak boson masses (~85.61 GeV), which numerically evaluates to approximately 0.0016. This dimensionless ratio encapsulates the profound hierarchical gap between the strong interaction scale and the electroweak scale and forms a cornerstone of the mass relations underlying our Dirac seesaw construction involving the 585 GeV electroweak fermion. Importantly, this ratio is not merely a numerical coincidence but has substantive implications for understanding nuclear stability and nuclear binding energy. The interplay of these fundamental mass scales suggests that the dynamics governing nuclear forces and nucleon interactions may be intimately connected to electroweak-scale physics mediated by the 585 GeV fermion. For a deeper exploration of how this mass ratio informs nuclear binding mechanisms and stability criteria, interested readers are encouraged to refer our recent preprints and other peer-reviewed publications [21,22], where these connections are discussed in detail with complementary theoretical and phenomenological analyses.

$$\frac{m_p}{M_{wf}} \cong 0.001605 \cong \left(\frac{\sqrt{\left(m_\pi c^2\right)^0 \left(m_\pi c^2\right)^\pm}}{\sqrt{\left(m_w c^2\right)^\pm \left(m_z c^2\right)^0}}\right) \cong \left(\frac{\sqrt{134.98\times139.57}\ \text{MeV}}{\sqrt{80379.0\times91187.6}\ \text{MeV}}\right) \cong 0.0016032 \cong \beta....(\text{say}) \tag{15}$$

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Based on this electroweak coefficient $\beta \cong 0.001605$, stability corresponding to nuclear beta decay can be understood with the following relation.

$$A_s \cong 2Z + \beta\left(2Z\right)^2 \cong 2Z + 0.00642Z^2 \tag{16A}$$

$$\frac{A_s - 2Z}{\left(2Z\right)^2} \cong \frac{A_s - 2Z}{4Z^2} \cong \beta \tag{16B}$$

One can find a similar relation in the literature [23]. This relation can be well tested for Z=21 to 92. For example,

$$\frac{45-(2\times 21)}{4(21)^2} \cong 0.00170; \quad \frac{63-(2\times 29)}{4(29)^2} \cong 0.00149; \quad \frac{89-(2\times 39)}{4(39)^2} \cong 0.00181;$$

$$\frac{109-(2\times 47)}{4(47)^2} \cong 0.0017; \quad \frac{169-(2\times 69)}{4(69)^2} \cong 0.00163; \quad \frac{238-(2\times 92)}{4(92)^2} \cong 0.001595;$$

This is one best practical and quantitative application of our proposed electroweak fermion and bosons. Following this relation and based on various semi empirical mass formulae [23–31], by knowing any stable mass number, its corresponding proton number can be estimated with,

$$Z \cong \frac{A_S}{1+\sqrt{1+0.0064A_S}} \cong \frac{A_S}{2+0.0153A_S^{2/3}} \tag{17}$$

where $\frac{a_c}{2a_{asy}} \cong \frac{0.71\text{ MeV}}{2\times 23.21\text{ MeV}} \cong \frac{0.6615\text{ MeV}}{2\times 21.6091\text{ MeV}} \cong 0.0153$

Considering this relation, we are working on understanding the stable super heavy elements.

One important point to be noted here is that, self-attractive (potential) energy of proton having a nuclear charge [9,10] of $e_n \cong 2.9464e$ and root mean square radius of 0.83 fm [11,32], can be expressed as,

$$\left(\frac{3}{5}\right)\frac{e_n^2}{4\pi\varepsilon_0 R_p} \cong \left(\frac{3}{5\alpha_s}\right)\frac{e^2}{4\pi\varepsilon_0\left(0.83\text{ fm}\right)} \cong 9.04\text{ MeV}$$

where, $R_p \cong$ Root mean square radius of proton (18)

$$\alpha_s \cong \left(\frac{e}{e_n}\right)^2 \cong \text{Strong coupling constant [9,10]} \cong 0.1152$$

With reference to the nuclear binding energy scheme, maximum binding energy per nucleon observed in the cases of Iron and Nickel atomic nuclei is around 8.8 MeV. Following this observation, independent of total binding energy calculations, maximum binding energy per nucleon for medium and heavy atomic nuclides can be expressed directly as,

$$\left\langle\frac{BE}{A_s}\right\rangle_{\max} \cong \left[1-\frac{\exp\left(A_s\beta\right)-1}{3}\right]\times\left(9.1\pm 0.05\right)\text{ MeV}$$

where $A_s > 56,\ \beta \cong 0.001605$ (19)

$$Z \approx \frac{A_s}{1+\sqrt{1+0.00642A_s}} \approx \frac{A_s}{2+0.015A_s^{2/3}}$$

Maximum binding energy per nucleon for light atomic nuclides can be expressed directly as,

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$$\left\langle \frac{BE}{A_s} \right\rangle_{\max} \cong \left(\frac{A_s}{56}\right)^{\alpha_s} \times \left(1-\left(\frac{\exp(A_s\beta)-1}{3}\right)\right) \times (9.1 \pm 0.05)\ \text{MeV} \tag{20}$$

where, $4 \le A_s \le 56$

$\alpha_s \cong$ Strong coupling constant $\cong 0.1152$

$\beta \cong 0.001605$

$$Z \approx \frac{A_s}{1+\sqrt{1+0.00642 A_s}} \approx \frac{A_s}{2+0.015 A_s^{2/3}}$$

Accuracy point of view, for light, medium and heavy atomic nuclides, energy coefficient seems to be around 9.15 MeV and for super heavy atomic nuclides, energy coefficient seems to be around 9.05 MeV. See the following Table 1 for the estimated data. It needs further study.

Proceeding further, investigations into the role of fundamental constants, notably the Planck length and the unified Stoney mass, reveal their significance in low-energy nuclear phenomena such as neutron lifetime measurements. Their inclusion in our seesaw neutrino mass formula is thus well motivated, providing an intermediate gravitational-electromagnetic mass scale that mediates neutrino mass suppression consistently with the Dirac framework.

Table 1. Estimated maximum binding energy per nucleon of assumed stable mass numbers.

Assumed stable mass number (A_s)	$(A_s\beta)$	Estimated maximum binding energy (MeV)	Estimated maximum binding energy per nucleon (MeV)	Assumed stable mass number (A_s)	$(A_s\beta)$	Estimated maximum binding energy (MeV)	Estimated maximum binding energy per nucleon (MeV)
4	0.00642	26.80	6.70	179	0.287295	1448.19	8.09
5	0.008025	34.35	6.87	180	0.2889	1455.11	8.08
6	0.00963	42.08	7.01	181	0.290505	1462.02	8.08
7	0.011235	49.94	7.13	182	0.29211	1468.91	8.07
8	0.01284	57.93	7.24	183	0.293715	1475.79	8.06
9	0.014445	66.03	7.34	184	0.29532	1482.65	8.06
10	0.01605	74.22	7.42	185	0.296925	1489.50	8.05
11	0.017655	82.49	7.50	186	0.29853	1496.33	8.04
12	0.01926	90.85	7.57	187	0.300135	1503.15	8.04
13	0.020865	99.28	7.64	188	0.30174	1509.95	8.03
14	0.02247	107.77	7.70	189	0.303345	1516.73	8.03
15	0.024075	116.33	7.76	190	0.30495	1523.50	8.02
16	0.02568	124.94	7.81	191	0.306555	1530.26	8.01
17	0.027285	133.61	7.86	192	0.30816	1537.00	8.01
18	0.02889	142.32	7.91	193	0.309765	1543.73	8.00
19	0.030495	151.08	7.95	194	0.31137	1550.44	7.99
20	0.0321	159.89	7.99	195	0.312975	1557.13	7.99
21	0.033705	168.73	8.03	196	0.31458	1563.81	7.98
22	0.03531	177.62	8.07	197	0.316185	1570.47	7.97
23	0.036915	186.54	8.11	198	0.31779	1577.12	7.97
24	0.03852	195.50	8.15	199	0.319395	1583.76	7.96
25	0.040125	204.49	8.18	200	0.321	1590.37	7.95
26	0.04173	213.51	8.21	201	0.322605	1596.98	7.95
27	0.043335	222.56	8.24	202	0.32421	1603.56	7.94

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28	0.04494	231.64	8.27
29	0.046545	240.75	8.30
30	0.04815	249.88	8.33
31	0.049755	259.04	8.36
32	0.05136	268.22	8.38
33	0.052965	277.43	8.41
34	0.05457	286.65	8.43
35	0.056175	295.90	8.45
36	0.05778	305.17	8.48
37	0.059385	314.46	8.50
38	0.06099	323.76	8.52
39	0.062595	333.08	8.54
40	0.0642	342.42	8.56
41	0.065805	351.78	8.58
42	0.06741	361.15	8.60
43	0.069015	370.53	8.62
44	0.07062	379.93	8.63
45	0.072225	389.34	8.65
46	0.07383	398.77	8.67
47	0.075435	408.21	8.69
48	0.07704	417.66	8.70
49	0.078645	427.12	8.72
50	0.08025	436.59	8.73
51	0.081855	446.07	8.75
52	0.08346	455.56	8.76
53	0.085065	465.07	8.77
54	0.08667	474.58	8.79
55	0.088275	484.10	8.80
56	0.08988	493.63	8.81
57	0.091485	502.14	8.81
58	0.09309	510.64	8.80
59	0.094695	519.12	8.80
60	0.0963	527.60	8.79
61	0.097905	536.07	8.79
62	0.09951	544.52	8.78
63	0.101115	552.97	8.78
64	0.10272	561.40	8.77
65	0.104325	569.82	8.77
66	0.10593	578.23	8.76
67	0.107535	586.63	8.76
68	0.10914	595.01	8.75
69	0.110745	603.39	8.74
70	0.11235	611.75	8.74
71	0.113955	620.10	8.73
72	0.11556	628.45	8.73
73	0.117165	636.77	8.72
74	0.11877	645.09	8.72
75	0.120375	653.40	8.71
76	0.12198	661.69	8.71
77	0.123585	669.98	8.70
78	0.12519	678.25	8.70
203	0.325815	1610.13	7.93
204	0.32742	1616.69	7.92
205	0.329025	1623.23	7.92
206	0.33063	1629.75	7.91
207	0.332235	1636.26	7.90
208	0.33384	1642.75	7.90
209	0.335445	1649.22	7.89
210	0.33705	1655.68	7.88
211	0.338655	1662.13	7.88
212	0.34026	1668.56	7.87
213	0.341865	1674.97	7.86
214	0.34347	1681.36	7.86
215	0.345075	1687.74	7.85
216	0.34668	1694.11	7.84
217	0.348285	1700.46	7.84
218	0.34989	1706.79	7.83
219	0.351495	1713.10	7.82
220	0.3531	1719.40	7.82
221	0.354705	1725.68	7.81
222	0.35631	1731.95	7.80
223	0.357915	1738.20	7.79
224	0.35952	1744.43	7.79
225	0.361125	1750.65	7.78
226	0.36273	1756.85	7.77
227	0.364335	1763.04	7.77
228	0.36594	1769.20	7.76
229	0.367545	1775.35	7.75
230	0.36915	1781.49	7.75
231	0.370755	1787.61	7.74
232	0.37236	1793.71	7.73
233	0.373965	1799.79	7.72
234	0.37557	1805.86	7.72
235	0.377175	1811.91	7.71
236	0.37878	1817.94	7.70
237	0.380385	1823.96	7.70
238	0.38199	1829.96	7.69
239	0.383595	1835.94	7.68
240	0.3852	1841.91	7.67
241	0.386805	1847.86	7.67
242	0.38841	1853.79	7.66
243	0.390015	1859.70	7.65
244	0.39162	1865.60	7.65
245	0.393225	1871.48	7.64
246	0.39483	1877.34	7.63
247	0.396435	1883.19	7.62
248	0.39804	1889.01	7.62
249	0.399645	1894.82	7.61
250	0.40125	1900.62	7.60
251	0.402855	1906.39	7.60
252	0.40446	1912.15	7.59
253	0.406065	1917.89	7.58

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79	0.126795	686.51	8.69
80	0.1284	694.75	8.68
81	0.130005	702.99	8.68
82	0.13161	711.21	8.67
83	0.133215	719.42	8.67
84	0.13482	727.62	8.66
85	0.136425	735.81	8.66
86	0.13803	743.99	8.65
87	0.139635	752.15	8.65
88	0.14124	760.31	8.64
89	0.142845	768.45	8.63
90	0.14445	776.57	8.63
91	0.146055	784.69	8.62
92	0.14766	792.80	8.62
93	0.149265	800.89	8.61
94	0.15087	808.97	8.61
95	0.152475	817.04	8.60
96	0.15408	825.09	8.59
97	0.155685	833.13	8.59
98	0.15729	841.17	8.58
99	0.158895	849.18	8.58
100	0.1605	857.19	8.57
101	0.162105	865.18	8.57
102	0.16371	873.17	8.56
103	0.165315	881.14	8.55
104	0.16692	889.09	8.55
105	0.168525	897.04	8.54
106	0.17013	904.97	8.54
107	0.171735	912.89	8.53
108	0.17334	920.80	8.53
109	0.174945	928.69	8.52
110	0.17655	936.57	8.51
111	0.178155	944.44	8.51
112	0.17976	952.30	8.50
113	0.181365	960.14	8.50
114	0.18297	967.97	8.49
115	0.184575	975.79	8.49
116	0.18618	983.59	8.48
117	0.187785	991.39	8.47
118	0.18939	999.17	8.47
119	0.190995	1006.93	8.46
120	0.1926	1014.69	8.46
121	0.194205	1022.43	8.45
122	0.19581	1030.16	8.44
123	0.197415	1037.87	8.44
124	0.19902	1045.57	8.43
125	0.200625	1053.26	8.43
126	0.20223	1060.94	8.42
127	0.203835	1068.60	8.41
128	0.20544	1076.25	8.41
129	0.207045	1083.89	8.40
254	0.40767	1923.62	7.57
255	0.409275	1929.32	7.57
256	0.41088	1935.01	7.56
257	0.412485	1940.68	7.55
258	0.41409	1946.33	7.54
259	0.415695	1951.97	7.54
260	0.4173	1957.58	7.53
261	0.418905	1963.18	7.52
262	0.42051	1968.76	7.51
263	0.422115	1974.33	7.51
264	0.42372	1979.87	7.50
265	0.425325	1985.40	7.49
266	0.42693	1990.91	7.48
267	0.428535	1996.40	7.48
268	0.43014	2001.87	7.47
269	0.431745	2007.33	7.46
270	0.43335	2012.76	7.45
271	0.434955	2018.18	7.45
272	0.43656	2023.58	7.44
273	0.438165	2028.96	7.43
274	0.43977	2034.32	7.42
275	0.441375	2039.67	7.42
276	0.44298	2044.99	7.41
277	0.444585	2050.30	7.40
278	0.44619	2055.59	7.39
279	0.447795	2060.86	7.39
280	0.4494	2066.11	7.38
281	0.451005	2071.35	7.37
282	0.45261	2076.56	7.36
283	0.454215	2081.76	7.36
284	0.45582	2086.93	7.35
285	0.457425	2092.09	7.34
286	0.45903	2097.23	7.33
287	0.460635	2102.35	7.33
288	0.46224	2107.45	7.32
289	0.463845	2112.53	7.31
290	0.46545	2117.59	7.30
291	0.467055	2122.64	7.29
292	0.46866	2127.66	7.29
293	0.470265	2132.67	7.28
294	0.47187	2137.65	7.27
295	0.473475	2142.62	7.26
296	0.47508	2147.57	7.26
297	0.476685	2152.50	7.25
298	0.47829	2157.41	7.24
299	0.479895	2162.29	7.23
300	0.4815	2167.16	7.22
301	0.483105	2172.01	7.22
302	0.48471	2176.85	7.21
303	0.486315	2181.66	7.20
304	0.48792	2186.45	7.19

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130	0.20865	1091.51	8.40	305	0.489525	2191.22	7.18
131	0.210255	1099.12	8.39	306	0.49113	2195.97	7.18
132	0.21186	1106.72	8.38	307	0.492735	2200.70	7.17
133	0.213465	1114.30	8.38	308	0.49434	2205.42	7.16
134	0.21507	1121.87	8.37	309	0.495945	2210.11	7.15
135	0.216675	1129.43	8.37	310	0.49755	2214.78	7.14
136	0.21828	1136.97	8.36	311	0.499155	2219.43	7.14
137	0.219885	1144.50	8.35	312	0.50076	2224.06	7.13
138	0.22149	1152.01	8.35	313	0.502365	2228.68	7.12
139	0.223095	1159.52	8.34	314	0.50397	2233.27	7.11
140	0.2247	1167.01	8.34	315	0.505575	2237.84	7.10
141	0.226305	1174.48	8.33	316	0.50718	2242.39	7.10
142	0.22791	1181.94	8.32	317	0.508785	2246.92	7.09
143	0.229515	1189.39	8.32	318	0.51039	2251.43	7.08
144	0.23112	1196.83	8.31	319	0.511995	2255.92	7.07
145	0.232725	1204.25	8.31	320	0.5136	2260.39	7.06
146	0.23433	1211.66	8.30	321	0.515205	2264.84	7.06
147	0.235935	1219.05	8.29	322	0.51681	2269.27	7.05
148	0.23754	1226.43	8.29	323	0.518415	2273.68	7.04
149	0.239145	1233.80	8.28	324	0.52002	2278.07	7.03
150	0.24075	1241.15	8.27	325	0.521625	2282.44	7.02
151	0.242355	1248.49	8.27	326	0.52323	2286.78	7.01
152	0.24396	1255.81	8.26	327	0.524835	2291.11	7.01
153	0.245565	1263.12	8.26	328	0.52644	2295.42	7.00
154	0.24717	1270.42	8.25	329	0.528045	2299.70	6.99
155	0.248775	1277.70	8.24	330	0.52965	2303.96	6.98
156	0.25038	1284.97	8.24	331	0.531255	2308.21	6.97
157	0.251985	1292.22	8.23	332	0.53286	2312.43	6.97
158	0.25359	1299.46	8.22	333	0.534465	2316.63	6.96
159	0.255195	1306.69	8.22	334	0.53607	2320.81	6.95
160	0.2568	1313.90	8.21	335	0.537675	2324.97	6.94
161	0.258405	1321.10	8.21	336	0.53928	2329.10	6.93
162	0.26001	1328.28	8.20	337	0.540885	2333.22	6.92
163	0.261615	1335.45	8.19	338	0.54249	2337.32	6.92
164	0.26322	1342.61	8.19	339	0.544095	2341.39	6.91
165	0.264825	1349.75	8.18	340	0.5457	2345.44	6.90
166	0.26643	1356.87	8.17	341	0.547305	2349.47	6.89
167	0.268035	1363.99	8.17	342	0.54891	2353.48	6.88
168	0.26964	1371.08	8.16	343	0.550515	2357.47	6.87
169	0.271245	1378.17	8.15	344	0.55212	2361.44	6.86
170	0.27285	1385.23	8.15	345	0.553725	2365.38	6.86
171	0.274455	1392.29	8.14	346	0.55533	2369.30	6.85
172	0.27606	1399.33	8.14	347	0.556935	2373.21	6.84
173	0.277665	1406.35	8.13	348	0.55854	2377.09	6.83
174	0.27927	1413.36	8.12	349	0.560145	2380.94	6.82
175	0.280875	1420.36	8.12	350	0.56175	2384.78	6.81
176	0.28248	1427.34	8.11	351	0.563355	2388.59	6.81
177	0.284085	1434.30	8.10	352	0.56496	2392.39	6.80
178	0.28569	1441.25	8.10	353	0.566565	2396.16	6.79

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Collectively, these theoretical and phenomenological findings position the 585 GeV electroweak Dirac fermion as a well-founded component connecting neutrino mass generation, nuclear structure, and cosmic high-energy phenomena. This synthesis motivates targeted experimental strategies both at collider experiments and in astrophysical observations to test the existence and properties of this particle, advancing our understanding of fundamental mass hierarchies and unification.

8. Conclusion Our 4G model of final unification, combined with a Dirac seesaw mechanism and lepton mass ratios, yields physically meaningful neutrino mass estimates consistent with known neutrino oscillations and cosmological data. Further exploration of the proposed 585 GeV Dirac mass and the unified gravitational Stoney mass may uncover deeper structures in neutrino physics. This approach offers a compelling alternative to conventional Majorana-based models, and its alignment with data encourages further theoretical and phenomenological development. Future studies may focus on refining the damping coefficient, exploring links with quantum gravity, and identifying potential experimental signals.

Data availability statement: The data that support the findings of this study are openly available.

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