The Supersymmetric Planck Model

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In the Planck Model, broken symmetries are manifested on the mass levels of the three Planck sequences. Superpartners, resulting from the breaking of supersymmetry, are arranged symmetrically about superlevels within each sequence. There are two types of superlevel: every third level in each sequence (Type 1) and every fifth level in each sequence (Type 2). The superpartners of each charged lepton and quark are identified; the superpartnerships are centred on superlevels of Type 1. The electron, the up quark and, intriguingly, the proton participate in superpartnerships that are symmetrically arranged about coincident superlevels of Type 1. The W and Z weak gauge bosons and the 126 GeV Higgs boson participate in a trio of superpartnerships about three coincident superlevels of Type 2. Coincident superlevels are rare, concentrated at known particle mass scales, and lie in a symmetric pattern that results from the interplay of the Planck sequences. The pattern of coincident superlevels extends from the GUT scale to meV scale, forming the background to the see-saw mechanism of neutrino mass generation.

1 Introduction

Since the early days of this project [1], there have been signs of supersymmetry, or rather the breaking of supersymmetry. Those signs were of baryon-meson superpartners: hadrons sharing some quantum numbers other than spin. Superpartners were found to be symmetrically arranged about mass levels within the Planck sequences [2, 3]. Here, a comprehensive phenomenological study is made of the charged leptons, quarks, weak gauge bosons and the Higgs boson, and their superpartners.

In the Planck Model [4], particles lie on mass levels within each of three geometric sequences. The sequences descend from the Planck Mass, $1.220932(73) \times 10^{19}$ GeV [5], and are of common ratio $1/\pi$ (Sequence 1), $2/\pi$ (Sequence 2) and $1/e$ (Sequence 3). Mass levels within the three sequences are assigned the level-numbers n_1, n_2 and n_3. For example, level-number $n_3 = 40$ refers to a level of mass $(1/e)^{40}.M_P$ within Sequence 3. Broken symmetries are manifested on the levels of the Planck sequences. All isospin doublets, the quarks of each generation, the spin-½ uds baryons, Λ (I=0) and Σ^0 (I=1), and the weak gauge bosons, $W^{\pm}$ and Z^0, are arranged symmetrically about mass levels, and sublevels of fractional level-number [6, 7]. The quark doublets are arranged about levels whose level-numbers are multiples of 5. The Λ and Σ^0

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baryons are arranged about a level. The weak gauge bosons are arranged about coincident half-levels. Since supersymmetry is broken in nature, the Planck Model offers a way of identifying superpartners from their arrangement on the mass levels.

The particle mass evaluations of the Particle Data Group [8] have been used with the exception of the quark masses, which are those of the Planck Model. There is no significant difference between the Planck Model values and the central values of Particle Data Group evaluation. The quark masses are shown in Table 1.

Quark	Mass in the Planck Model [4]	Central value of Particle Data Group evaluation [8]
up	2.177 MeV	2.3 MeV
down	4.888 MeV	4.8 MeV
strange	96.13 MeV	95 MeV
charm	1.271 GeV	1.275 GeV
bottom	4.275 GeV	4.18 GeV ($\overline{MS}$) 4.66 GeV (1S)
top	174.1 GeV	173.1 GeV

Table 1: Quark masses in the Planck Model

A two-dimensional representation of the mass level structure is used in the figures so that the occupation by particles of coincident levels is highlighted. In such a representation the particles are constrained to lie on a diagonal line since level-numbers in the three Planck sequences are in constant ratio. The error bars would lie along the diagonal line but their lengths are insignificant.

2 Superpartners of the charged leptons

The charged leptons and their evident charged spin-0 partners are arranged symmetrically about Type 1 superlevels (levels whose level-numbers are multiples of 3), as shown in Figures 1 and 2. The following charged lepton-pseudoscalar meson partnerships may be seen:

- $\mu - \pi^-$, about Level 102 in Sequence 2
- $e - K^-$, about Levels 42, 106.5 and 48 in Sequences 1, 2 and 3, respectively
- $\tau - D^-$, about Level 96 in Sequence 2

Note that the $e - K^-$ partnership is centred on a superlevel coincidence, i.e. (42, 48) in Sequences 1 and 3, and on a half-superlevel (Level 106.5) in Sequence 2. Superlevel coincidences are rare and significant locations in the Planck Model.

Two other close superlevel coincidences are shown in Figure 1: (39, 99) in Sequences 1 and 2, occupied by the K mesons, and (45, 114) in Sequences 1 and 2, occupied by the electron.

3 Superpartners of the quarks

The up quark lies in symmetrical arrangement with the $\mu - \pi^-$ partnership about the same level coincidence as the $e - K^-$ partnership: (42, 106.5, 48). The $\mu - \pi^-$ partnership is represented in mass by the geometric mean of the two particle masses. The $u - (\mu - \pi^-)$ partnership is shown on the levels of Sequences 1 and 2 in Figure 3.

The down quark lies in symmetrical arrangement with the η meson about the level coincidence (41, 104) in Sequences 1 and 2, as shown in Figure 4. The up – down weak isospin doublet, centred on Level 110 in Sequence 2 [7], lies in symmetrical arrangement with the ω vector meson about the same level coincidence: (41, 104).

The (down-type) strange quark lies in symmetrical arrangement with the η' meson about Level 100 (a superlevel) in Sequence 2, adjacent to the Type 2 superlevel coincidence (100, 45) in Sequences 1 and 3, as shown in Figure 5. Type 2 superlevels have level-numbers that are multiples of 5. Level 102 in Sequence 2 and the ϕ vector meson are arranged symmetrically about Level 45 in Sequence 3, again adjacent to the superlevel coincidence (100, 45) in Sequences 1 and 3. Level 102, which is adjacent to the strange quark mass, has been suggested as the domain of a unit of strange hadron mass [1]. That unit is here conjectured to be a neutral fermion, s´. The neutron is included in Figure 5 as it is symmetrically arranged with the η' meson about Level 44 in Sequence 3.

The (up-type) charm quark is arranged about the level/half-superlevel coincidence (38, 43.5) in Sequences 1 and 3 with the $\tau - D^-$ partnership, as shown on the levels of Sequences 1 and 3 in Figure 6. The $\tau - D^-$ partnership is represented in mass by the geometric mean of the two particle masses. Level 97 in Sequence 2 and the D_s^* charged vector meson are arranged

symmetrically about the coincidence (38, 43.5) in Sequences 1 and 3, and also about a ⅓-level (Level 97.333) in Sequence 2, as shown in Figure 7. Such sublevels (⅓-levels) have been observed previously [9]. Level 97 in Sequence 2, which is adjacent to the charm quark mass, has been suggested as the domain of a unit of charmed hadron mass [1]. That unit is here conjectured to be a charged fermion, c´.

The (down-type) bottom quark is arranged about Level 37 in Sequence 1 with the B^0 meson, as shown in Figure 8. Level 94 in Sequence 2 and the B_s* neutral vector meson are arranged symmetrically about Level 37. Level 94 is conjectured to be the domain of a neutral fermion, b´, a unit of bottom hadron mass.

To conclude, the up-type quarks partner charged mesons, which themselves are in partnership with charged leptons. The down-type quarks partner neutral mesons. Precisely symmetric arrangements exist between the conjectured fermions, s´, c´ and b´, and vector mesons with strange quark content.

The various partnerships are grouped according to quark content in Table 2.

First group	$\mu - \pi^-$	$u - (\mu - \pi^-)$	$(u - d) - \omega$
		$d - \eta$	
Second group	$e - K^-$	$s - \eta'$	$s' - \phi$
Third group	$\tau - D^-$	$c - (\tau - D^-)$	$c' - D_s^*$
Fourth group	-	$b - B^0$	$b' - B_s^*$

Table 2: Four groups of supersymmetric partnerships in the Planck Model, involving the charged leptons and quarks, grouped according to quark content. Superpartners are shown connected by dashes. The conjectured fermions s', c' and b' occupy Levels 102, 97 and 94, respectively, in Sequence 2.

4 The (b – t) – WZH trio of superpartnerships

The bottom – top quark doublet partners three groups of bosons ($W^{\pm} - Z^0$, $Z^0 - H^0$ and $W^{\pm} - H^0$), separately, about the Type 2 superlevel coincidence (35, 40) in Sequences 1 and 3, as shown in Figures 9–11. Each group of bosons is arranged in doublet configuration (symmetrically) about

a prominent level or levels in the Planck sequences. The $W^{\pm} - Z^0$ arrangement is symmetrically arranged about coincident half-levels in Sequences 1 and 3. The $Z^0 - H^0$ arrangement is symmetrically arranged about Level 87, a superlevel, in Sequence 2. The $W^{\pm} - H^0$ arrangement is symmetrically arranged about a sublevel in Sequence 3. The (b – t) – ($W^{\pm} - Z^0$) superpartnership is centred on Level 35 in Sequence 1. The (b – t) – ($Z^0 - H^0$) superpartnership is centred on Level 88.5, a Type 1 half-superlevel, in Sequence 2. The (b – t) – ($W^{\pm} - H^0$) superpartnership is centred on Level 40 in Sequence 3.

5 A stable partnership

Atomic nuclei occupy mass sublevels within the Planck sequences [10, 11]. Stable nuclei, in particular those of lightest mass and those of double magic number, occupy the most prominent sublevels. The proton and the ^{56}Fe atomic nucleus, spin-0 boson, have now been found to be symmetrically arranged about the most precise superlevel coincidence known: (93, 42) in Sequences 2 and 3, of mass 7.0 GeV, as shown in Figure 12. The ^{56}Fe nucleus, which occupies Level 40 in Sequence 3, has the highest binding energy per nucleon of any atomic nucleus.

6 The symmetric pattern of coincident superlevels

The five most precise superlevel coincidences that occur at mass scales between 1 eV and 1000 TeV are:

- (45, 114) in Sequences 1 and 2, the domain of the electron
- (39, 99) in Sequences 1 and 2, the domain of the K mesons
- (42, 48) in Sequences 1 and 3, the centre of both the e – K^- and the u – ($\mu - \pi^-$) partnerships
- (93, 42) in Sequences 2 and 3, the centre of the p–^{56}Fe partnership
- (35, 40) in Sequences 1 and 3, the centre of the (b – t) – WZH trio

Closely coincident superlevels are concentrated in the mass range 0.1 MeV – 100 GeV, as are the known particles. The interplay of the three Planck sequences gives rise to this phenomenon. A detailed search for coincident superlevels of the two types (with level-numbers that are multiples of 3 or 5) has revealed a symmetric pattern of coincident superlevels that extends from within three orders of magnitude of the Planck Mass to meV scale. The pattern is shown in Table 3. The mass scales of the coincident superlevels are shown in Figure 13.

Sequence 1	Sequence 2	Sequence 3	Occupying superpartnership, particle, or mass scale
6	15	6	$1\text{-}3 \times 10^{16}$ GeV
	33	15	$\sim 4 \times 10^{12}$ GeV
21		24	$\sim 4.5 \times 10^{8}$ GeV
35	90	40	$(b - t) - (W^{\pm} - Z^{0})$ (S1) $(b - t) - (Z^{0} - H^{0})$ (S2) $(b - t) - (W^{\pm} - H^{0})$ (S3)
	93	42	$p - {}^{56}Fe$
39	99		K^{-}
40	100	45	$s - \eta'$ (S2) $s' - \phi$ (S3)
42		48	$e - K^{-}$ $u - (\mu - \pi^{-})$
45	114		e
60	153	69	10-20 meV

Table 3: The symmetrical pattern of coincident superlevels. The level-numbers of coincident superlevels of each type are shown on the same row. Orange indicates coincident superlevels of Type 1. Blue indicates coincident superlevels of Type 2. The integer level-numbers in each sequence have been compared with the corresponding non-integer level-numbers in the other two sequences. Closely coincident superlevels have level-numbers that are within about 0.1 of each other, both (integer) level-numbers being multiples of either 3 or 5. The triple coincidences are slightly more approximate. The partnerships identified at triple superlevel coincidences are symmetrically arranged about superlevels (in one case, a half-superlevel) within the sequences shown in brackets.

Four approximate triple superlevel coincidences occur within the pattern of coincident superlevels. One of these, (35, 90, 40), lies at the centre of the (b – t) – WZH trio. One, (40, 100, 45), lies at the centre of the s – η', s' – ϕ duo. One, (6, 15, 6), lies at a scale of 1-3 x 10^{16} GeV, ~ GUT scale. The fourth triple superlevel coincidence, (60, 153, 69), lies at a scale of 10-20 meV, which is within the range of credible neutrino masses and is consistent with the upper bound of 0.26 eV on the sum of the neutrino masses from Planck data [12].

7 The neutrino mass scale

In the Planck Model, the GUT scale, the mass of the electron and the masses of the up-type quarks are related to Planck scale through multiplication by integer powers of $(\pi/2)^{25}$ and α, the fine structure constant. Now, it seems that the (lightest?) neutrino mass scale is similarly related to Planck scale, as shown in Table 4.

Particle or scale	Mass from experiment*	Relationship to Planck scale in the Planck Model	Value in the Planck Model
GUT scale	2.1×10^{16} GeV	$M_{GUT} = \propto^{-1} \left(\frac{\pi}{2}\right)^{-25} M_{Planck}$	2.092×10^{16} GeV
top quark	173.1 GeV [8]	$m_{top} = \propto \left(\frac{\pi}{2}\right)^{-75} M_{Planck}$	174.1 GeV
charm quark	1.275 GeV [8]	$m_{\text{charm}} = \propto^{2} \left(\frac{\pi}{2}\right)^{-75} M_{Planck}$	1.271 GeV
up quark	2.3 MeV [8]	$m_{up} = \propto \left(\frac{\pi}{2}\right)^{-100} M_{Planck}$	2.177 MeV
electron	0.5110 MeV	$m_{electron} = \propto^{-1} \left(\frac{\pi}{2}\right)^{-125} M_{Planck}$	0.5111 MeV
neutrino	-	$m_{neutrino} = \propto^{-2} \left(\frac{\pi}{2}\right)^{-175} M_{Planck}$	10.95 meV

*Central values

Table 4: Mass scales in the Planck Model

8 Discussion

A self-consistent set of fermion-boson mass relationships has been found. The partnerships are centred on mass levels in general and, as shown here, on superlevels and coincident superlevels. In the extra-dimensional geometry of the Planck Model, supersymmetry is broken on D-branes,

and in particular on the intersections of D-branes that wrap covering spaces [13]. Arkani-Hamed, Dimopoulos, Dvali and Kaloper have shown that gravity can be localised to the intersection of orthogonal (2+n)-branes lying in an infinite AdS_{n+4} spacetime [14]. Our spacetime may include a spherical component, the intersecting D-branes being located in an $AdS_6 \times S^4$ spacetime [9].

The particle mass scales of the world arise from the interplay of the Planck sequences. The pattern of coincident superlevels extends from ~ 2×10^{16} GeV, the GUT scale, to ~ 15 meV, forming the background to the see-saw mechanism of neutrino mass generation. See [15] for a review of neutrino mass models. The Planck Model particle mass equations suggest that the lightest neutrino has a mass of 10.95 meV.

9 References

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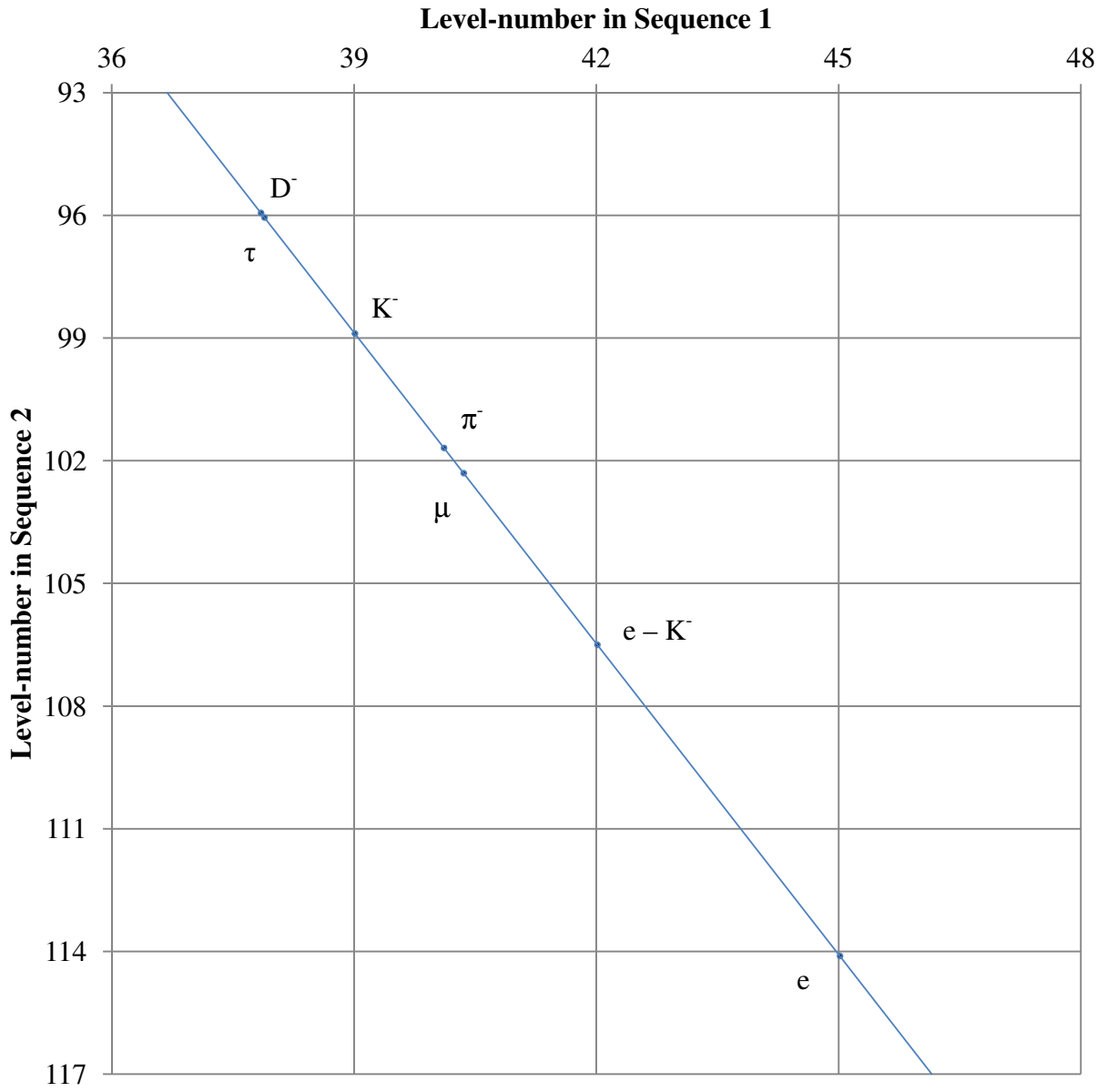

Figure 1: The charged leptons and their pseudoscalar partners in Sequences 1 and 2. Each partnership is centred on a Type 1 superlevel (a level assigned a number that is a multiple of 3). The electron – charged K meson partnership is centred on Level 42 in Sequence 1 and Level 106.5, a half-superlevel, in Sequence 2. Particles are constrained to lie on the blue line.

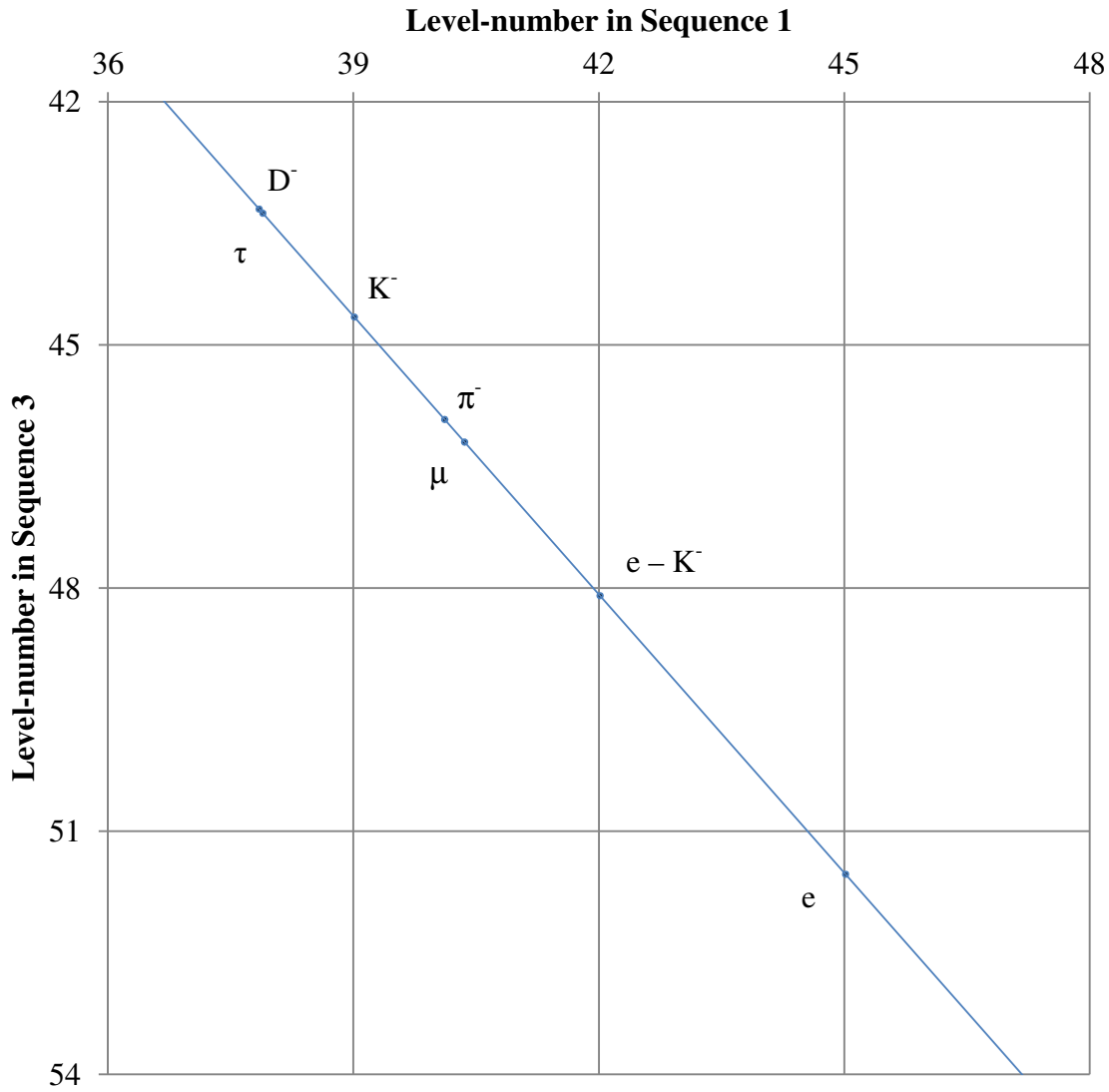

Figure 2: The charged leptons and their pseudoscalar partners in Sequences 1 and 3. The electron – charged K meson partnership is centred on the Type 1 superlevel coincidence (42, 48).

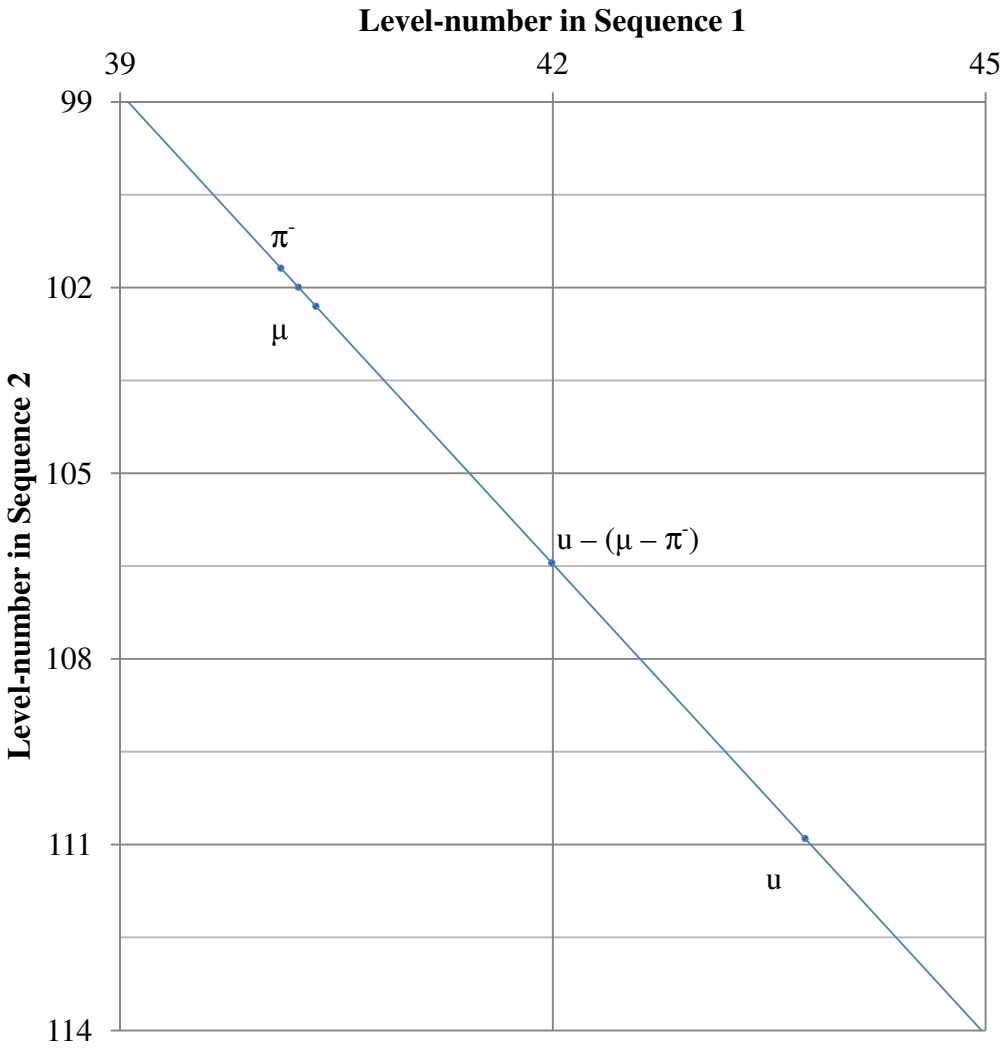

Figure 3: The up quark in partnership with the muon and charged pion on the Type 1 superlevels of Sequences 1 and 2. The $\mu - \pi^-$ partnership is represented in mass by the geometric mean of the two masses, which is marked with a dot. The $u - (\mu - \pi^-)$ partnership is centred on the superlevel/half-superlevel coincidence (42, 106.5) in Sequences 1 and 2, and on Level 48, a superlevel, in Sequence 2, as is the electron – charged K meson partnership.

The quark mass used here (2.177 MeV) is that of the Planck Model and does not differ significantly from the Particle Data Group central value (2.3 MeV).

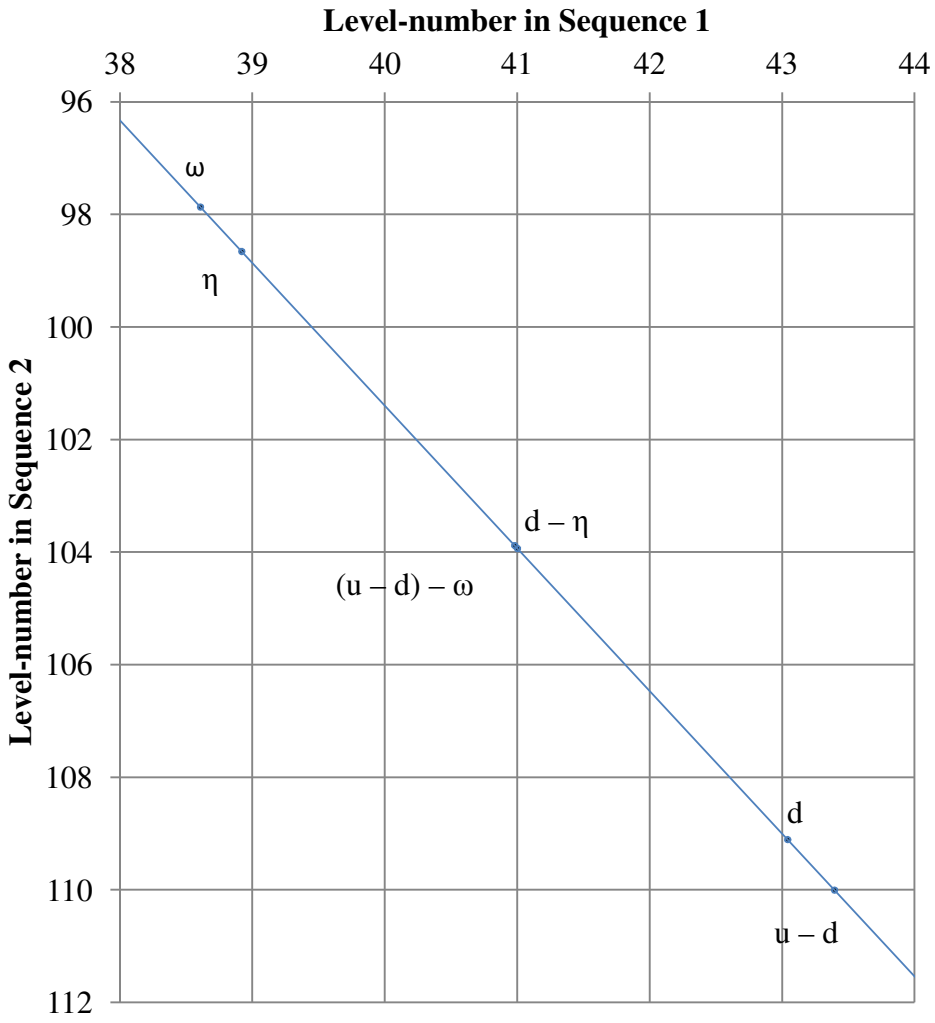

Figure 4: The down quark in partnership with the η meson on the levels of Sequences 1 and 2. Also, the partnership of the u – d quark doublet, which is centred on Level 110 in Sequence 2 [7], and the ω vector meson. Both partnerships are centred on the level coincidence (41, 104) in Sequences 1 and 2.

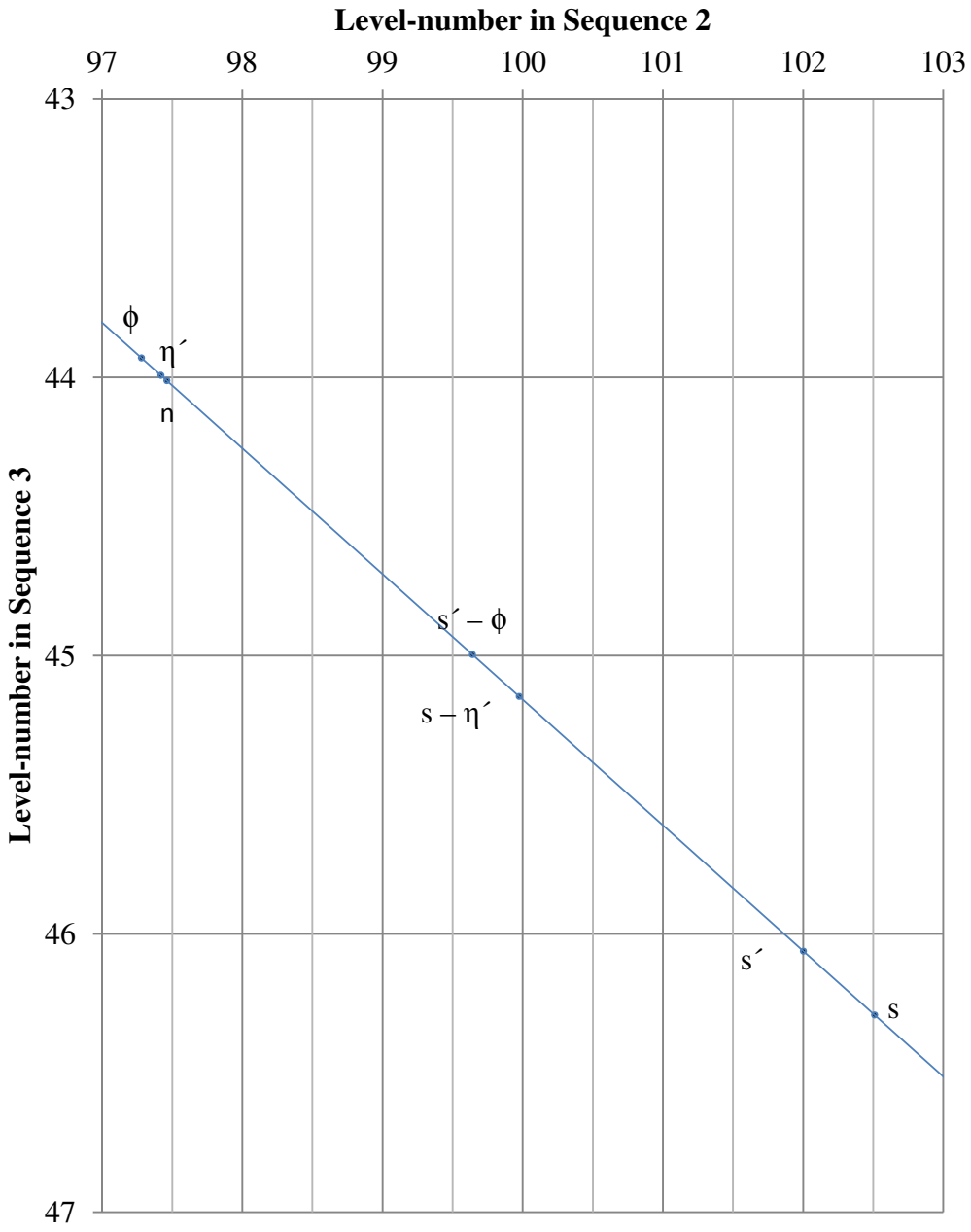

Figure 5: The strange quark in partnership with the η´ meson on the levels of Sequences 2 and 3. Also, the partnership of a conjectured neutral fermion (s´) occupying Level 102 in Sequence 2 and the ϕ vector meson. Each partnership is centred on a superlevel adjacent to the Type 2 superlevel coincidence (100, 45) in Sequences 2 and 3. The neutron lies in a symmetric arrangement with the η´ meson about Level 44 in Sequence 3.

The strange quark mass used here (96.13 MeV) is that of the Planck Model and does not differ significantly from the Particle Data Group central value (95 MeV).

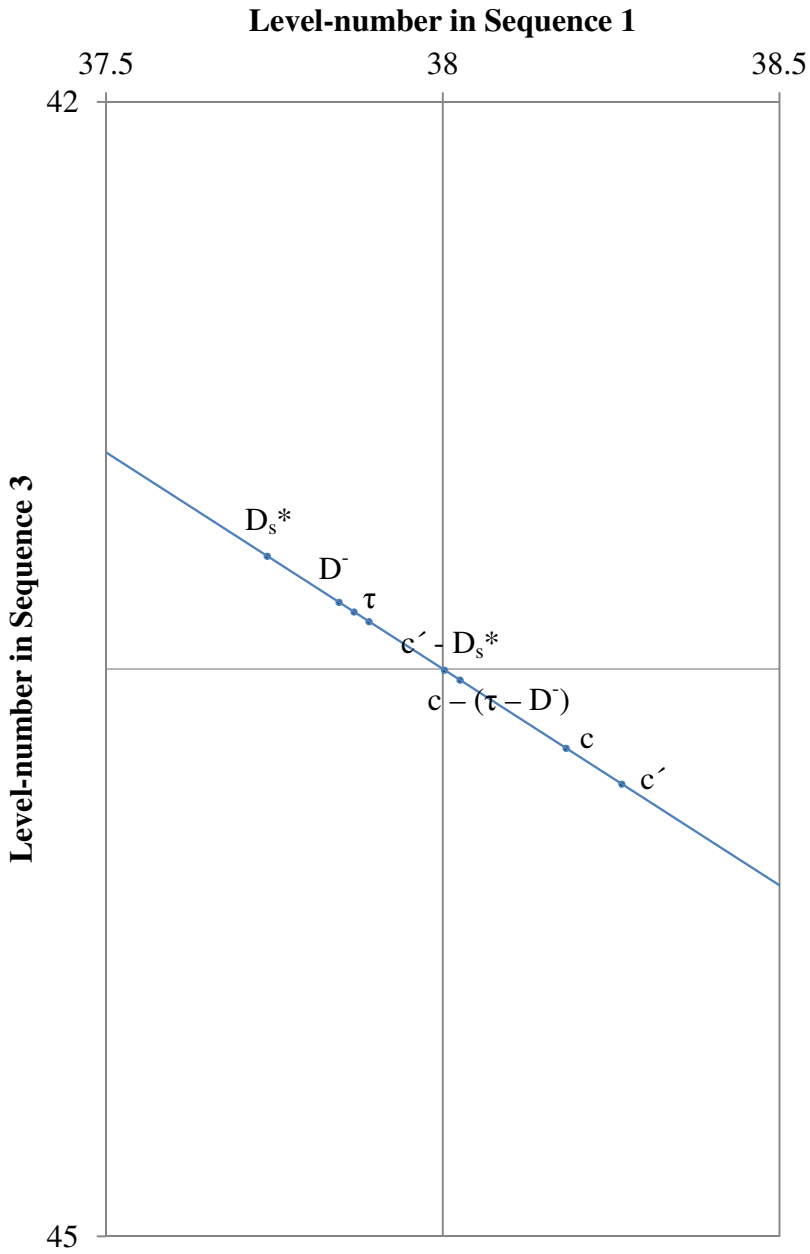

Figure 6: The charm quark in partnership with the tau lepton and charged D meson on the levels of Sequences 1 and 3; the $\tau - D^-$ partnership is represented in mass by the geometric mean of the two masses, which is marked with a dot. Also, the partnership of a conjectured charged fermion (c´) occupying Level 97 in Sequence 2 and the D_s* vector meson. The partnerships are centred on the level/half-superlevel coincidence (38, 43.5) in Sequences 1 and 3.

The charm quark mass used here (1.271 GeV) is that of the Planck Model and does not differ significantly from the Particle Data Group central value (1.275 GeV).

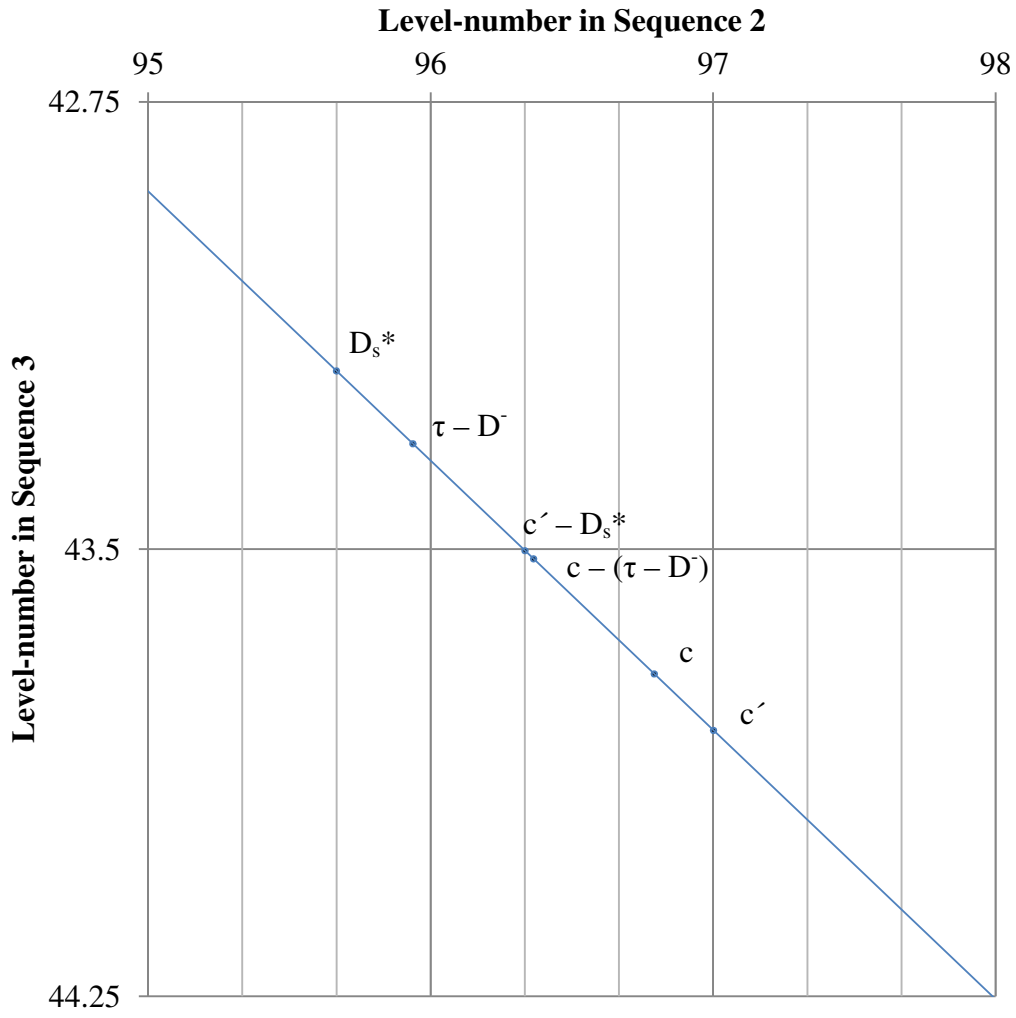

Figure 7: The c – D^- and c´ – D_s* partnerships on the levels of Sequences 2 and 3. The partnerships are centred on a ⅓-level in Sequence 2; such sublevels (⅓-levels) have been observed previously [9].

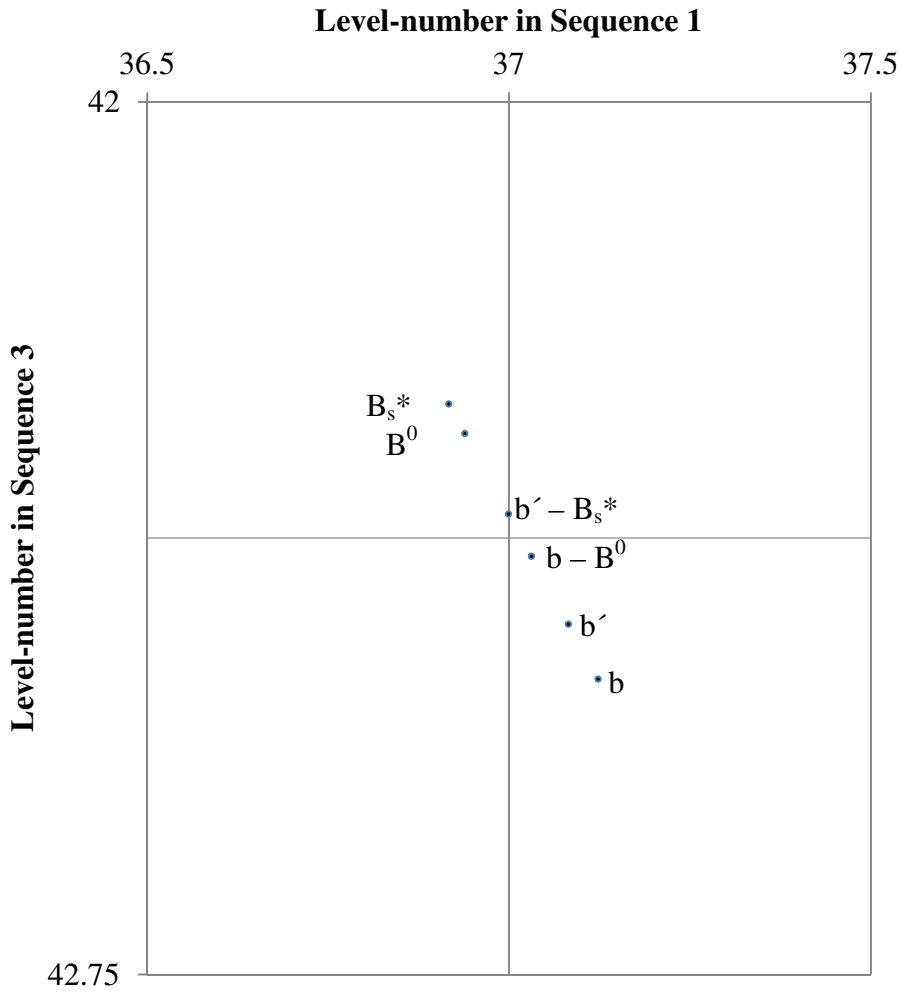

Figure 8: The bottom quark in partnership with the neutral B meson on the levels of Sequences 1 and 3. Also, the partnership of a conjectured neutral fermion (b´) occupying Level 94 in Sequence 2 and the B_s* vector meson. The partnerships are centred on Level 37 in Sequence 1.

The bottom quark mass used here (4.275 GeV) is that of the Planck Model.

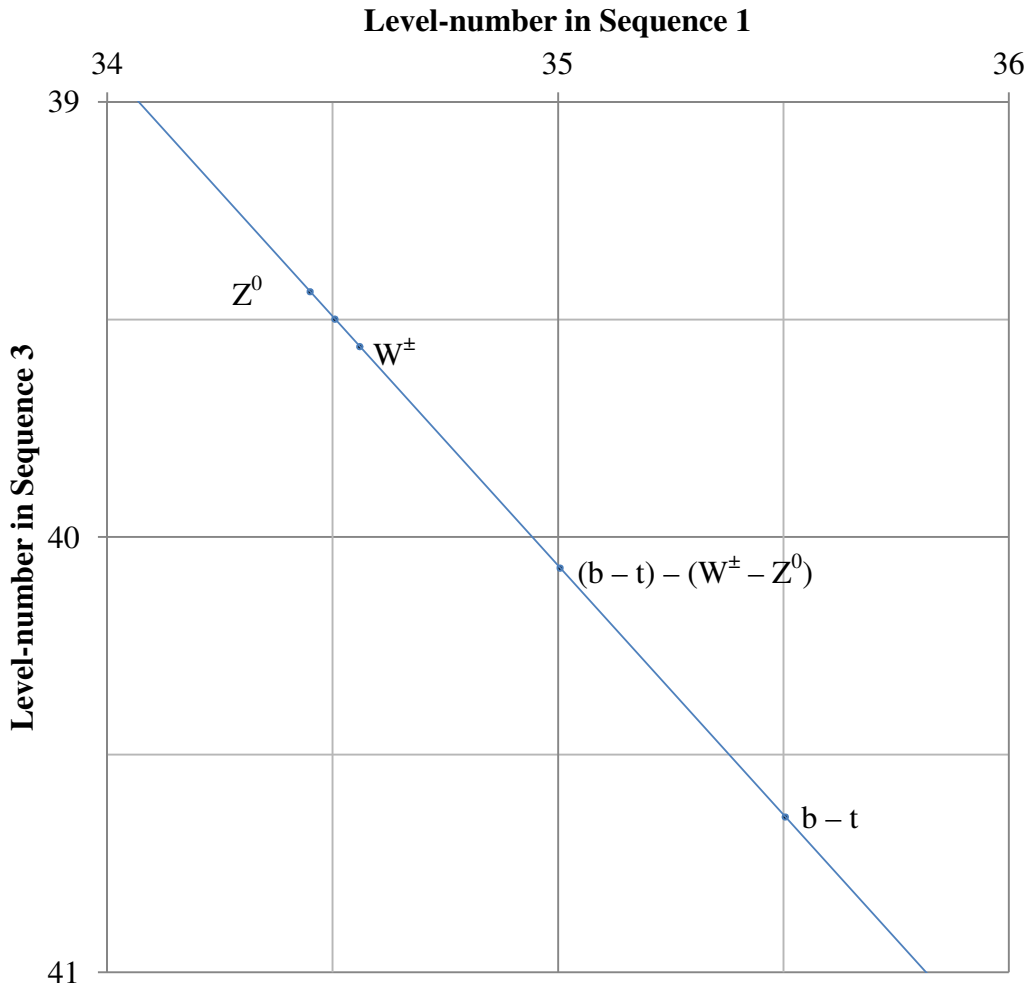

Figure 9: The bottom – top quark doublet in symmetrical arrangement with the $W^{\pm} - Z^0$ arrangement on the levels of Sequences 1 and 3. The b – t quark doublet is centred on Level 90 in Sequence 2 [7]. The $W^{\pm} - Z^0$ arrangement is centred on the half-level coincidence (34.5, 87.5, 39.5); the centre of the arrangement is marked here with a dot. The (b – t) – ($W^{\pm} - Z^0$) partnership is centred on Level 35 in Sequence 1, at the Type 2 superlevel coincidence (35, 40) in Sequences 1 and 3. Particles are constrained to lie on the blue line.

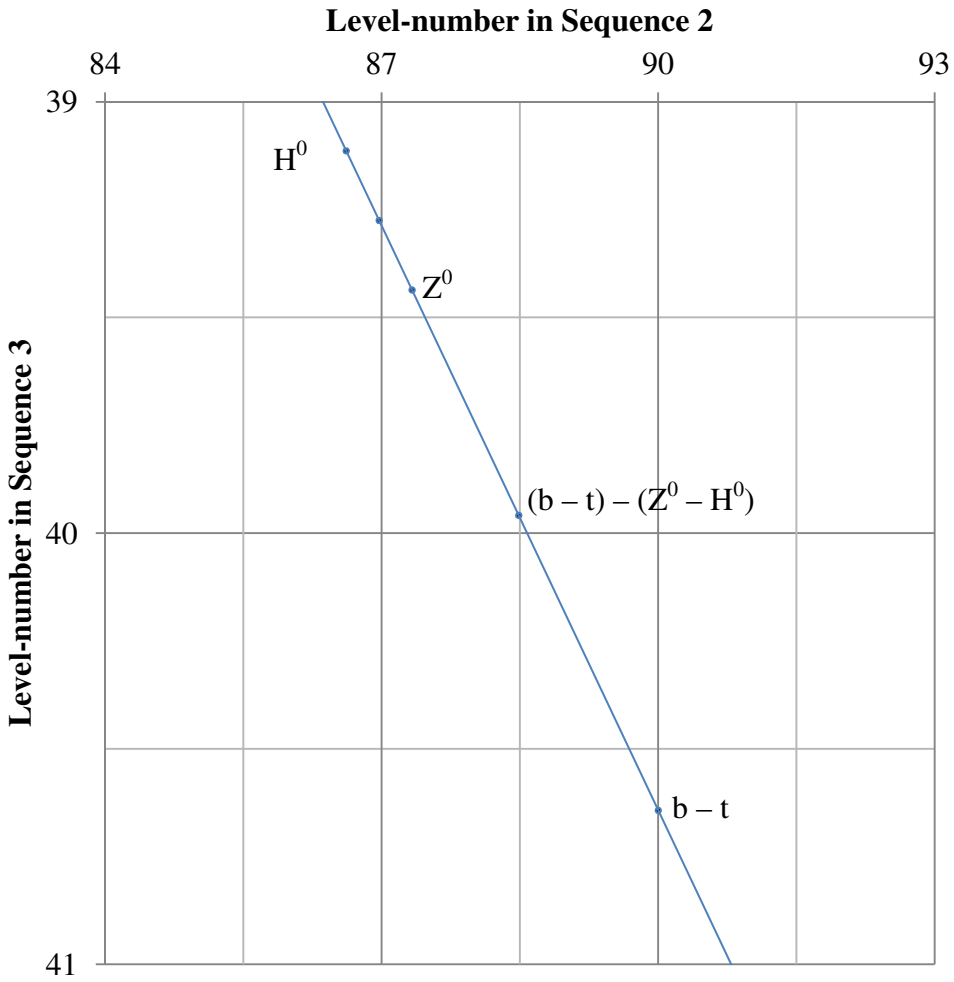

Figure 10: The bottom – top quark doublet in symmetrical arrangement with the H^0 – Z^0 arrangement, the centre of which is marked with a dot, on the levels of Sequences 2 and 3. The (b – t) – (Z^0 – H^0) partnership is centred on Level 88.5 in Sequence 2, at the Type 2 superlevel coincidence (35, 40) in Sequences 1 and 3. Particles are constrained to lie on the blue line.

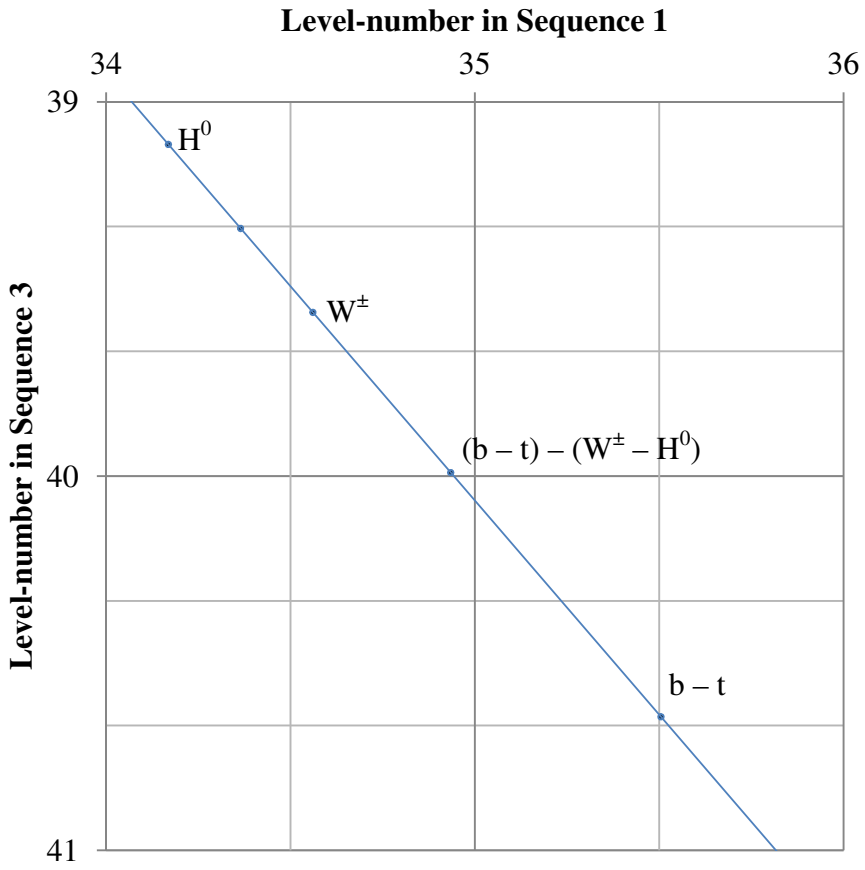

Figure 11: The bottom – top quark doublet in symmetrical arrangement with the $W^{\pm}$ – H^0 arrangement, the centre of which is marked with a dot, on the levels of Sequences 1 and 3. The (b – t) – ($W^{\pm}$ – H^0) partnership is centred on Level 40 in Sequence 3, at the Type 2 superlevel coincidence (35, 40) in Sequences 1 and 3. Particles are constrained to lie on the blue line.

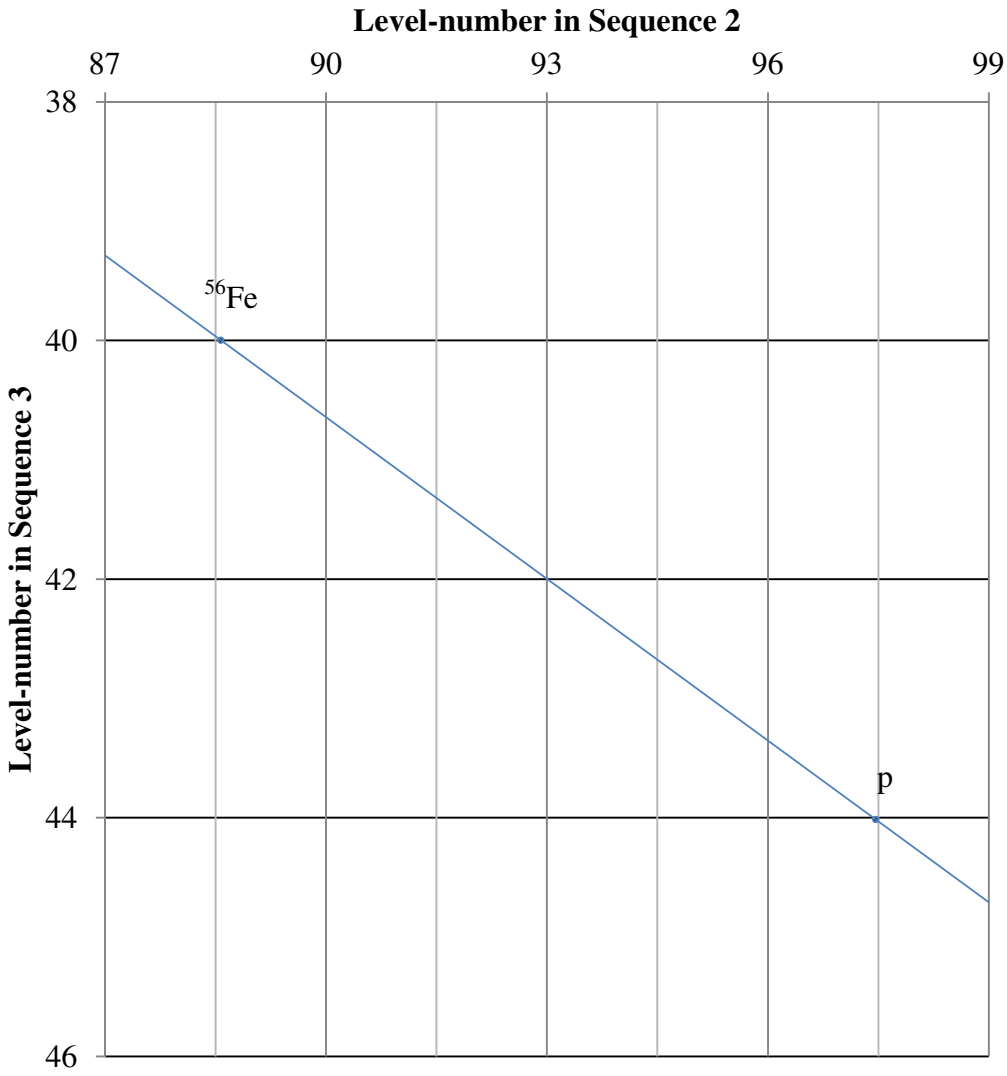

Figure 12: The proton and the ^{56}Fe atomic nucleus, of spin-0, arranged symmetrically about the most precise superlevel coincidence known: (93, 42) in Sequences 2 and 3, of mass 7.0 GeV. ^{56}Fe has the highest binding energy per nucleon of any atomic nucleus. Particles are constrained to lie on the blue line.

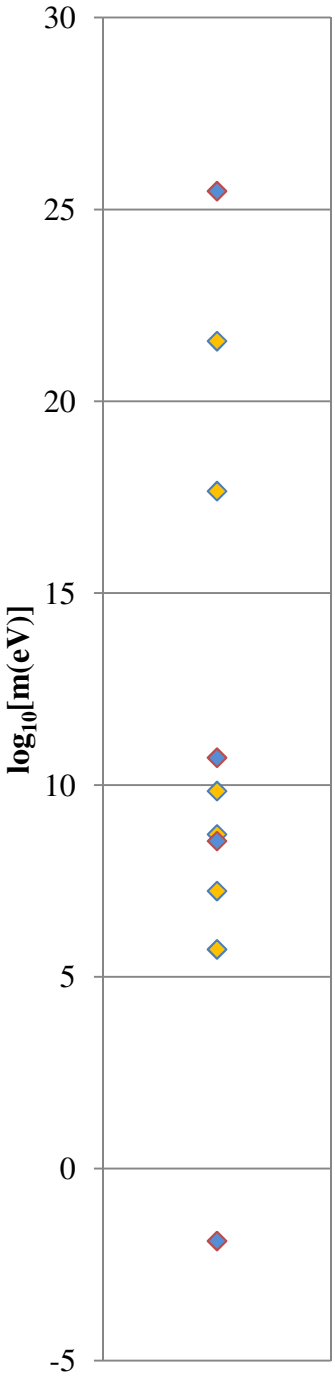

Figure 13: The mass scales of coincident superlevels. Orange diamonds represent coincident superlevels. Blue diamonds represent approximate triple superlevel coincidences.