Toponium at 30.4 GeV?

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Prof. Matt Strassler tells about a gem found from old data files of ALEPH experiment (see http://tinyurl.com/ze6l5wr) by Arno Heisner [C1](see http://tinyurl.com/hy8ugf4). The 3-sigma bump appears at 30.40 GeV and could be a statistical fluctuation and probably is so. It has been found to decay to muon pairs and b-quark pairs. The particle that Strassler christens V (V for vector) would have spin 1.

Years ago [K1] I have commented a candidate for scaled down top quark reported by Aleph: this had mass around 55 GeV and the proposal was that it corresponds to p-adically scaled up b quark with estimated mass of 52.3 GeV.

Could TGD allow to identify V as a scaled up variant of some spin 1 meson?

1. p-Adic length scale hypothesis states that particle mass scales correspond to certain primes $p \simeq 2^k$, $k > 0$ integer. Prime values of k are of special interest. Ordinary hadronic space-time sheets would correspond to hadronic space-time sheets labelled by Mersenne prime $p = M_{107} = 2^{107} - 1$ and quarks would be labelled by corresponding integers k.

2. For low mass mesons the contribution from color magnetic flux tubes to mass dominates whereas for higher mass mesons consisting of heavy quarks heavy quark contribution is dominant. This suggests that the large mass of V must result by an upwards scaling of some light quark mass or downwards scaling of top quark mass by a power of square root of 2.

3. The mass of b quark is around 4.2-4.6 GeV and Upsilon meson has mass about 9.5 GeV so that at most about 1.4 GeV from total mass would correspond to the non-perturbative color contribution partially from the magnetic body. Top quark mass is about 172.4 GeV and p-adic mass calculations suggest $k = 94$ (M_{89}) for top. If the masses for heavy quark mesons are additive as the example of Upsilon suggests, the non-existing top pair vector meson (toponium) (see https://en.wikipedia.org/wiki/Quarkonium) would have mass about $m(toponium) = 2 \times 172.4$ GeV $= 344.8$ GeV.

4. Could the observed bump correspond to p-adically scaled down version of toponium with $k = 94 + 7 = 101$, which is prime? The mass of toponium would be 30.47 GeV, which is consistent with the mass of the bump. If this picture is correct, V would be premature toponium able to exist for prime $k = 101$. Its decays to b quark pair are consistent with this.

5. Tommaso Dorigo (see http://tinyurl.com/zhgyecd) argues that the signal is spurious since the produced muons tend to be parallel to b quarks in cm system of Z^0. Matt Strassler identifies the production mechanism as a direct decay of Z^0 and in this case Tommaso would be right: the direct 3-particle decay of $Z^0 \rightarrow b + \overline{b} + V$ would produce different angular distribution for V. One cannot of course exclude the possibility that the interpretation of Tommaso is that muon pairs are from decays of V in its own rest frame in which case they certainly cannot be parallel to b quarks. So elementary mistake from a professional particle physicist looks rather implausible. The challenge of the experiments was indeed to distinguish the muon pairs from muons resulting from b quarks decaying semileptonically and being highly parallel to b quarks.

   A further objection of Tommaso is that the gluons should have roughly opposite momenta and fusion seems highly implausible classically since the gluons tend to be emitted in opposite directions. Quantally the argument does not look so lethal if one thinks in terms of plane waves rather than wave packets. Also fermion exchange is involved so that the fusion is not local process.

6. How the bump appearing in $Z^0 \rightarrow b + \overline{b} + V$ would be produced if toponium is in question? The mechanism would be essentially the same as in the production of Ψ/J meson by a $c + \overline{c}$ pair. The lowest order diagram would correspond to gluon fusion. Both b and $\overline{b}$ emit gluon and these could annihilate to a top pair and these would form the bound state. Do virtual t and $\overline{t}$ have ordinary masses 172 GeV or scaled down masses of about 15 GeV? The checking which option is correct would require numerical calculation and a model for the fusion of the pair to toponium.

   That the momenta of muons are parallel to those of b and $\overline{b}$ might be understood. One can approximate gluons with energy about 15 GeV as a brehmstrahlung almost parallel/antiparallel to the direction of b /$\overline{b}$ both having energy about 45 GeV in the cm system of Z^0. In cm they would combine to V with helicity in direction of axis nearly parallel to the direction defined by the opposite momenta of b and $\overline{b}$. The V with spin 1 would decay to a muon pair with helicities in the direction of this axis, and since relativistic muons are in question, the momenta would by helicity conservation tend to be in the direction of this axis as observed.

Are there other indications for scaled variants of quarks?

1. Tony Smith [C2] has talked about indications for several mass peaks for top quark. I have discussed this in [K2] in terms of p-adic length scale hypothesis. There is evidence for a sharp peak in the mass distribution of the top quark in 140-150 GeV range). There is also a peak slightly below 120 GeV, which could correspond to a p-adically scaled down variant t quark with $k = 93$ having mass 121.6 GeV for $(Y_e = 0, Y_t = 1)$. There is also a small peak also around 265 GeV which could relate to $m(t(95)) = 243.2$ GeV. Therefore top could appear at least at p-adic scales $k = 93, 94, 95$. This argument does not explain the peak in 140-150 GeV range rather near to top quark mass.

2. What about Aleph anomaly? The value of $k(b)$ in $p_b \simeq 2^{k_b}$ uncertain. $k(b) = 103$ is one possible value. In [K1]. I have considered the explanation of Aleph anomaly in terms of $k = 96$ variant of b quark. The mass scaling would be by factor of $2^{7/2}$, which would assign to mass $m_b = 4.6$ GeV mass of about 52 GeV to be compared with 55 GeV.

To sum up, the objections of Tommasso Dorigo might well kill the toponium proposal and the bump is probably a statistical fluctuation. It is however amazing that its mass comes out correctly from p-adic length scale hypothesis which does not allow fitting.

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