Preons: New Model consistent with many modes of decay of sub-atomic particles

George Baxter. 1st March 2022

Abstract

Preons are postulated sub-units of quarks and other sub-atomic particles of the Standard Model. Their investigation and theoretical development have historically been limited due to the lack of experimental evidence to date. This article proposes a completely new model of preons and demonstrates a high degree of consistency with the observed decay modes of many sub-atomic particles and with the observed radioactive decays of atomic nuclei, and it also suggests deeper order below the quarks.

Preons and observational evidence

This topic was discussed more fully in the pre-print paper, Observational Data for Strong Quark Influence on the Radioactive Decay of Atomic Nuclei (Baxter 2021). It demonstrated that the Z/A plot was improved by replacing the protons and neutrons with their quark Up & Down numbers. However, as noted at the time, there was scope for improvement, in order to remove the persistent "clumpiness"

A brief review of that paper is included here.
The atomic theory of the nucleus consisting of protons and neutrons can be shown graphically in the Karlsruhe Nuclide Chart (Soti, Z., Magill, J., Dreher, R., 2018) . This shows order within the isotopes, and the elements cluster into groups. The ratio of the neutrons to protons is an indicator of which isotope may be stable, and which may be unstable (Figure 1).

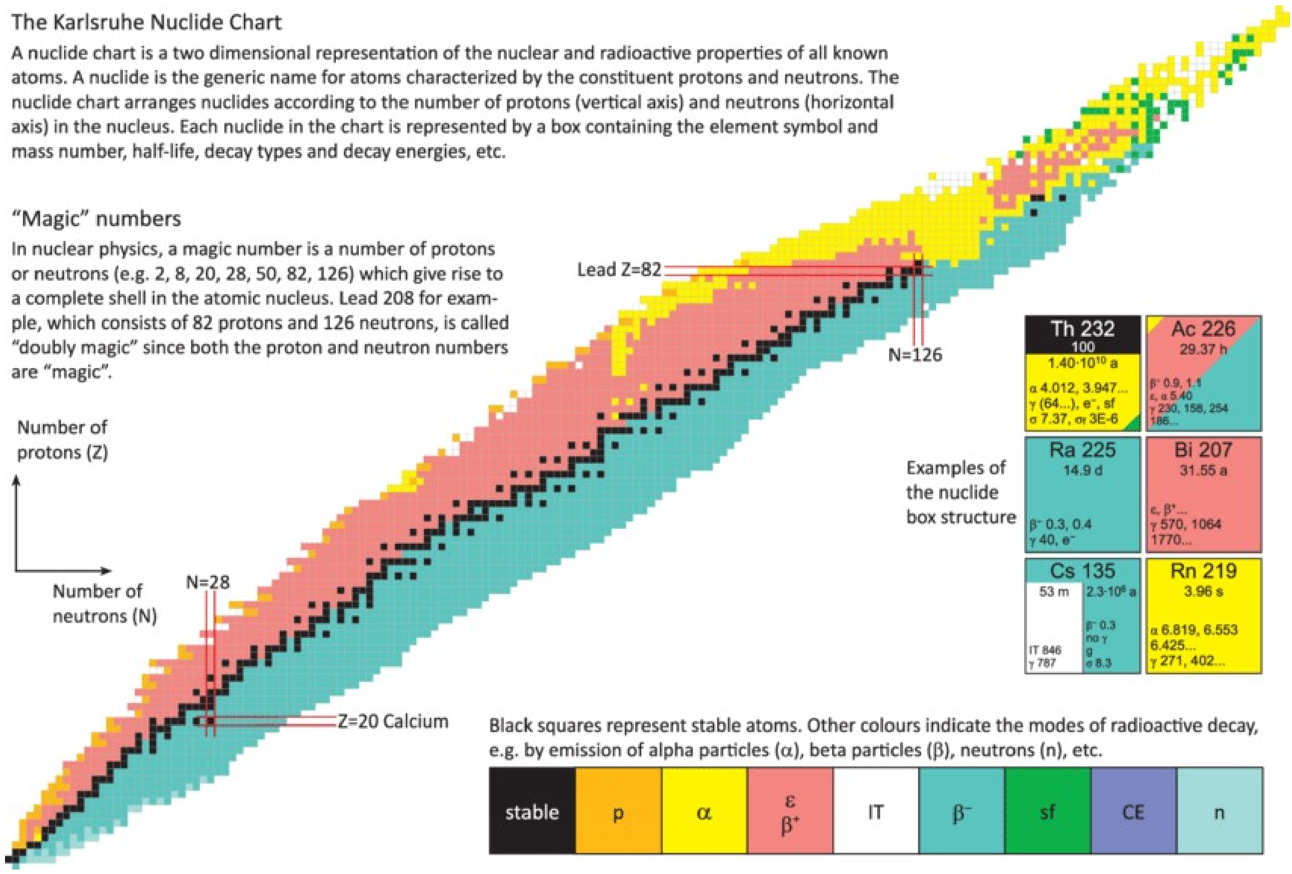


Figure 1 Chart of the nuclides. A clear structure can be seen, as well as many observational anomalies

Is there another plot to resolve the clumpiness and anomalies?

There is. A closer look at the clumpiness reveals a pattern of three. An interval of three can be observed between the constant Up quark number points and similarly there is an interval of three between the constant Down quark number points (Figure 2).

	FY	FZ	GA	GB	GC	GD	GE	GF	GG	GH	GI	GJ	GK	GL	GM	GN	GO	GP	GQ	GR	GS	GT	GU	GV	GW	GX	GY
156		-1			-1																						
157	0			-1			-1																				
158			-1			-1			-1																		
159		0			-1			-1																			
160	1			0			-1			-2																	
161			0			0			-1			-2															
162		0			1			-1			-1			-2													
163	98			3			1			-1			-1														
164			3			2			0			-1			-1												
165		22			22			1			0			-1			-2										
166	99			1			3			0			-1			-1											
167			99			3			3			0			-1			-1									
168		2			99			0			2			0			-1			-2							
169	3			4			99			2			1			-1			-1								
170			3			2			99			0			1			-1			-1						
171		2			5			5			99			1			0			-1			-2				
172	1			2			4			2			4			0			0			-1			-1		
173			2			3			98			99			98			0			0			-1			-2
174		1			2			3			6			5			7			0			-1			-1	
175	0			1			3			3			99			99			98			0			-1		
176			0			1			3			2			98			6			5			0			-1
177		0			1			2			4			6			99			7			12			0	
178	-1			0			1			1			3			5			99			6			3		
179			-1			0			2			2			29			6			99			5			3
180					0			0			2			1			4			6			4			4	
181				-1			0			1			2			3			98			99			31		
182						-1			0			1			2			1			6			3			3
183								-1			0			1			3			4			99			14	
184										0			0			1			2			2			99		
185									-1			0			1			2			5			5			99

Figure 2. Clumpiness still shows in the lines of constant Up & Down quark numbers. E.g. Rows 73,75, 81, and columns GG, GM, GQ

That is suggestive of more structure yet to be plotted, a structure beyond the quark model.

Preons

Preons have long been suggested as a next level of order, beyond the quarks. For example, the Rishon model (Harari, H. and Seiberg, N. 1981)   suggests three preons with a charge of 1/3 e.

The idea of a 1/3 e charge is appealing. The Down quark has -1/3e and the Up quark has +2/3 e. Although this model has been explored before, it has not produced useful results.

A new Preon model (Npreon), with two Npreons may suffice. The model has a few nuances.

The Npreon model proposed in this work has a single charged particle, with charge +/- 1/6 e and an uncharged Npreon. The particles are provisionally designated Sextion (charged) and Umbron* (uncharged). The charged particles are not necessarily anti-particles. That is explained further on when a colour is introduced.

The proposed basic combinations are shown in Table 1. Sextions are denoted with a capital S,

Particle \ NPreon	S+	S-	U
Electron	0	6	0
Up quark	5	1	1
Down quark	2	4	2

Table 1. Particles and Npreons

Notation.

At this point, in order to keep track of the Npreons, a simple notation is introduced. An ordered triplet (#S+, #S-, #U) indicates the number of S+, S- and U Npreons in a particle.

In the Npreon notation we have:

electron	(0 , 6 , 0)
Up quark	(5 , 1 , 1)
Down quark	(2 , 4 , 2)

Note. In this notation, an anti-particle is achieved by transposing component 1 with component 2.

E.g. the electron is (0 , 6 , 0), the positron is (6 , 0 ,0)

Note. The notation will also include a postulated new virtual particle. Using the new algebra it is denoted by (3 , 3 , 0). This virtual particle is its own anti-particle.

What happens with the plot?

When a new scattergram is plotted with S+, S- and the half-life order, the clumpiness vanishes. See Figure 3, which shows the same region of data as Figure 1

.

	A	SG	SH	SI	SJ	SK	SL	SM	SN	SO	SP	SQ	SR	SS	ST	SU	SV	SW	SX	SY	SZ	TA	TB	TC	TD	TE	TF	TG	TH	TI	TJ	TK
1		1503	1506	1509	1512	1515	1518	1521	1524	1527	1530	1533	1536	1539	1542	1545	1548	1551	1554	1557	1560	1563	1566	1569	1572	1575	1578	1581	1584	1587	1590	1593
560	1983			5						2																						
561	1986		10						3																							
562	1989	3						99																								
563	1992						7						3																			
564	1995					4						1																				
565	1998				1						99																					
566	2001			2						5						2																
567	2004		2						98						2																	
568	2007	0						3						6																		
569	2010						3						99																			
570	2013					2						5						0														
571	2016				0						4						99															
572	2019			-1						2						5																
573	2022		-3						0						99						0											
574	2025							1						4						3												
575	2028						-1						3						5													
576	2031					-2						2						99						1								
577	2034										2						4						4									
578	2037									0						3						3										
579	2040								-2						3						99						1					
580	2043													2						4						2						
581	2046												0						4						3							
582	2049											-1						3						99						1		
583	2052										4						2						5						5			
584	2055															1						4						1				
585	2058														-1						3						99					
586	2061													-2						2						6						1
587	2064																		1						12						1	
588	2067																	0						3						6		
589	2070																-2						3						99			
590	2073																					2						5				

Figure 3. Scattergram plotted using S+, S- and the half-life order, suggesting that Npreons are part of the makeup of quarks and electrons.

Proposed properties of Npreons.

The electron is composed of six S-. The electrostatic repulsion necessitates a very strong binding force. Quantum Chromodynamics uses three colours, and their anti-colour, giving six colours. This is consistent with, and suggests a possible link between, QCD and Npreons.

If the Npreons of the electron have six colours, then that would allow the electron to be “colourless” in any interaction.

The S- and S+ are antiparticles if, and only if, they also have identical colour. In the case of the Up quark, consisting of five S+ and one S-, the S- is not an antiparticle, as it doesn’t match the colour of any of the S+. That is why the S- does not annihilate one of the S+

Similarly, the Down quark, consisting of four S- and two S+ does not have Npreon annihilation, as all the colours are different.

What is the role of the Umbron?

The Umbron, at first glance, seems superfluous. However, the mass difference between an electron and the quarks needs to be accounted for.

There is also the question of stability of the composite particle. The electron, as noted above, is stable due to the six colour charges resulting in a binding force. There is no scope for Npreon annihilation, and therefore it is stable.

In the case of the Up and Down quarks in a nucleon, e.g. a proton, there is scope for annihilation, and therefore instability due to the oppositely charge and colour Npreons being in proximity in a quark; however, the Umbrons also interact via the colours and provide possible means to stabilise the particle.

Mass is another consideration. The mass of the Down quark is approximately twice that of the Up quark. The Down quark has two Umbrons and the Up quark has one umbron. Although the mass of the quark does not exactly scale with the number of Umbrons, is suggestive of that.

Properties of the Umbron.

The Umbron has zero electric charge. It has mass (to be estimated). It interacts with Npreons via the colour charge.

Speculation.

Dark matter is predicted to be a chargeless particle. It does not interact with light. A free Umbron could be a candidate for a dark matter particle. Particle decays can potentially be a source of free Umbrons

Decay modes

A key point of this model is to demonstrate that the decay modes of sub-atomic particles are clearly, accurately and simply explained. Indeed, explaining the dual decay mode of the neutral kaon in the SM requires a lot of contrived theory, and the decay of a free neutron is poorly defined. The Npreon model, on the other hand, explains both items naturally, and elegantly.

Neutron decay.

A free neutron decays in approximately 885.7 seconds.However, there is an anomaly with other measurements far beyond experimental error. By comparison, a free neutron will decay into a proton, an electron, and a neutrino, with a half-life of 879 s (Zyla *et al.* 2020)

That opens the possibility that other decay modes, not possible in the Standard Model, are feasible. The Npreon model allows for the possible dual modes of decay.

Neutron decay, in the Standard Model, is shown as

$$n \rightarrow p^+ + e^- + \nu_e$$

n is made up of 1 Up quark and 2 Down quarks.

Using the new notation, a neutron becomes

n = (5,1,1) + (2,4,2) + (2,4,2) = (9,9,5)

and the decay is shown as

neutron → proton + electron + Umbron + anti-electron neutrino
(9,9,5,) → (12,6,4) + (0,6,0) + (0,0,1) + (0,0,0)

The first observation is that the number of Sextions is not fixed. This implies the need for the virtual particle (3, 3 ,0). There can also be intermediate combinations of preons that do not correspond to currently observed particles. An example appears in the following free neutron decay

neutron → neutron + virtual → Unobserved

(9,9,5,) → (9,9,5) + (3,3,0) → (12,12,5)

Unobserved → proton + electron + Umbron + anti-electron-neutrino

(12,12,5) →(12,6,4) + (0,6,0) + (0,0,1) +(0,0,0)

A second decay mode could be

neutron → Unobserved + electron → Unobserved + virtual + electron →

(9,9,5,) → (9,3 ,5) + (0,6,0) →(9,3 ,5)+(3,3,0) + (0,6,0) →

→proton + electron + Umbron + anti-electron-neutrino

→(12,6,4) + (0,6,0) + (0,0,1) +(0,0,0)

The neutron decay liberates an Umbron

An important point is that the Standard Model would not allow a dual decay mode of the neutron. The Npreon model does permit alternative decay modes

Pion Decay

The SM representation of a pion decay is

$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$

A pion$^+$ is one Up quark and one anti-Down quark
In the Npreon notation it becomes

(5,1,1) + (4,2,0) → (9,3,1)

The decay pion to muon becomes:

pion$^+$ → muon$^+$ + neutrino + Umbron

(9 , 3 , 1) → (9 , 3 , 0) + (0 , 0 , 0) + (0 , 0 , 1)

Observation.
The pion is mesonic. The muon is leptonic. They are from different families in the Standard Model. However, the difference between the two families, using the Npreon notation, becomes far less pronounced. This provides a tentative path to unification of mesons and leptons.

Muon decay

The SM representation of the muon$^+$ decay is:

$$\mu^+ \rightarrow e^+ + \nu_e$$

In the Npreon notation it becomes

muon+ → positron + virtual → positron + neutrino

(9 , 3 , 0) → (6 , 0 , 0) + (3 ,3 ,0) → (6,0,0) + (0,0,0)

Observations

First observation.

Firstly, the energy for the decay comes from the annihilation of the Npreons. That provides a direct link to the Npreons and not specifically the positron. The Casimir effect demonstrated that virtual particles can be created and annihilated in free space. This suggests a path for a virtual Npreon particle that can be a catalyst for other decay modes.

As noted above, a new, virtual Npreon particle was proposed:

That is (3 , 3 , 0)

This particle would also be its own anti-particle.

Therefore (0, 0, 0) → (3 , 3 , 0) → (0, 0, 0) is valid

Second observation.

The muon is known to have an anomalous magnetic moment. Both the muon- and the electron have the same net charge. In the SM that is -1 e.

In Npreon notation, the net charge is the same, but via a different distribution of charged Npreons

electron	(0 , 6 , 0)
muon-	(3 , 9 , 0)

The difference in magnet dipole moment could be due to the additional charged Npreons. The mass difference can be accounted for by the energies associated with the masses of the charged Npreons, and the binding energy.

Third observation.

Neutrino oscillations

Although neutrinos have historically been considered to be massless, recent observations have detected a neutrino oscillation (Forero *et al.* 2014); that is, the type of neutrino can change with time. One interpretation is that the neutrino has mass, and so can have an internal time. That would be a pathway for a neutrino to change type over time.

There are problems with the mass idea. One of them is that there is no way to directly measure the mass. Theoretical estimates currently put the mass at < 10^-6 eV. Theoretically, the mass of a neutrino is not simply defined either, but it is assumed to be some combination of the masses of the other neutrino types. Moreover, astronomical observations do not support the neutrino having mass. If a neutrino had any mass, its velocity would be less than the speed of light in a vacuum. Over large distances, that velocity difference would be detectable. To date, no such difference has been noted.

The Npreon model allows a different and simple explanation that restores the neutrino to be massless whilst explaining the oscillation.

There are two charged Npreons. A three-colour plan for the Npreon is proposed. A charged Npreon can only be annihilated by an Npreon of the opposite charge *and same* colour.

There are three different types of neutrino: the electron, muon, and tau. They are known to be distinct.

The proposal is that each charged Npreon is annihilated by its own colour and generates a neutrino with that colour and anti-colour pair.
That is, if the production of a neutrino favours a single colour, then the neutrino will inherit that colour. That could be accounted for in the Npreon notation with an additional component. (0 , 0, 0, colour/anti-colour)

If a neutrino, with its intrinsic colour, interacts with a free Umbron, then one outcome could be that the colour of the neutrino is changed

$$(0 , 0 , 0)_{c1} + (0 , 0 , 1) \rightarrow (0 , 0 , 0)_{c2} + (0 , 0 , 1)$$

Another possible scenario is that the Umbron could have a colour. That is to be investigated.

A more intriguing possibility springs to mind.

The current Npreon algebra of a neutrino is (0 , 0 , 0). Essentially, it appears to be “fresh air”. However, if colour is a key attribute, then extending the Npreon algebra to a fourth component is needed.

For example (S+ , S- , U , Cl)

The fourth component could be colour, or a pair of colour and anti-colour. That means that the neutrino would also be colour-neutral, but retain some memory of the original colour.

An Electron neutrino could have one colour pair.
A Mu neutrino could have a different colour pair.
A Tau neutrino could have the final colour pair.

Oscillation could occur when a colour pair switches to another colour pair.

In none of these scenarios is there a need for a neutrino to possess mass. Oscillation, therefore, can be explained without the need to invoke mass.

Observation.

If neutrinos oscillate when interacting with a free Umbron, and free Umbrons are a candidate for Dark Matter, then neutrinos could provide a means to detect Dark Matter via Umbrons.

Down to Up quark decay

In the same way we can represent this decay as

d → u + W- → u + e- + anti-electron neutrino

via a virtual W- boson

In Npreon notation

Down + virtual → Unobserved → Up + W-
(2 , 4 , 2) + (3 , 3 , 0) → (5 , 7 , 2) → (5 , 1 , 1) + (0 , 6 , 1)

→ Up + electron + anti-neutrino + umbron

→(5,1,1) + (0 ,6, 0) + (0 , 0 ,0) + (0 , 0 , 1)

Stronger indications supporting the Npreon model

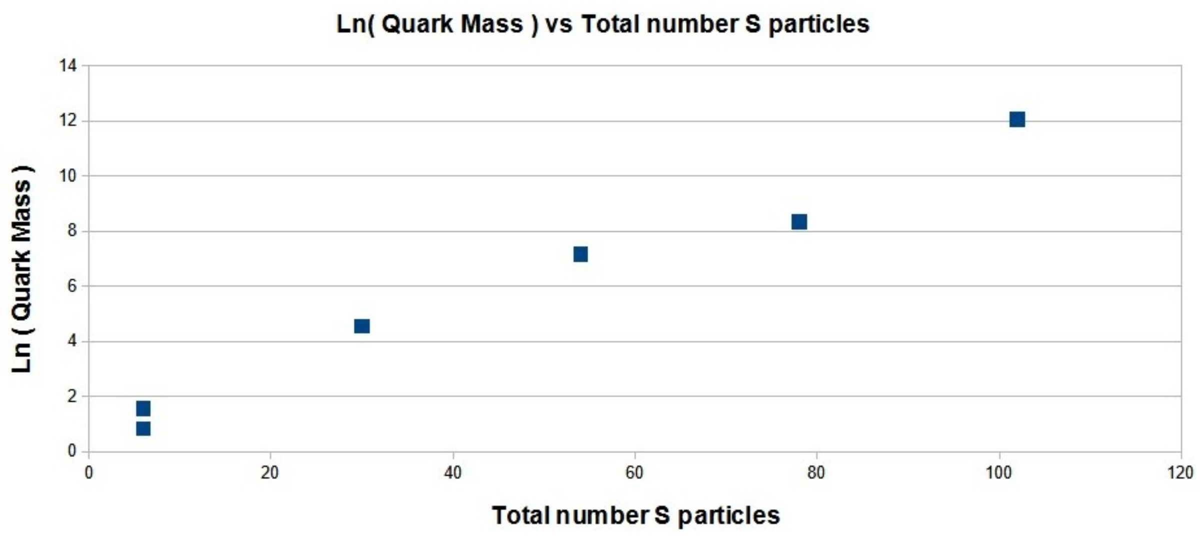
Examining some of the main decay modes of the quarks allows a measure of the numbers of Npreons in each quark.

Table 3. List of the quarks, with their Npreon numbers, and the mass, in MeV.

Quark	Mass (MeV)	S+	S-	U	S+ + S-	Ln(Mass)
U	2.3	5	1	1	6	0.83
D	4.8	2	4	2	6	1.57
S	95	14	16	2	30	4.55
C	1275	29	25	1	54	7.15
B	4180	38	40	2	78	8.34
T	173210	53	49	1	102	12.06

Column 6 is the sum of the S+ and S- Npreons
Column 7 is the natural logarithm of the mass of the quarks.

Plotting the sum of the charged Npreons, vs the Ln(mass) reveals a linear graph (Fig 4).



(Fig. 4) The graph is linear, indicative of a strong link between the total number of charged Npreons and the mass. This works well despite the large range of masses.

Suggested way to test the Npreon model.

So far, the discussion has been looking at the model and the existing observational data that is consistent with the model. There follows a potential experiment involving inelastic positron – neutron collisions, to stimulate the neutron decay.

Using the Npreon notation

positron + neutron → unknown particle
(6 , 0 ,0) + (9 , 9 , 5) → (15 , 9 , 5)

The S+ / S- ratio is 15/9 or 1.6667

Looking at the data for other nuclides in the region of that ratio, 1.667, most are highly unstable and decay within times of the order of 10^-21s or less.

The immediate decay of a neutron via the inelastic collision would provide a means of detection and experimental confirmation of the Npreons.

Conclusions

There are clear reasons to continue the exploration of the Npreon model. It has confirmed some additional structures not seen before and opens the possibility of an explanation for Dark Matter, without further need to look for additional particles, especially super-symmetric particles.

The Npreon model offers a simplification. Although simplification is not, in itself, a reason for it to be a full solution, generally, as more theoretical frameworks are studied, unification and simplification seem to follow.

There is a need for a mathematical formulation, in order to make the observational model more robust. This could be via an extension of the Dirac model, or perhaps new physics needs new mathematics. Fermionisation offers one potential solution. Octonions may offer novel solutions for spin.

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* Disclaimer: The designation Umbron for the proposed particle has no relation to any object or fictitious character of the same name.