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The Elementary Particle Base Masses

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Abstract

The authors empirically based contention that there exists an integral mass system for the principal baryons and the electron is put into a theoretical framework. This framework predicts a neutrally charged lepton which must correspond to the neutrino, generates very accurate base masses for the major leptons, mesons, and baryons and extremely accurate mass splitting for the principal octet of baryons. In addition, it predicts a totally new class of super heavy particles the lightest of which would have a mass greater than 38 GeV.

The masses of the particles dealt with here will be represented by their respective symbols. In particular: e, electron; p, proton; and n, neutron.

It has been proposed (Dixon, 1973) that the mass system in which $e = 2^6$ mass units is one in which the masses of the baryons of the principal octet take on integral values. In particular, $e = 2^6$ units implies $p = 117{,}511$ units and $n = 117{,}673$ units. The original impetus behind this conjecture lies in the observation that conversion from the MeV system to the $e = 2^6$ system of the best available value for $(n - p)$ gives $n - p = 161{\cdot}995$ units. Note that $n - p = 162$ units in the $e = 2^6$ system when their respective masses are given the values above. Hereafter, all masses considered will be in the $e = 2^6$ mass system.

It was further proposed (Dixon, 1973) that $N = 7^6$ units is the base mass (unbroken symmetry) of the principal octet of baryons. This value was chosen because $7^6 = 117{,}649$ falls between the values given for p and n and $N = 7^6$ is of the same arithmetic form as $e = 2^6$. The following model offers an explanation of this apparent coincidence.

Begin by creating a new spin number $s = 0, \frac{1}{2}, 1, \ldots$ and postulate the existence of a collection of strictly elementary particles which can be partitioned into disjoint sets M_s of particles with the same spin s. The actual spin of each of these particles I assume to be $\frac{1}{2}\hbar$ and shall refer to it no more.

M_0 will consist of the electron and $M_{1/2}$ will consist of the three quarks.

Let m_s be the order of M_s. $m_0 = 1$ and $m_{\frac{1}{2}} = 3$ and, assuming a linear relation, $m_s = 4s + 1$ in general.

For those cases with which we are familiar, $s = 0$ and $s = \frac{1}{2}$, nature seems to prefer bound systems of $4s + 1$ spin-s particles or $2s$ spin-s particles with $2s$ spin-s anti-particles. I shall assume this in general and shall refer to these as closed spin-s systems and specifically as the conserved spin-s system and the unconserved spin-s system, respectively.

Introduce into this system a state supplied with an internal structure of six sub-states. A state is to be occupied by a closed spin-s system and the sub-states of the occupied state are to be occupied by the constituents of the system. A spin-s particle or anti-particle can occupy a sub-state in any of $2s + 1$ orientations and I shall assume, in order to make the model work, that a sub-state can be occupied by at most one particle or anti-particle and need not be occupied at all. It is a simple problem in combinatorics to compute the number of different ways the constituents of a closed spin-s system can occupy the six sub-states of an occupied state. In the conserved spin-s system there are $4s + 1$ constituents and $2s + 1$ orientations per constituent. There are therefore $(4s + 1)(2s + 1) + 1$ different ways each sub-state can be occupied by these constituents where I have added one to take into account the empty sub-state. This implies there are $((4s + 1)(2s + 1) + 1)^6$ different ways the $4s + 1$ constituents of the conserved spin-s system can occupy the collection of six sub-states of an occupied state. For $s = 0$ and $s = \frac{1}{2}$ this becomes 2^6 and 7^6 ways, respectively.

Now it is merely necessary to postulate that to occupy states in as many different ways as possible is the first order of business of any closed spin-s system and that each state occupied represents one unit of mass. Thus the electron generates a mass of 2^6 units and the baryon a mass of 7^6 units.

The mass generated by the unconserved spin-s system (except for the $s = 0$ case which will be mentioned later) will be $(4s(2s + 1) + 1)^6$ units. The base mass of the mesons would correspond to the $s = \frac{1}{2}$ case and would be $5^6 =$ 15,625 units. The mass of the neutral pion is close to $15{,}625 + 20(2^6) = 16{,}905$ units. 5^6 is therefore of the same order as the masses of the lightest mesons and, as the symmetry is so badly broken in this case, the size of the mass splittings poses no real problem.

One of the most important aspects of this model is its prediction of a class of super heavy particles corresponding to closed spin-s systems for $s = 1, 1\frac{1}{2}, 2, \ldots$. The lightest such particle would be the unconserved spin-1 system and would have a mass of 13^6 units which is about 38·5 GeV.

Many of the properties of the closed spin-s systems for these higher values of s can be formulated as generalisations of the $s = 0$ and especially the $s = \frac{1}{2}$ cases. We should expect the conserved spin-s particles to be subject to super strong forces whose exchange particles would be the unconserved spin-s particles. We should also expect the symmetry involved to be $U(m_s)$. We can generalise the concept of lepton and baryon numbers and produce a sequence of B_s numbers due to the $U(1)$ subgroup of $U(m_s)$. For a spin-s particle in M_s, $B_s = 1/m_s$. Below is a table of $SU(m_s)$ weights for an arbitrary m_s.

$SU(m_s)$ weights

Weight labels					Charge
W_1	W_2	W_3	W_4	$\ldots W_{m_s-1}$	Q
$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\ldots 1/m_s$	$1 - 1/m_s$
$-\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\ldots 1/m_s$	$-1/m_s$
0	$-\frac{2}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	$\ldots 1/m_s$	$-1/m_s$
0	0	$-\frac{3}{4}$	$\frac{1}{5}$	$\ldots 1/m_s$	$-1/m_s$
0	0	0	$-\frac{4}{5}$	$\ldots 1/m_s$	$-1/m_s$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
0	0	0	0	$\ldots (1/m_s) - 1$	$-1/m_s$

For $s \neq 0$ I have computed the charge by the formula

$$Q = \sum_{n=1}^{m_s-1} (W_n)/n$$

because it satisfies the two requirements that for $s = \frac{1}{2}$, $Q = I_3 + Y/2 = W_1 + W_2/2$, and that the charge of any closed spin-s system be integral.

There are no special unitary weights when $s = 0$ and we cannot as easily compute charges. By generalising downward from those cases where $s > 0$ we can determine much about the $s = 0$ case. A conserved spin-s system can have any charge in the set $(-1, 0, 1, \ldots, 4s)$. Generalising to the $s = 0$ case we find that a conserved spin-0 system can have a charge of -1 or 0. In other words, this model predicts a neutrally charged lepton which must correspond to the electron neutrino. Therefore, we should not consider the electron as an element of M_0, but as one of two possible states of the M_0 particle. Why only one of these particles should have a mass of 2^6 units is a question that should succumb to a more mathematical version of this theory.

A bound system of $2s$ spin-s particles with $2s$ spin-s anti-particles can take on any charge in the set $(-2s, \ldots, -1, 0, 1, \ldots, 2s)$. The exchange particle (unconserved spin-0 system) of the force which dominates the $s = 0$ case is the photon and, since $-2s = 2s = 0$, the charge of the photon is correctly predicted by generalisation to be 0. Also, since it contains no spin-0 constituents, it should have zero rest mass although a strict generalisation gives it a rest mass of 1 unit.

This model offers an impressively accurate explanation of the weak mass splitting of the sigma triplet and cascade doublet in the principal octet. Postulate that the quark with hypercharge $Y = -\frac{2}{3}$, when bound in a conserved spin-$\frac{1}{2}$ triplet of quarks, can occupy states as part of a closed doublet consisting of itself and any other particle of the triplet. In the meson case we saw that a doublet of spin-$\frac{1}{2}$ particles generates a mass of $5^6 = 15{,}625$ units. In the case of the sigma triplet there is one $Y = -\frac{2}{3}$ in each of the three baryons and as a result two possible doublets of quarks in each baryon containing this quark. Therefore, $2(5^6) = 31{,}250$ units of mass are generated in addition to the octet base mass of 7^6 units. This gives the sigma triplet a base mass after weak mass splitting of 148,899 units. $\Sigma^+ - 148{,}899$ is approximately 72 units $= 3(n - 7^6)$.

A cascade particle contains two $Y = -\frac{2}{3}$ quarks and all three possible quark doublets in this bound triplet contain a $Y = -\frac{2}{3}$ quark. As a result $3(5^6) =$ 46,875 additional units of mass are generated. This gives the cascade doublet a base mass after weak splitting of $3(5^6) + 7^6 = 164{,}524$ units. $\Xi^0 - 164{,}524$ is approximately equal to 144 units $= (7^6 - p + 6)$. This is excellent agreement with experiment.

This model is badly in need of being translated into a rigorous mathematical structure. That this can be done I have little doubt for the model as it stands correlates quite well both qualitatively and quantitatively over a broad spectrum of reasonably well-established particle theory.

References

Dixon, G. M. (1973). *Particles & Nuclei*, 5, 23.