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A formula to break degeneration of Susy multiplets

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Abstract: We suggest a very simple operator to break mass degeneration in representations of the Poincare group, and comment on some experimental evidence

Representations of the 3+1 Poincare algebra can be labeled with two polynomial or Casimir invariants, $\mathcal{C}_1$ and $\mathcal{C}_2$, that in the massive case correspond respectively to the P^2 and W^2, the latter being the square of Pauli-Lubanski vector. Upon a (m, s) representation the quadratic Casimir $\mathcal{C}_1$ has eigenvalue m^2 while the quartic Casimir $\mathcal{C}_2$ has eigenvalues $-m^2 s(s+1)$

For a set of equal mass (m, s_i) representations such as the ones happening in a supersymmetry multiplet, if we want to break mass degeneracy then the simplest way that preserves the limit of high spin is to use the formula

$$M^2_{(s)} \equiv \frac{1}{2}(\mathcal{C}_2 + \sqrt{(\mathcal{C}_2)^2 - 4\mathcal{C}_1\mathcal{C}_2}) \tag{1}$$

so that M^2 upon a (m, s) representation has eigenvalue $(m^2/2)((s(s+1))^2 + 4s(s+1))^{1/2} - s(s+1))$, that in the limit $s \to \infty$ approaches to m^2. Given its extreme simplicity this kind of expressions is not rarely found in supersymmetry textbooks but we have never seen suggested its use to break mass degeneracy.

Starting from a primitive relativistic quantum mechanics model, De Vries found [1] (see also footnote in [3]) that the eigenvalue expression of the above operator, when evaluated both at $s = 1/2$ and $s = 1$ -with degenerated mass- were able to produce a definite number

$$s^2_{dV} \equiv 1 - \frac{M^2_{s=1/2}}{M^2_{s=1}} = 0.22310132... \tag{2}$$

and that a mass-related quantity with a similar experimental value seems to exist in Nature; indeed we can take from the global fit of [4, 2]

$$s^2_W = 0.22306 \pm 0.00033 \tag{3}$$

So that the quotient between experimental mass-shell value of Weinberg sine and the theoretical De Vries "sine" happens to be

$$s^2_{W,exp}/s^2_{dV} = 0.9998 \pm .0015 \tag{4}$$

Let us to stress that at the time of De Vries estimate, November 2004, the experimental value and error were slightly different so that the s^2_{dV} was more than one sigma away from the measurement. The new results of mass of W and other parameters have moved the global fit so that now s^2_{dV} is very centered inside 0.13σ.

Of course we have the paradoxical situation that we have produce this quantity in the context of a susy-like relationship between spin 1/2 and spin 1, while Nature seems to have it produced for two spin 1 particles. The transition from one situation to the other shall be given by the still unknown mechanism of electroweak symmetry breaking. This is to be added to the other mysterious coincidence of the scale of electroweak breaking, the value of Yukawian top coupling y_t, that currently [5] is expected to be about 0.991 ± 0.013. In principle both y_t and s_W are running quantities coming from the GUT scale, but now we see that they get very singular values just exactly at the moment that the electroweak symmetry breaks.

References

[1] Hans de Vries, informal communication, online at www.physicsforums.com

[2] J. Erler, *Precision Electroweak Physics*, `hep-ph/0604035`

[3] H. de Vries and A. Rivero, `hep-ph/0503104`

[4] Particle Data Group, *Review of Particle Properties 2006*, to be published

[5] vv. aa. *Combination of CDF and D0 Results on the Mass of the Top Quark* `hep-ex/0603039`