Anomalies/Deviations of experiment from Standard Model explained as non-perturbative effects due to large top-yukawa coupling

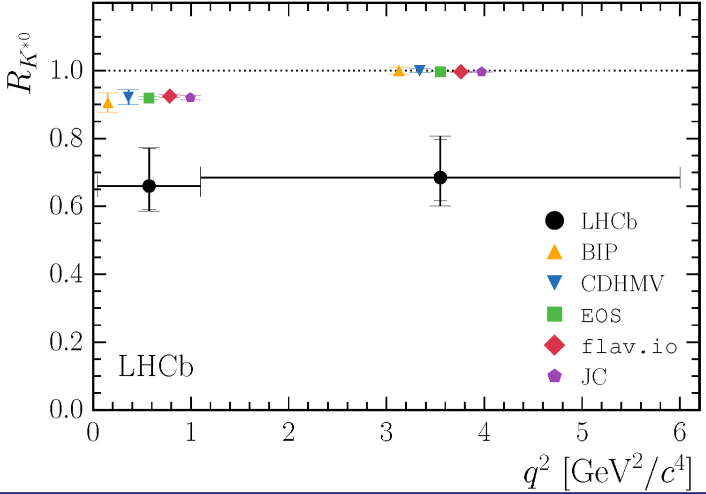
H.B. Nielsen, Niels Bohr Institutet
Colin D. Froggatt, Glasgow

Korfu 4. September , 2018

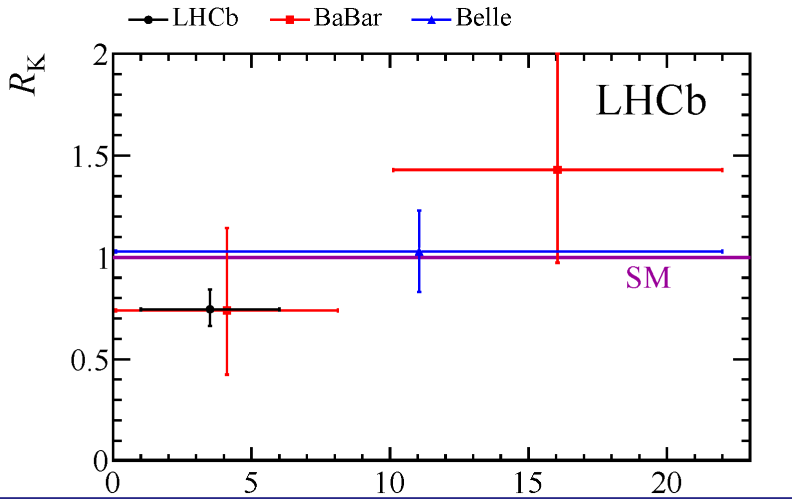
Are the LHCb etc. Tensions due to Non-perturbative Effects in Pure Standard Model ?

Standard Model works surprisingly well for LHC physics: Almost no new physics, and at least nothing truly statistically significant!
So we must be very happy for a few small very few standard deviation tensions!: Small lepton universality violating deviations, say.
The present proposal is that even these small tensions are not due to genuine new physics, but rather to effects forgotten because of the systematic use of perturbation theory except for the QCD-sector; i.e.the tensions should be non-perturbative effects.

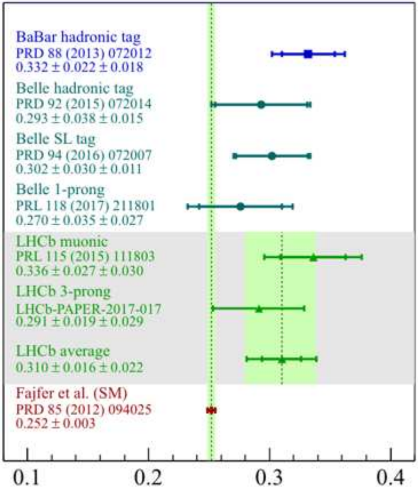
Ratio R_{K*} of $\mu\mu$ versus ee for $B \to K^* l\bar{l}$, anomalous.



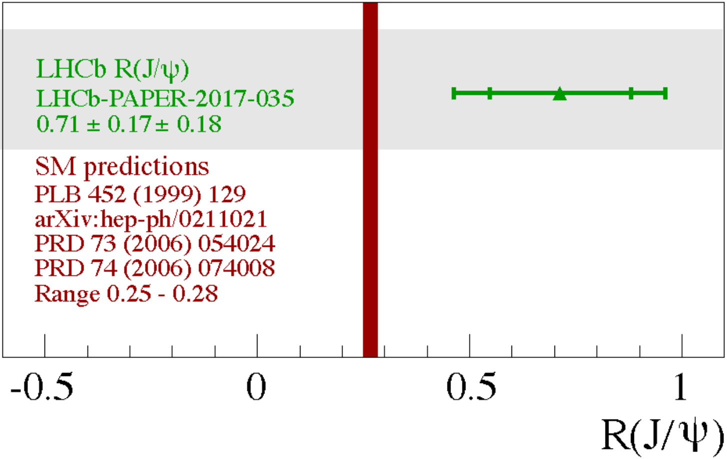
Ratio R_K of $\mu\bar{\mu}$ to $e\bar{e}$ Ratio for $B^+ \to K^+ l\bar{l}$ decay, anomalous for seperate q^2?.



Ratio $\tau\nu_\tau$ versus $\mu\nu_\mu$ for $B \to D^*\nu + lepton$, an anomaly



Ratio $R(J/\Psi)$ of $\tau\nu_\tau$ versus $\mu\nu_\mu$ also in $B \to J/\Psi + \nu + lepton$ an anomaly.



The two Deviations from SM at LHCb:

Channel	Branch. fraction	"R" Ratio	Deviation relative	Anomali-amplitude
$B \to K^* \mu^+ \mu^-$ neutral c current	10^{-6}	exp. 0.66 SM 1.00	-34 %	$-0.34\sqrt{10^{-6}}/2 = -1._7 * 10^{-4} = -1._7 * 10^{-3}\sqrt{\%}$
$B \to D^* \tau \nu_\tau$ charged current	2%	exp. 0.31 SM 0.25	+24 %	$0.24\sqrt{0.02}/2$ $=0.017$ $=0.17\sqrt{\%}$
Ratio	$2 * 10^4$			-10^2
Pred. ratio				$\sim 0.4 * (\frac{m_\tau}{m_\mu})^2 = \simeq 115$

0.4 some order of unity number

In fact our of order unity factor 0.4 with some rule of ours is

$$\frac{V_{tb}V_{ts}g_2^2}{V_{bc}g_t^2} = 0.4. \tag{1}$$

The numerically more significant factor is the ratio

$$\frac{g_\tau^2}{g_\mu^2} = \frac{m_\tau^2}{m_\mu^2} = \frac{1777^2}{105.7^2} = 283. \tag{2}$$

The numerical coincidence, that should suggest the truth of our non-perturbative effect idea is:

$$\frac{(R(D^*)|_{exp}/R(D^*)|_{SM}-1)\sqrt{B(B\to D^*\tau\nu_\tau)}}{(R(K^*)|_{exp}/R(K^*)|_{SM}-1)\sqrt{B(B\to K^*\mu\bar{\mu})}} \approx \frac{m_\tau^2}{m_\mu^2}. \quad (3)$$

Here the "R'' ratios are defined:

$$R(K^*) = \frac{B(B\to K^*\mu\bar{\mu})}{B(B\to K^*e\bar{e})}; \quad (4)$$

$$R(D^*) = \frac{B(B\to D^*\tau\bar{\nu_\tau})}{B(B\to D^*\mu\bar{\nu_\mu})}. \quad (5)$$

Note that these "R'' ratios test the lepton universality, the numerator and the denominator only deviating by the flavour of the lepton pair produced. But in $R(D^*)$it is the ratio τ-pair over μ-pair, while $R(K^*)$ is for μ-pair over e-pair.

Decays into channels only deviating by "hadronic details" support such model as e.g. ours, "nonperturbative"

That approximately

$$\frac{R(K)|_{exp}}{R(K)|_{SM}} = 0.75 \quad \approx \quad 0.66 = \frac{R(K^*)_{exp}}{R(K^*)_{SM}}, \tag{6}$$

$$\frac{R(J/\psi)|_{exp}}{R(J/\psi)|_{SM}} = 2.3 \quad \approx \quad 1.24 = \frac{R(D^*)_{exp}}{R(D^*)|_{SM}} \tag{7}$$

confirms that the anomaly is approximately the same for different hadronic developments with same weak process behind, thus supporting an e.g. non-perturbative effect, or a new physics at the weak scale.

Have now to build arguments that the lepton pair needs to couple twise with its Higgs Yukawa coupling to the strongly interacting particles/sector.

We imagine there is some coupling g_t which is so strong that very complicated diagrams with it get relevant.
But somehow we hope to argue that the leptons only get interacting with the bunch of “new strong” interaction particles via two Higgs couplings in the processes we looked at with the anomalies.

Also a coincidence for the anomali in the anomalous magnetic moment for the μ, $a_\mu = (g-2)/2|_\mu$.

We get a correction in our non-perturbative model fitting using an overall fitting constant K for the non-perturbative effects - to be explained later - to the anomalous magnetic moment for the muon:

$$(a_\mu|_{full} - a_\mu|_{prturbative}) * \frac{e}{m_\mu} \approx K * < \phi_{Higgs} > (\frac{g_\mu}{g_t})^3. \quad (8)$$

With our fit $K \sim \frac{1}{5GeV^2}$, we get $a_\mu|_{full} - a_\mu|_{prturbative} \approx \frac{246GeV * .105GeV}{(5 * GeV^2 1700^3} = 1 * 10^{-9}$ to be compared with the anomali found experimentally $2.7 * 10^{-9}$.

Thesis of the Talk suggeted from the few Agreements with “Anomalies” barely seen relative to Standard Model:

Standard Model Perfectly O.K. Even with Anomalies Provided One Inculdes Non-perturbative Effects

not only from Q.C.D.

but Also strong from the Top Yukawa Coupling g_t being “Strong”.

Does it mean: No New Physics ?

Logically :

Yes, no new physics!

but

in reality:

Explanation for: why g_t so strong? is suggested to be new principle of ours:

Multiple Point Principle:

Nature likes the couplings, as e.g. g_t, to be critical, on phase border!

I and even others talked about the multiple point principle as: the coupling constants get fine tuned so as to make several vacua have the same/ or very small energy density.

Analogy and Deviation form Q.C.D.

Analogies: At the scales we can care for, “weak ” “strong ” scales, experimentally:

- Both

$$\sqrt{\frac{8+18?}{4\pi}}g_S \quad = \quad \sqrt{(8+18?)\alpha_S} \approx 1$$

and

$$\sqrt{\frac{16?}{4\pi}} * g_t \quad \approx \quad 1,$$

- and they both run stronger towards the low energy scale $(t- > -\infty)$ and weaker towards the high energy scales $(t - - > +\infty)$ (assymptotical freedom, almost for g_t too):

$$\frac{dg_t(t)}{dt} = \beta_{g_t} > 0 \quad \text{and} \quad \frac{d\alpha_S(t)}{dt} = \beta_{\alpha_S} > 0$$

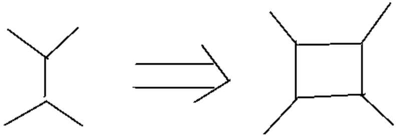
Analogies and Differences (Continued)

Difference between g_t and g_S:
The scale for g_t being "strong" seems **connected** to the Higgs scale ??
But the **Q.C.D. scale** seems **not connected** with any Higgs-like field scale.

Our multiple point principle may give the explanation, that the Higgs field scale is **adjusted to (fine tuned by our principle!) the scale of the strong scale t, where** $g_t(t) \approx 1$, because the strong $g_t(t)$ produces a new phase "at the scale t".

Except for α_S the strongest coupling in Standard Model is the Top Yukawa Coupling g_t.

Adding one loop to a Feynman diagam:



does it increase or decrease in numerical size ?

Very crudely a factor

$$g\hat{\ }2 \int \frac{d^4q}{(2\pi)^4} \frac{1}{(q^2+m_t^2)^n}$$

The Border Coupling between Weak and Strong for Only One Component is $g \sim 4\pi$.

Taking very crudely by a "dimensional argument"

$$\int \frac{d|q|}{|q|} \sim 1 \text{ (by dimensional argument)}$$

and the borderline coupling g_{border} to have the increase factor by adding a loop

$$g^2 \int \frac{d^4 q}{(2\pi)^4 |q|^4} \approx 1 \text{ (ignoring the mass squares in the propagators)}$$

we get

$$g_{\text{border}} \approx \sqrt{\frac{(2\pi)^4}{\pi^2}} = 4\pi.$$

Rydberg constant

$$R_\infty = \frac{\alpha^2 m_e c}{4\pi\hbar} = \frac{\alpha^2}{2\lambda_e} = \frac{\alpha}{4\pi a_0}$$

is of the order of the mass-energy $m_e c^2$ for

$$R_\infty = m_e c^2 \quad (9)$$

implying (10)

$$1 = \frac{\alpha^2}{4\pi c\hbar} \quad (11)$$

or (12)

$$\alpha^2 = 4\pi \text{ for } c = \hbar = 1. \quad (13)$$

meaning (14)

$$e = \sqrt[4]{(4\pi)^3} \quad (15)$$

$$= (4\pi)^{3/4} \approx 6 \quad (16)$$

Size of Coupling and Number of "Components"

If there were e.g. a color quantum number taking N values for the particle type encircling the loop, then there would be N various loops for each one, in case of no such inner degree of freedom. According to our philosophy of the increase factor by inserting a loop

$$g_{\text{border}}^2 N \int \frac{d^4q}{(2\pi)^4|q|^4} \approx 1 \tag{17}$$

then the N-dependence of the borderline coupling between perturbative and non-perturbative would be

$$g_{\text{border}} \propto \sqrt{\frac{1}{N}}. \tag{18}$$

For say 16 "Components" Borderline Coupling $\sim$ 1.5 to 3

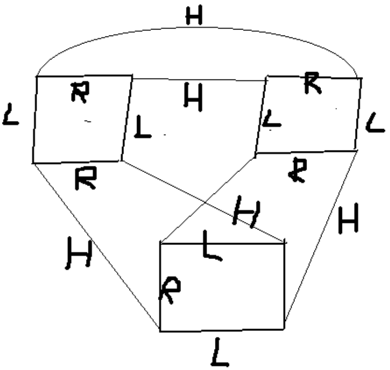
Very crudely counting particle and antiparticle also as different "components" and counting together both the Higgs with its 4 real components and the top with its 3*2*2=12 we get in total for the particles interacting via the top yukawa coupling g_t 12+4 = 16 components. Thus the borderline value for g_t becomes

$$g_{t\ \text{border}} \approx (6 \text{ to } 4\pi)/\sqrt{16} = 1.5 \text{ to } 3. \tag{19}$$

Experimentally

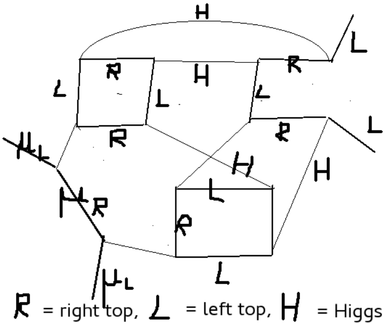
$$g_{t\ \text{exp}} = 0.93_5 \tag{20}$$

Very High Order Diagrams Likely to be Important



R = right top, L = left top, H = Higgs

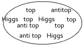
Diagrams with Almost Only Top-Yukawa Couplings of High Order Could be Significant and give the Anomalies about to be Statistically Significant “Tensions”.



L	can be both left top and left bottom, strange, d
R	right can be only top.
H	can be both eaten Higgs and the “radial” observed Higgs
-	

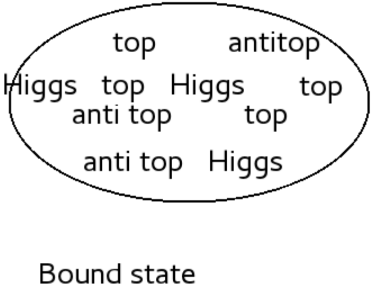
Physical Picture is Some Bound State or Other Virtual Possibility

Have in mind that some combination of Higgs particles and top quarks (right and left) because of the in fact strong g_t yukawa-coupling form e.g. a bound state, which is surprisingly light for the mass of its constituents, but still very heavy compared to B-meson masses and the scale of most of the experiments, so that the effect of it will be ususally well enough described by some effective field theory Lagrangian terms of dimension, so that they are not renomalizable (the renormalizable ones are just fit to experiment anyway and thus not seperately observable).



Bound state

Speculate some Bound state of the Particles interacting via g_t, which is Large



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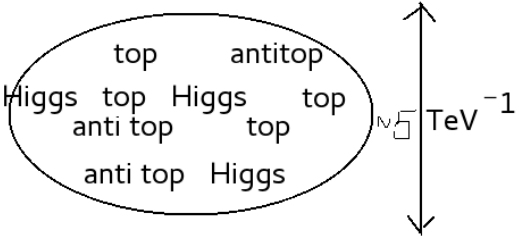
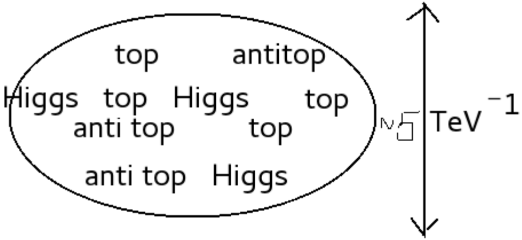


Bound state

Mass say ~ 750 GeV

Heisenberg uncertainty relation implies that 4-momenta in the propagators for the constituents give important contributions up to inverse size of the bound state.



Bound state

Mass say ~ 750 GeV

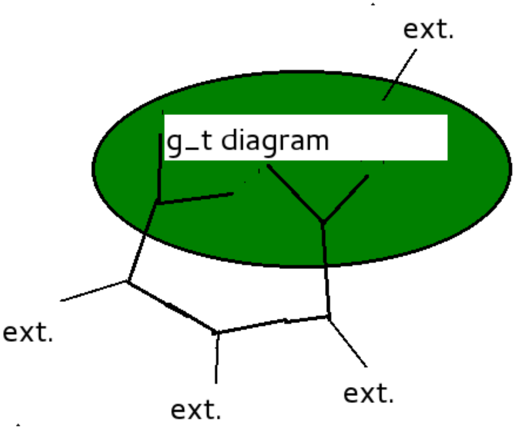
Attaching External lines to development or one or more Virtual Bound States

Whether we attach the external particles for which we shall construct an effective field theory term to a loop of the bound state going arround or just to a bound state propagator, the process in terms of the fundamental propagators of the Standard Model, will be very complicated / large order diagrams with loop momenta being important up to momenta of the order of $\hbar$ divided by the size (radius) of the bound state.
Compared to these large important loop 4-momenta the external 4-momenta in a usual experimentally accessible process such as a B-meson decay will be small, if we are guessing right that the size is a few TeV^{-1}.

Too many extra propagators added to the diagram with only g_t spoils the staying inside bound state.

If a Standard Model particle couples several times successively to external particles in a diagram involving our non-perturbative diagrams as part, the successive series of propagators will make low 4-momenta favoured and the particle will be effectively in an in momentum narrow state preventing it from being concentrated in the bound state.

The more successive (only with exteral lines attached in between) propagators, the more gets the binding spoiled.



Suggested Proceedure of Model

We imagine a lot of Feynman diagrams - that shall be summed up of course - each with almost only the top-Yukawa coupling g_t in it, and only a few external lines/propagators of other types (like muon say). Then the rules/assumptions:

- The sum over the many diagrams with only g_t from which we modify a bit by putting external lines on are all supposed to give just one **overall factor, which we must fit.**
- When we use an external L line as a left bottom, strange or d quark line, we include a V_{tb}, V_{ts}, or V_{td} **mixing angle factor**
- Other couplings than g_t needed must give rise to the extra factors being these couplings, compared to the g_t they replace.
- Propagators for W, Higgs, top,... are similar order of magnitudewise, and we ignore the differences in our crude rule.

From the Physics involving Rather Heavy Particles the Result of the Nonperturbative Effects should be Effective Lagragian Terms, and not to be Renormalized away of Dimensionality making them Unrenormalizable.

The rather high mass of the particles like top and Higgs involved in the diagrams developping non-perturbative effects suggests this effect at the relatively low energies involved, in B-meson decay say, to be described by an effective field theory. The effective terms which have dimension of the operator like in renormalizable theory are already present in the Standard Model, and thus such non-perturbative effects contributing to terms with dimension less than or equal to $[GeV^4]$ would just be absorbed into these terms already present in the Standard model.

Effective Langrange Density Terms (Continued)

We can only realistically hope to measure terms not of this renormalizable type, because otherwise we would need some knowledge about the bare couplings not comming from the usual measurements:
Denoting say leptons and quark fields by ψ_q and ψ_l and the bosons as W_μ, Z_μ and ϕ effective field theory terms that might result from non-perturbative effects could have e.g. the forms (P_L is left handed γ_5 projector)

$$\bar{\psi}_t \phi \psi_t \quad : \quad \text{of renormalizable theory dimension}[GeV^4]$$
$$\bar{\psi}_b \gamma_\nu P_L \psi_s \bar{\psi}_\mu \gamma^\nu P_L \psi_\mu \quad : \quad \text{Dimension } [GeV^6]\text{, so not renormalizable.}$$

Example of an Effective Lagrangian Density Coefficient Estimated in Our Non-perturbative Scheme:

Say we want the coefficient to the term of the form

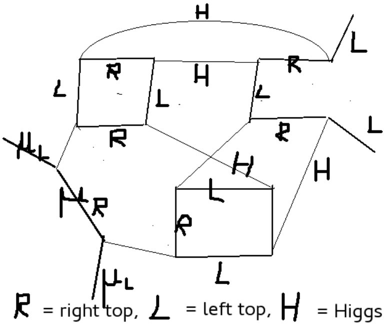
$$\bar{\psi}_b(x)\gamma_\nu\psi_s(x)\bar{\psi}_\mu(x)\gamma^\nu\psi_\mu(x),$$

which can represent that a bottom quark b described by $\psi_b(x)$ becomes a strange quark s described by ψ_s by a "neutral current exchange" and the production of a muon antimuon pair produced by the operator

$$\bar{\psi}_\mu(x)\gamma^\nu\psi_\mu(x).$$

Then we need a diagram with the four external particles corresponding to b→s, μ $\bar{\mu}$.

Diagrams with Almost Only Top-Yukawa Couplings of High Order Could be Significant and give the Anomalies about to be Statistically Significant “Tensions”.



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-	

Example c$\rightarrow$ s, $\bar{\mu}$, and μ (Continued)

It shall be a series of diagrams with an arbitrary number of g_t vertices and associated t_L, t_R and Higgs, but as few as possible other - and therefore smaller - couplings (except we might include the strong QCD couplings).
If the b and the s are taken to be of the left handed helicity, b_L and s_L, so that we really go for the coefficient to

$$\bar{\psi}_b(x)\gamma_\nu P_L \psi_s(x)\bar{\psi}_\mu(x)\gamma^\nu \psi_\mu(x), \tag{21}$$

and we can interprete it, that the weak $SU(2)$ partner of the left handed top-components t_L, which are also allowed in the bulk of our diagrams are already with amplitudes respectively V_{tb} and V_{ts} respectively the left handed b_L and s_L,then they do not "cost" extra coupling factors except for these KMC matrix elements, V_{tb} and V_{ts}.

Example c$\rightarrow$ s, $\bar{\mu}$, and μ (Yet Continued)

Ignoring the propagators and thereby the masses we have in the bulk diagram perfect formal conservation of weak charge $SU(2)$, and thus the two left handed quarks b and s - and thus doublets - cannot couple to only one Higgs. We must have **two** external Higgs bosons coupling to the muon-antimuon pair.
The muon cannot be interpreted as being already there in the bulk diagram and must instead be coupled to - as we argued two - Higgs-bosons. This cause the applicably type of diagram to include a factor g_μ^2 - or if we want to consider it a replacement of g_t couplings by analogous g_μ's, it must include a factor $\left(\frac{g_\mu}{g}\right)^2$. So the coefficient to (21) becomes

$$\text{“coefficient to c}\rightarrow\text{s}\bar{\mu}\ \mu\text{''} = K * V_{tb}V_{ts}\left(\frac{g_\mu}{g_t}\right)^2. \qquad (22)$$

Example b $\rightarrow$ s,$\bar{\mu}, \mu$ Transition Coefficient Estimate (Yet Yet Continued)

The coefficient to (21):

$$\bar{\psi}_b(x)\gamma_\nu P_L \psi_s(x)\bar{\psi}_\mu(x)\gamma^\nu \psi_\mu(x),$$

became

$$\text{“coefficient to c}\rightarrow\text{s}\bar{\mu}\ \mu'' = K * V_{tb}V_{ts}\left(\frac{g_\mu}{g_t}\right)^2, \qquad (23)$$

and here K is an overall constant depending on the non-perturbative part of the calculation, which we cannot do, and thus must fit via this overall factor K, while g_t, and g_μ are the Yukawa couplings to the Higgs by respectively top and muon, and V_{tb} and V_{ts} the mixing matrix elements.

Another Example: b $\rightarrow$ c, $\bar{\tau}$, ν_τ; Charged Current Process

The coefficient to the "non-renormalizable" charged current simulating effective field theory term

$$\bar{\psi}_b \gamma_\nu P_L \psi_c \bar{\psi}_\tau \gamma^\nu P_L \psi_{\nu_\tau} \tag{24}$$

becomes similarly

$$K * V_{tb}(V_{tb}V_{bc} \text{``}+\text{''}\, V_{ts}V_{sc} \text{``}+\text{''}\, V_{td}V_{dc}) \left(\frac{g_2}{g_t}\frac{g_\tau}{g_t}\right)^2 \tag{25}$$

where g_2 is weak $SU(2)$ gauge theory coupling, and as before: K the over all non-perturbative constant, V_{qq} the mixing matrix elements, and g_t, g_τ the respective Yukawa Higgs couplings. Order of magnitudewise we only care for the dominant one of the three mixing matrix element products.

Fitting our overall constant K:

With the notation

$$H_{eff} = -\frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^* \frac{e^2}{16\pi} \sum (C_i O_i + C_i' O_i') + h.c. \qquad (26)$$

and

$$O_9^{(\prime)} = (\bar{s}\gamma_\mu P_{L(R)} b)(\bar{l}\gamma^\mu l),$$

the fit of the "new physics" NP in the coefficient C_9 to the effective term O_9, which we considered is about

$$C_9 \approx -1.3. \qquad (27)$$

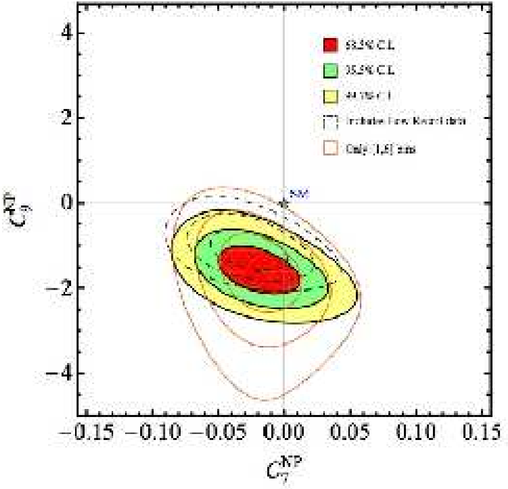


FIG. 1: Fit to (C_7^{NP}, C_9^{NP}), using the three large-recoil bins for $B \to K^* \mu^+ \mu^-$ observables, together with $B \to X_s \gamma$, $B \to X_s \mu^+ \mu^-$, $B \to K^* \gamma$ and $B_s \to \mu^+ \mu^-$. The dashed contours include both large- and low-recoil bins, whereas the orange (solid) ones use only the 1-6 GeV^2 bin for $B \to K^* \mu^+ \mu^-$

Fitting K (continued)

The conventional $V_{tb}V_{ts}^*$ factors in

$$H_{eff} = -\frac{4G_F}{\sqrt{2}} V_{tb}V_{ts}^* \frac{e^2}{16\pi} \sum (C_i O_i + C_i' O_i') + h.c.$$

are just the same as in our formula for the non-perturbative effect coefficicient

$$\text{“coefficient to c}\rightarrow\text{s}\bar{\mu}\ \mu\text{''} = K * V_{tb}V_{ts} \left(\frac{g_\mu}{g_t}\right)^2.$$

Thus we should fit to

$$\begin{aligned} K * \left(\frac{g_\mu}{g_t}\right)^2 &= -\frac{4G_F}{\sqrt{2}} \frac{e^2}{16\pi} * C_9 = -\frac{G_F}{\sqrt{2}} \alpha * C_9 \\ &= 1.1663787(6)10^{-5} GeV^{-2}/(\sqrt{2} * 137.037) * (-1.3) \\ &= -0.00000824754 GeV/137.037 * (-1.3) \\ &= -6.01847886 * 10^{-8} GeV^{-2} * (-1.3). \end{aligned}$$

Fitting K (Still)

We shall fit to

$$K * \left(\frac{g_\mu}{g_t}\right)^2 = -6.01847886 * 10^{-8} GeV^{-2} * (-1.3)$$

Since
$\left(\frac{g_\mu}{g_t}\right)^2 = (0.1056583745/172.44)^2 = (6.137 * 10^{-4})^2 = 3.77 * 10^{-7}$
we get from fitting the O_9 coefficient

$$\begin{aligned} K &= \frac{6.018 * 10^{-8} GeV^{-2}}{3.77 * 10^{-7}} * 1.3 \\ &= 1.64 * 10^{-1} * 1.3 GeV^{-2} \\ &= 0.21 GeV^{-2} \\ &= \frac{1}{4 \text{ to } 5 GeV^2} \end{aligned}$$

Embarrasingly Huge Overall Constant $K \sim \frac{1}{4GeV^2}$ for the Non-perturbative.

Imagine that the non-perturbative effect in reality is the effect of some loop with or just effect of bound state formed from the top-quarks and the Higgs. If consisting as we usually speculate of 6 top + 6 anti top its consituent mass would be $12m_t = 2.1\,TeV$ and even if we did not count suppression from there being a loop say an order of magnitude $\frac{1}{4\,TeV^2}$ would have been rather expected. But now if we have about 12 consituents in the bound state a top-quark or a Higgs would couple to such a bound state with a total coupling of the order of $12g_t$. Very optimistically a diagram with four external lines would have four such factors and the resulting K would be enhanced by a factor $(12g_t)^4 \approx 20000$ which would bring $\frac{1}{4\,TeV^2}$ up to $\frac{1}{200\,GeV^2}$.

Still Wondering How Big the Fitted $K \sim 1/(4GeV^2)$ turned out.

If the bound state mass were say 750 GeV rather than 2.1 TeV a reduction by a factor $(2.1/.75)^2$ of the above speculated $\frac{1}{200GeV^2}$ would be argued for, and we could say we could understand if K were $\frac{1}{20GeV^2}$, but the fitted value $\frac{1}{4GeV^2}$ seems still to be a bit - a factor 5 - bigger than we would even speculate optimistically.
But of course the point is that it is too hard to compute or even speculate the overall strength K, so that we must rather trust a fit.

The Value $K = \frac{1}{(4 \text{ to } 5)_{GeV^2}}$ is quite Absurd.

The value of K we found would give us a non-renormalizable Lagrangian term for say top-quark scattering, which would not be suppressed,

$$\sim \frac{1}{5GeV^2}\bar{t}(x)\gamma^\mu t(x) * \bar{t}(x)\gamma_\mu t(x), \tag{28}$$

which is quite absurd, if you think of using corresponding to cut off scale of say the order of $\Lambda \sim 0.5TeV$ or a "lattice scale" of the order $a \sim \frac{1}{0.5TeV}$.

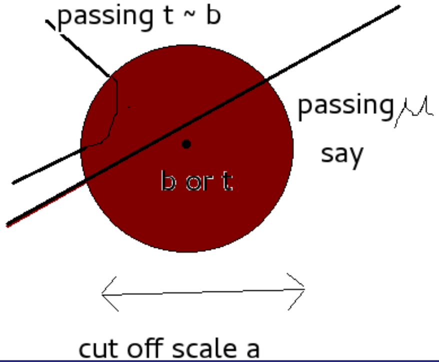
We would in fact like to argue *that you cannot use perturbation theory for such a coupling unless one for*

$$K * \bar{t}(x)\gamma^\mu t(x) * \bar{t}(x)\gamma_\mu t(x) \tag{29}$$

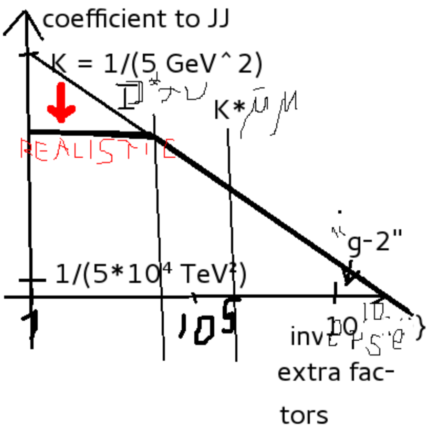
has

$$K * a^2 \leq 1 \tag{30}$$

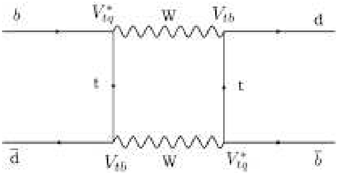
Too Strong (Effective) Coupling Term gets Absurd/not PerturbativeIt Applicable, when $Ka^2 > 1$ for dim =6

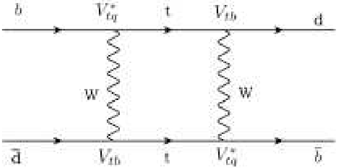


If there is not a correction factor reducing the K to be sensible, we cannot take it seriously, but must correct it down:



If Absurdly Higg K were taken Seriously $K^0\bar{K}^0$, $B\bar{B}$, etc Mixings would get Dramatically Influenced by Anomaly!





The weak box diagram

modified by new strong interaction

Even just letting the t's interact via a blob of non-perturbative with $K = 1/(5GeV^2)$ would cause too much anomaly for the meson-mixings !

But if we cut it down by setting an upper limit on strength of the $\bar{t}\gamma^\mu P_L t * \bar{t}\gamma_\mu P_L t$ means we have put in the scale down to which to use our effective coupling a as a new parameter, that we can use to fit. We shall of course seek to choose the second parameter in our model a so small as length, that we can avoid predicting more mixing physics change than can be tolerated; but then we may get to that the least suppressed of our uses for anomalies, namely that for the charged current $B \to D^{(*)}\tau\nu_\tau$ gets influenced by the correction too.

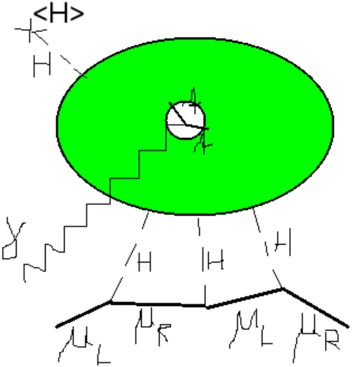
If we avoid "selling" our agreement for the $R(D^{(*)})$ ratio out, we have to use that our model is only a very crude order of magnitude one to escape from predicting too much mixing.

Thinking of sub-models of Standard Model

In the "new strong interactions" based on the "large" g_t yukawa coupling for there are only the **three** particles involved:

- Right top quark, really a Weyl particle in three color versions.
- the linear combinations of left handed top and corresponding d,s, and b; weak doublet of Weyl fermions in three color versions.
- Higgs doublet.(so called eaten Higgses included)

The $g-2$ anomaly



Conclusion

- We have sucessfully confronted the three anomalies studied here with the speculation : **that the Standard Model is perfectly enough, even including these anomalies, provided only that we allow for the order one property of the top-yukawa-coupling g_t allows us to have high order diagrams involving this coupling give huge contributions**, which we parametrized by an overall scale $K \sim 1/(5GeV^2)$. The three anomalies are : $R(D^{(*)})$ (charged current), $R(K^{(*)})$ (neutral current), and the "$g-2$ anomaly".

Conclusion (continued)

- WE fitted the three tensions, we treated,
  - the LUV in $B \to D^{(*)}\tau\nu_\tau$ relative to it with e or μ,
  - the LUV in the neutral current $B \to K^{(*)}\mu\bar{\mu}$ relative to the analogue with e
  - and the $g-2$ anomaly,

  very crudely with one parameter/ an overall scale K.
- But to avoid a wild prediction for the meson anti meson mixings, we must introduce yet a parameter a used to screw down the K to be used when it is not "sufficiently " suppressed by our rule.

Conclusion yet continued

- The "rule" of the model is that in a blop taking care of the non-perturbative effects:
  - we accept the vertex top-yukawa unrestricted.
  - other vertices included with their coupling relative to g_t.
  - vertices ignored.
  - coupling using the Higgs vacuum expectation value must be explicitely included.

Interference or Not Does Not Matter by Accident.

The ratio of the experimentally found quite seperate anomalies measured in their rates/branching ratios is

$$\frac{\text{“Anomalous rate } B \to X_c \tau \nu_\tau\text{”}}{\text{“Anomalous rate } B \to X_s \mu \nu_\mu\text{”}} = (-)1 * 10^4$$

while the ratio of the normal rates is:

$$\frac{BR(B \to X_c \tau \nu_\tau)}{BR(B \to X_s \mu \nu_\mu)} = \frac{2\%}{2 * 10^{-6}} = 1 * 10^4$$

corresponding to an amplitude ratio:

$$\frac{A(B \to X_c \tau \nu_\tau)}{A(B \to X_s \mu \nu_\mu)} = \sqrt{\frac{2\%}{2 * 10^{-6}}} = 1 * 10^2.$$

Amplitude Ratio for the Anomalous Parts of a factor 100 Needed Experimentally.

By accident it does not matter whether the anomalies come by interference - as we think they do - or by just adding to the rate, in any case it is needed experimentally that the ratio of the two anomalous parts of the amplitude must be ~ 100:

$$\frac{A_{anomalous}(B \to X_c \tau \nu_\tau)}{A_{anomalous}(B \to X_s \bar{\mu}\mu)} = 100. \tag{31}$$

Is that then what our model predict ?:

$$\frac{A_{anomalous}(B \to X_c \tau \nu_\tau)}{A_{anomalous}(B \to X_s \bar{\mu}\mu)} =$$

$$= \frac{K * V_{tb}(V_{tb}V_{bc} \text{``}+\text{''}\, V_{ts}V_{sc} \text{``}+\text{''}\, V_{td}V_{dc}) \left(\frac{g_2}{g_t}\frac{g_\tau}{g_t}\right)^2}{K * V_{tb}V_{ts}\left(\frac{g_\mu}{g_t}\right)^2}$$

Our Prediction for the Ratio of the Charged Current B$\to X_c\tau\nu_\tau$ to the Neutral Current one B$\to X_s\bar{\mu}\mu$.(continued)

Our amplitude ratio prediction

$$\frac{A_{anomalous}(B \to X_c\tau\nu_\tau)}{A_{anomalous}(B \to X_s\bar{\mu}\mu)} =$$

$$\approx \frac{V_{tb}V_{bc}}{V_{ts}} * \frac{g_2^2 g_\tau^2}{g_\mu^2 g_t^2} \tag{33}$$

$$\approx 1 * 0.4 * \frac{m_\tau^2}{m_\mu^2} \tag{34}$$

$$= 0.4 * \frac{1777^2}{105^2} = 115. \tag{35}$$

Experiment gave ~ 100, Very good agreement!

Dominant Anomaly in $B^+- > K^+ tau^+ tau^-$

Our prediction for the branching ratio for $B^+- > K^+ tau^+ tau^-$:
The anomaly amplitude is enhanced by the factor m_{tau}^2/m_{mu}^2 compared to the $B \to K^+ mu^+ mu^-$ anomaly amplitude and therefore **dominates the usual SM** amplitude.
So the branching ratio value is for $B^+ \to K^+ tau^+ tau^-$:

	Branching ratio
For SM	$\sim .2 \times 10^{-7}$
For our anomaly	$\sim 3 \times 10^{-4}$
Experiment.	$< 2.25 \times 10^{-3}$

We have Long Worked on the Speculation, that Non-perturbative Effects Caused aVery Strongly Bound State of 6 Top + 6 Anti Top Quarks, and a New Vacuum with a Condensate of such Bound States, Very Successfully.

Our speculation based on non-perturbative effects has:

- Dark matter consists of bubles of a new phase of vacuum filled with atoms.
- These dark matter "pearls" with mass $\sim 500000t$ made 6400 volcanoes of the Kimberlite pipe type found on earth (and probably many more not found).

Some Successful Numbers Fitted/Predicted by Our Non-perturbative Standard Model Based Models for Dark Matter:

Quantity	Predicted	"experiment"	from
Weak scale	$\sim 30 GeV$	$\sim 100 GeV$	"Tunguska"
line 3.5 keV	4.5 keV	3.5 keV	"homolumo-gap"
"Life time, 3.5 keV"	$10^{29}s$?	$10^{28}s$	pearl collissions
Double supernova burst	14 hours	5 hours	neutron-eating

Conclusion

- We proposed, that two (small) tensions found in respectively neutral ($c \to s$) and chagrged current ($b \to c$) transitions in B-decay are due to non-perturbative effects inside the Standard Model.
- The ratio between the anomalous amplitudes for the two processes/decays of B-mesons $B \to X_s \bar{\mu}\mu$ and $B \to X_c \tau \nu_\tau$ seems to be observed to $\sim \frac{1}{100}$ in agreement with the prediction resulting from our "practical proceedure" for calculating this ratio of amplitudes from our assumption, that they result from non-perturbative effects due to the top-yukawa coupling g_t being of order unity.
- So colorredStandard Model could be perfectly correct even with these anomalies/tensions being true physical effects.

Conclusion (continued)

- In the neutral current decay $B \to K\tau^+\tau^-$ we PREdict the anomaly to dominate.
- We have earlier used this non-perturbative effect for a model for dark matter, thus completely inside the Standard Model.

Thank You

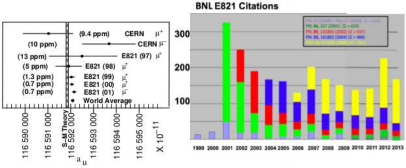
Thanks to Organizers, to COST and EU-tax-payers

Presently Un-understood Anomalies, Tensions

- **The Proton Radius Anomaly:** With μ .84 fm; with e^- 0.877 fm.
- **The neutron lifetime anomaly:** "bottle": 879.3 ± 0.75 s; "beam": 888 ± 2.1 s.
- **The Hubble constant anomaly:** $H_0 = 67.8 \pm 0.9$ km/s/kpc from Planck sattelite MWB; $H_0 = 73.24 \pm 1.74$ km/s/kpc from WFC3 cepheids. endframe

Muon anomalous magnetic moment anomaly?

$$
\begin{aligned}
a_e^{exp} &= 1159652180.73(28) \times 10^{-12} \pm 0.24 ppb \\
a_\mu^{exp} &= 116592089(63) \times 10^{-11} \pm 0.54 ppm \\
&\quad \text{Two slightly different theoretical calculations:} \\
a_\mu^{SM} &= 116591802 \\
&\quad \pm 42(H-LO) \pm 26(H-HO) \pm 2(other)(\pm 49 tot) \times 10^{-11} \\
a_\mu^{SM} &= 116591828 \\
&\quad \pm 43(H-LO) \pm 26(H-HO) \pm 2(other)(\pm 50 tot) \times 10^{-11}
\end{aligned}
$$



(a) (b)

Figure 7: (a)Measurements of a_μ from CERN and BNL E821. The vertical band is the SM value using the hadronic contribution from Ref. [20] (see Table 1). (b) Citations to the E821 papers by year.

of New Physics, the E821 results have been highly cited, with more than 2450 citations to date.

3 Expected Improvements in the Standard-Model Value

The present uncertainty on the theoretical value is dominated by the hadronic contributions [20, 21] (see Table 1). The lowest-order contribution determined from $e^+e^- \to$ hadrons data using a dispersion relation is theoretically relatively straightforward. It does require the combination of data sets from different experiments. The only significant theoretical uncertainty comes from radiative corrections, such as vacuum polarization (running α), along with initial and final state radiation effects, which are needed to obtain the correct hadronic cross section at the required level of precision. This was a problem for the older data sets. In the analysis of the data collected over the past 15 years, which now dominate the determination of the hadronic contribution, the treatment of radiative corrections has been significantly improved. Nevertheless, an additional uncertainty due to the treatment of these radiative corrections in the older data sets has been estimated to be of the order of 20×10^{-11} [21]. As more data become available, this uncertainty will be significantly reduced.

There are two methods that have been used to measure the hadronic cross sections: The energy scan (see Fig. 4(b)), and using initial state radiation with a fixed beam energy to measure the cross section for energies below the total center-of-mass energy of the colliding

Can Tensions on Lepton Flavour Universality mainly be Non-Linear Effects Inside the Standard Model?

Abstract:
We suggest that due to the relatively large size of the top-quark yukawa coupling some non-perturbative effects, such as e.g. bound states, or just high order diagrams being of importance, could give *seemingly* new physics, which, however, in reality rather *is* inside the Standard Model. The for the time appearing on the borderline of statistical significance deviation from the Standard Model, especially from flavour universality, in both charged and neutral current weak decays of B-mesons is suggested by us to indeed be due to such non-oerturbative effects.

The abstract continues on next slide.

Continued Abstract:

The phenomenologically suggestion, that the neutral current effect say should be due to the a C_9 term with $\mu\bar{\mu}$ (but not with e^-e^+) fits very well with our model; but most impressive for supporting our idea is that the ratio of the charged current lepton universality by a too high measured $\tau\nu_\tau$ rate in B-decay fits order of magnitude with an over all rate scale fixed by the neutral current adjustment, in spite of two rates of decay we compare deviate by four orders of magnitude (we predict about 5).

Explaining "C_9'':

Effective Hamiltonian.

The effective Hamiltonian for $b \to s$ transitions can be written as

$$H_{eff} = -\frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^* \frac{e^2}{16\pi} \sum (C_i O_i + C_i' O_i') + h.c. \quad (36)$$

and we consider NP effects in the following set of dimension-6 operators,

$$O_7^{(\prime)} = \frac{m_b}{e} (\bar{s}\sigma_{\mu\nu} P_{R(L)} b) F^{\mu\nu}, \quad (37)$$

$$O_9^{(\prime)} = (\bar{s}\gamma_\mu P_{L(R)} b)(\bar{l}\gamma^\mu l), \quad (38)$$

$$O_{10}^{(\prime)} = (\bar{s}\gamma_\mu P_{L(R)} b)(\bar{l}\gamma^\mu \gamma_5 l) \quad (39)$$

Plan of talk: Tensions in Lepton Flavour Universality... Perturbative Effect.

- Introduction
- Non-perturbative Some thoughts on especially the significance of the number of species components involved in the strong coupling sector, and the main idea.
- Non-renormalizable Effective field theory terms in the Lagrangian of higher dimension coefficients.
- Decoration Our way of thinking of the high order terms as represented by normal diagrams, which then should give the true digrams by “decoration”.

Plan continues on next slide.

bf Plan for "Tensions... Perturbative Effect." contnued:

- Data Review of some data.
- Ratio We make an order of magnitude estimate of the decay branching ratios of a charged current anomalous channel with $\tau\nu_\tau$ and a neutral current and much smaller in absolute rate anomaly with $\mu\mu^-$.
- Speculation We seek to relate the absolute size scale of the tension fitting to the ealier speculative studies of $6t +$ 6anti$t$ bound state of mass 750 GeV?
- Conclusion We conclude, that we have a very crude picture for the (barely) observed anomalies, with *remarkably* only *one* overall rate parameter, and that without needing any new physics!

Analysis in Terms of Dimension 6 terms ...

On the following slide one sees the fitting of the most from 0 deviating term C_9, when fitting to the slight anomalies in B-meson decay.

This term with coefficient C_9 is a term of the type

$$\bar{s}_L\gamma^\mu b_L\bar{\mu}\gamma\mu. \tag{40}$$

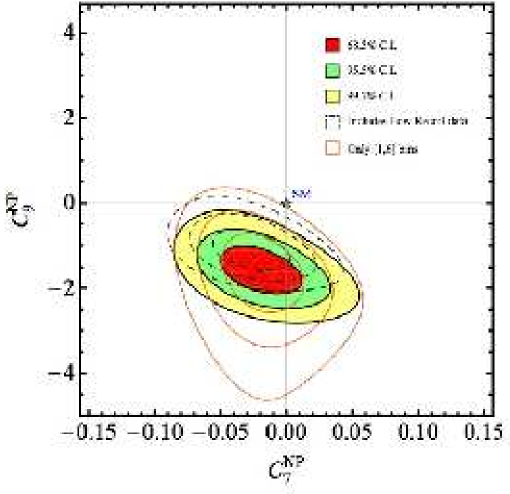


FIG. 1: Fit to (C_7^{NP}, C_9^{NP}), using the three large-recoil bins for $B \to K^* \mu^+ \mu^-$ observables, together with $B \to X_s \gamma$, $B \to X_s \mu^+ \mu^-$, $B \to K^* \gamma$ and $B_s \to \mu^+ \mu^-$. The dashed contours include both large- and low-recoil bins, whereas the orange (solid) ones use only the 1-6 GeV^2 bin for $B \to K^* \mu^+ \mu^-$

Spirit of our Non-perturbative Effect Idea.

Our speculation is that the coupling constant of the Higgs to the top-quark - the Yukawa-coupling - is so large compared to the relevant size for non-perturbative effects becomming important, that we have in practice to go to all or very high orders in this coupling g_t. It happens to be just of order 1 but presumably it is rather $g_t^2/(2\pi)$ or a quantity with even more 2π's in the denominator, that matters. However the number of types of particles also counts. Since the top quark have three color-possibilities and two spin-possibilities and a possibility of being an antiquark or a quark we therefore may have of the order of 2*2*3 different components and presumably we should tereby be able to compensate some of 2π factors.

Our Non-perturbative Model diagrams

We think of all the many diagrams that can have a lot of g_t vertices but otherwise being of as low order as possible, by proposing one of them and saying that we shall **decorate that diagram** meaning that we imagine splitting some of the top or Higgs propagators and replace some pieces of the diagram by inserting more Higgs and top propagators and thus adding more and more g_t vertices too. On the following figure the part of the diagram that should be modified to deliver the in g_t higher and higher order diagrams has been put into a red ellipse. All the decorating diagrams of course are meant to have the same outer lines. On the figure they should make contribution to the process of the type multiplied by the coefficient called C_9.

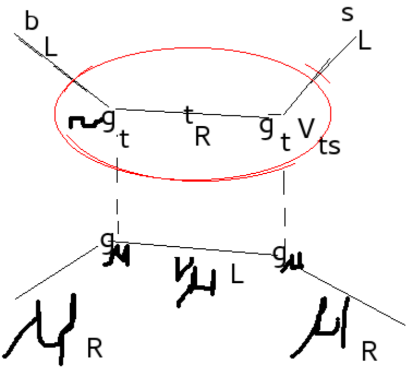


Diagram for C_9

It shall be decorated in the ellipse.

How to Think of Our Diagram with Decoration

The idea meant with this diagram drawing is:

- The red ellipse arround mainly the top-propagator is to be thought of as an ellipse arround the very complicated hiugh order diagram with **only** g_t vertices, which is to be the resultof the “decoration”.
- Then one shall think that *a priori* there only can come the three strongly couling particle types - t_r, t_l and Higgs-doublet - out of the diagram.
- The whole magnitude of the interior of the ellipse then is non-perturbative and **cannot** be perturbaltively or otherwise properly calculated. (It can only be speculatively guessed, or one must simply fit the value.)

Thinking about the Decoration continued.

- So we shall think of the particles/propagators exiting from the ellipse as being one of the three sorts allowed, but truly say a left handed top t_L is in reality a superposition - mainly of course of true top, but - with amplitude V_{tc} a left b, and with V_{ts} a left handed strange quark, amd so on.
- The Higgses comming out in some sense are counted as just Higses -without caring for their masses - untill they come out and couple with their yukawa couplings say to e.g. muons or taus etc.

Second Thought on "Decoration"

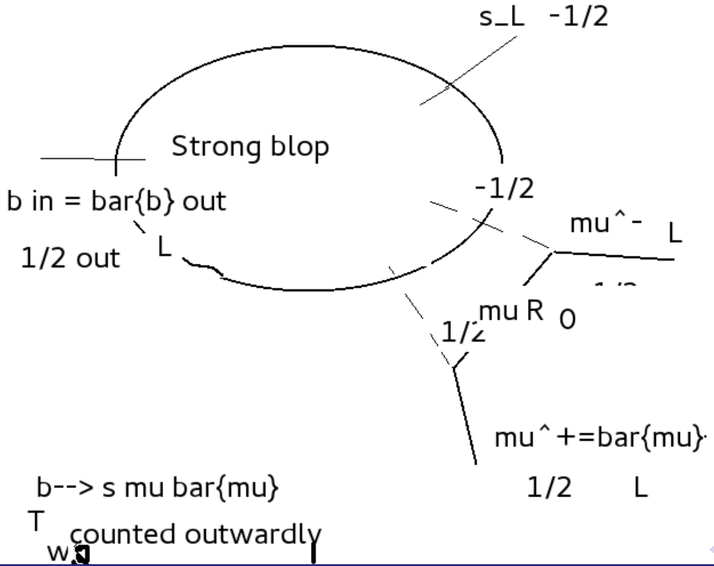
Actually thinking on one diagram and then only modify that by "decoration" may be a bit dangerous, because you may forget to think of some of the diagrams. So we think that it may better to think more abstractly on a very large order diagram mainly consisting only of the g_t vertices each of which being met by the three propagators right t, left t, and Higgs.

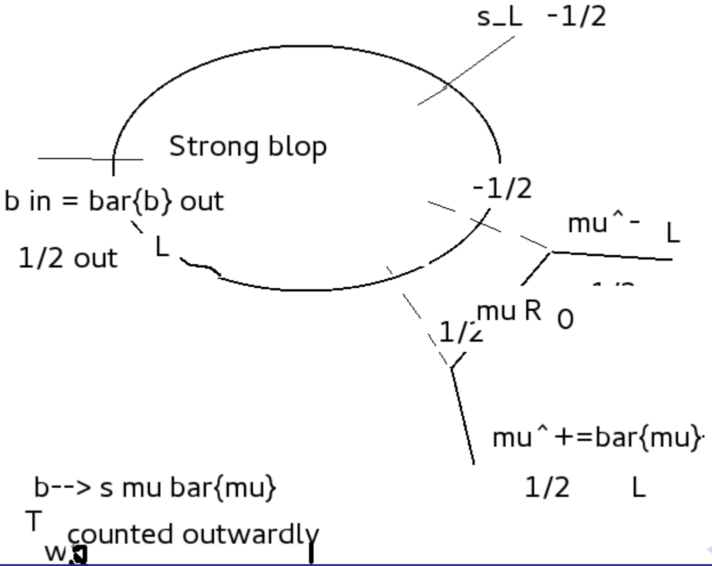
The external particles/ i.e. the propagators passing the ellipse are then for our $c \to s\mu\bar{\mu}$

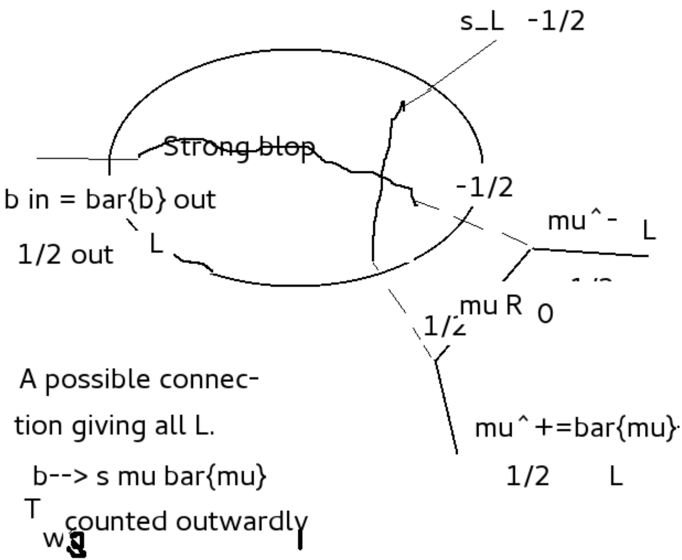
- The s and the b quarks are - if left handed - to be considered one of the components in the left top defined to corresond the the right hand top by Higgs coupling. So in this way we can consider with correction factors V_{ts} or V_{tb} that it is a left top-quark propagator, which comes out of the ellipse zone.
- The exit-propagator, we need is higgses, so that they can couple to the muons.

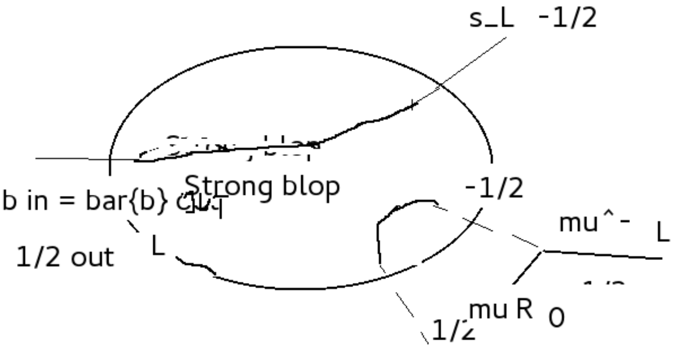
Classifying Diagrams for C_9

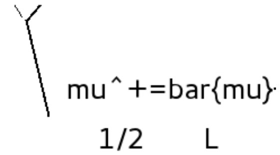
The external to ellipse propagators needed for our wished for C_9 were the Higgs and the left top, which both are weak $SU(2)$ doublets, while the third particle in the new strong couppling scheme the right top is $SU(2)$-singlet.
So these external particles to ellipse region have to be connected by series of weak $SU(2)$ doublets taht can be traced through the very high order and complicated diagram.
In the following figures we think of the classification according to which such chain of successive weak doublets go from which outer particle to which.
We denote them by curves drawn across the interior of the ellipse.


s_L -1/2
Strong blop
b in = bar{b} out
1/2 out
L
-1/2
mu^- L
mu R 0
1/2
mu^+=bar{mu}
1/2 L
b--> s mu bar{mu}
T
counted outwardly


s_L -1/2
Strong blop
b in = bar{b} out
1/2 out
L
-1/2
mu^- L
mu R 0
1/2
mu^+=bar{mu}
1/2 L
b--> s mu bar{mu}
T
counted outwardly
W


s_L -1/2
Strong blop
b in = bar{b} out
1/2 out
L
-1/2
mu^- L
mu R 0
1/2
A possible connec-
tion giving all L.
b--> s mu bar{mu}
T
counted outwardly
mu^+=bar{mu}
1/2 L





A possible connection giving all L.

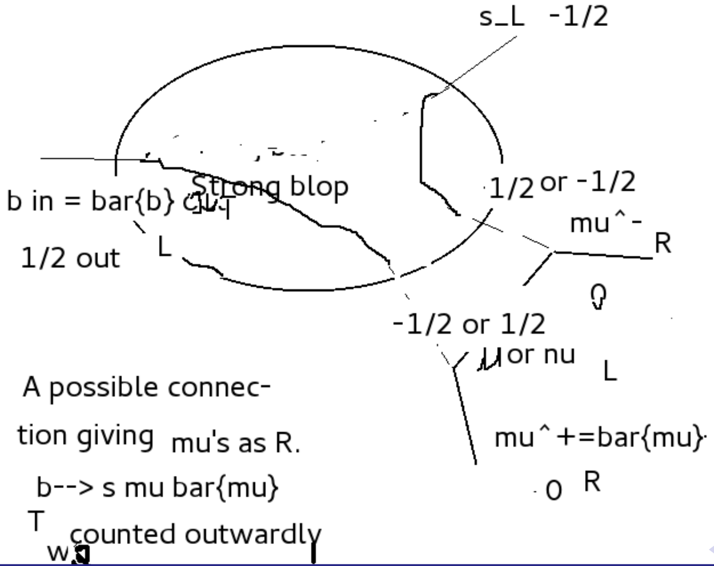
b--> s mu bar{mu}

T counted outwardly

w

Also about getting the Muons R

It is a little bit easier to get the external muons to couple as right handed R than as left handed as we illustrated the possibility for on the last two slides. In this case of going for mu R the intermediate mu-propagator must be a left mu or a left muon neutrino. There is thus two possibilities for the T_{W3} comming out of the elliptic zone: It can be both 1/2 , -1/2 and the opposite combination -1/2 , 1/2. This possibility opens for the chanse of using another connection of the "doublet"curves / chains of propagators inside the ellipse. So there are 3 possibilies of connectons allowing R-muons, but only 2 possibilities allowing L muons.


s_L -1/2
Strong blop
b in = bar{b} out
1/2 out
L
1/2 or -1/2
mu^-
R
0
-1/2 or 1/2
or nu
L
mu^+=bar{mu}
0
R
A possible connec-
tion giving mu's as R.
b--> s mu bar{mu}
T
counted outwardly

Size of the Term ?

Because we have to supplement the diagram on forgoing picture by the "decoration" it gets of course in practice hopeless to truly calculate the size of it and thereby the size of the C_9 coefficient. Only if we should have the good luck of finding related anomalies such as an C_9 anomaly with the muon replaced be a tau e.g. Then we would know that if our idea were right the tau-tau process contribution would be just m_{tau}^2/m_μ^2 times bigger than the term we claim here to be "observed" for muons.

But it is only **one** overall factor, we do not know. The diagram on the figue above has additional to the overall unknown factor the factors: the mixing angle V_{st}, the square of the Yukawa coupling for the muon, g_μ^2.

$$C_9(\text{for } \mu) \quad \propto \quad V_{ts} g_\mu^2 \tag{41}$$

Improved Philosophy/Physics

In first approximation the diagrams that are significant for the non-perturbative effects by adding up - in large numbers - contain only the three types of propagators t_R, t_L and *Higgs*, and only one type of vertex the g_t-yukawa-vertex. However, by just poluting it with a very small number of different types of propagators will only decrease the value of the whole diagram by essentially the ratio arising from the "replacements" of vertices. If the foreign propagator sits so relative to the t_R, t_L and *Higgs*'s that there can go 4-momentum through it returning via the mentioned three "strong" ones, then the loop momentum through this propagator will have a very broad range of important contributions, and therefore the mass of the propagator will be almost irrelevant.

On How to Look at it, replacements

So the estimation of the magnitude of the whole diagram with the replacement will be the unmodified diagram multiplied by the ratios of the foreign coupling constants relative to the "strong " ones - i.e. the g_t's - they replace. After such replacement the otherwise only top-quarks and Higgses that could come out as external lines can be different sorts of particles.
Presumably the physically most correct philosophy is to think of the propagators with the large loop momenta through them as being part of the "strong diagram".

Diagrams with Minor Modifications

In fact they just happen to have some lower size couplings giving just an overall decrease in the value of the sum of the non-perturbative set of diagrams.
The physics of this is in position space that these propoagators make interaction between nearby top and Higgses. So in the sense of being geometrically close to the non-perturbative phenomena they thus are indeed participants in the “strong stuff”.

Hope of getting Accurate Results ?

If we could think of calculating the contributions to various higher dimension terms in the effective Lagrangian as making various replacements or modifications in one sum of a lot of "new strong" diagrams, by replacing a few of the g_t vertices by weaker coupling ones, then we may have the hope that correction due to this **replacement** could be estimated so well, that we could get rather accurate estimates of the relative strength of various effective terms and thus end up with numerically rather accurate predictions.

Data on the LHCb-neutral current anomaly

In arXiv:1703.09189v3 [hep-ph] 2 Jun 2017, "Status of the $B \to K^* \mu^+ \mu^-$ anomaly after Moriond 2017" Wolfgang Altmannshofer, Christoph Niehoff, Peter Stangl, David M. Straub Department of Physics, University of Cincinnati, Cincinnati, Ohio 45221, USA and Excellence Cluster Universe, Boltzmannstr. 2, 85748 Garching, Germany
arXiv:1703.09189v3 [hep-ph] 2 Jun 2017
we find
$ReC_9($ best fit$) = -1.1$ from the $K^{(*)}\mu\bar{\mu}$ from looking at figure.

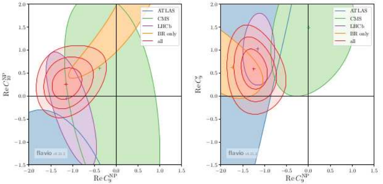


Figure 1: Two-dimensional constraints in the plane of NP contributions to the real parts of the Wilson coefficients C_9 and C_{10} (left) or C_9 and C_9' (right), assuming all other Wilson coefficients to be SM-like. For the constraints from the $B \to K^*\mu^+\mu^-$ and $B_s \to \phi\mu^+\mu^-$ angular observables from individual experiments as well as for the constraints from branching ratio measurements of all experiments ("BR only"), we show the 1σ ($\Delta\chi^2 \approx 2.3$) contours, while for the global fit ("all"), we show the 1, 2, and 3σ contours.

contours showing the constraints coming from the angular analyses of individual experiments, as well as from branching ratio measurements of all experiments.

We observe that the individual constraints are all compatible with the global fit at the 1σ or 2σ level. While the CMS angular analysis shows good agreement with the SM expectations, all other individual constraints show a deviation from the SM. In view of their precision, the angular analysis and branching ratio measurements of LHCb still dominate the global fit (cf. Figs. 5, 7, 6 and 8), leading to a similar allowed region as in previous analyses. We do not find any significant preference for non-zero NP contributions in C_{10} or C_9' in these two simple scenarios.

Similarly to our analysis of scenarios with NP in one Wilson coefficient, we repeat the fits doubling the form factor uncertainties and doubling the uncertainties of non-factorizable corrections. For NP in C_9 and C_{10}, we find that the pull is reduced from 5.0σ to 3.7σ and 4.1σ, respectively. For NP in C_9 and C_9' the pull is reduced from 5.3σ to 4.1σ and 4.4σ, respectively. The impact of the inflated uncertainties is also illustrated in Fig. 2. Doubling the hadronic uncertainties is not sufficient to achieve agreement between data and SM predictions at the 3σ level.

3.3. New physics or hadronic effects?

It is conceivable that hadronic effects that are largely underestimated could mimic new physics in the Wilson coefficient C_9 [24]. As first quantified in [60] and later considered in [23,25,26,33],

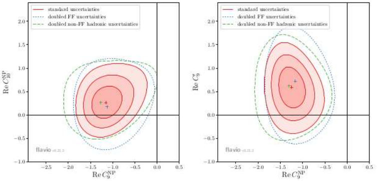


Figure 2: Allowed regions in the Re(C_9^{NP})-Re(C_{10}^{NP}) plane (left) and the Re(C_9^{NP})-Re(C_9') plane (right). In red the 1σ, 2σ, and 3σ best fit regions with nominal hadronic uncertainties. The green dashed and blue short-dashed contours correspond to the 3σ regions in scenarios with doubled uncertainties from non-factorizable corrections and doubled form factor uncertainties, respectively.

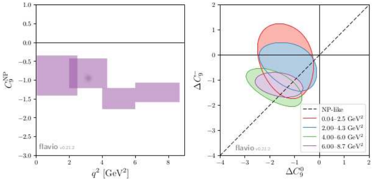
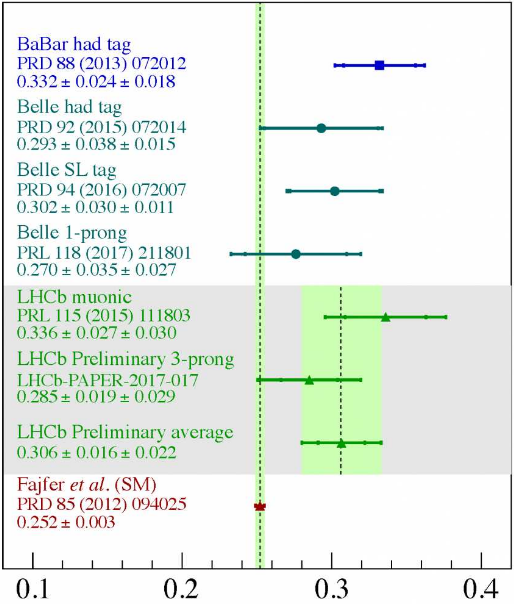


Figure 3: Left: preferred 1σ ranges for a new physics contribution to C_9 from fits in different q^2 bins. Right: preferred 1σ ranges for helicity dependent contributions to C_9 from fits in different q^2 bins. The dashed diagonal line corresponds to a helicity universal contribution, as predicted by new physics.

Standard Model Predictions for Charged Current $B \to D^* \tau \nu_\tau$:

of

$$B(B \to \bar{D}^0 \tau^+ \nu_\tau)_{SM} = (0.66 \pm 0.05)\% \quad (42)$$
$$B(B^0 \to D^- \tau^+ \nu_\tau)_{SM} = (0.64 \pm 0.05)\% \quad (43)$$
$$B(B^+ \to \bar{D}^{*0} \tau^+ \nu_\tau)_{SM} = (1.43 \pm 0.05)\% \quad (44)$$
$$B(B^0 \to D^{*-} \tau^+ \nu_\tau)_{SM} = (1.29 \pm 0.06)\%. \quad (45)$$


BaBar had tag
PRD 88 (2013) 072012
0.332 ± 0.024 ± 0.018
Belle had tag
PRD 92 (2015) 072014
0.293 ± 0.038 ± 0.015
Belle SL tag
PRD 94 (2016) 072007
0.302 ± 0.030 ± 0.011
Belle 1-prong
PRL 118 (2017) 211801
0.270 ± 0.035 ± 0.027
LHCb muonic
PRL 115 (2015) 111803
0.336 ± 0.027 ± 0.030
LHCb Preliminary 3-prong
LHCb-PAPER-2017-017
0.285 ± 0.019 ± 0.029
LHCb Preliminary average
0.306 ± 0.016 ± 0.022
Fajfer et al. (SM)
PRD 85 (2012) 094025
0.252 ± 0.003
0.1
0.2
0.3
0.4

Estimating Absolute Anomaly Seen

Assuming the anomaly ratios

$$R(D^*) = 0.25(\text{expected by SM}) \quad (46)$$

$$R(D^*) = 0.31(\text{Exp.}) \quad (47)$$

and that it is only the decay rate into the $\tau\nu_\tau$, which contatin the anomaly, the anomaly makes up $(.31/.25 - 1) * 100\% = 24\%$ of the rate to $\tau\nu_\tau$ meaning 24% of 1.36%, if we take the average over the charges of the $B \to D^*\tau\nu_\tau$ decay rates in the statndard model to be 1.36%. So the anomalous part of the decay to $D^*\tau\nu_\tau$ is as absolute decay rate 0.33%.

X International Conference on Kaon Physics IOP Conf. Series: Journal of Physics: Conf. Series 800 (2017) 012012 IOP Publishing doi:10.1088/1742-6596/800/1/012012 International Conference on Recent Trends in Physics 2016 (ICRTP2016) IOP Publishing Journal of Physics: Conference Series 755 (2016) 011001 doi:10.1088/1742-6596/755/1/011001

"Rare B Decays And Lepton Flavour Universality Tests at LHCb"

Dr. Siim Tolk University of Cambridge, LHCb, CERN E-mail: siim.tolk@cern.ch

Abstract.

In the lepton sector the Standard Model incorporates both lepton-flavour and lepton-number universality. In a generic New Physics scenario this is not necessarily the case and these symmetries need to be experimentally tested. (Continues on next slide)

Continuation of abstract of Dr. Siim Tolk.

Numerous searches have failed to find any signs of Lepton Flavour Violation (LFU) or Lepton Flavour Universality Violation (LFUV). New Physics could, however, generate LFUV in the heavy flavour sector where the existing experimental constraints are weaker. Recent searches at LHCb focus on precisely this unexplored territory by studying the B decays involving $b \to c\tau\nu$ and $b \to sl^+l^-$ transitions. Several theoretically and experimentally clean observables, such as $R(D^*)$ or $R(K)$, diverge from the Standard Model predictions and could be the first signs of LFUV.

The $R(K)$ ratio (for Neutral Current)

$$R(K)_{SM} = \frac{B(B^+ \to K\mu^+\mu^{+\text{but must be meant -}})}{B(B^+ \to Ke^+e^{+\text{but must be meant -}})} \quad (48)$$

$$= 1 \pm O(10^3), \quad (49)$$

(it must be a prinitng mistake by Siim Tolk that he has two μ^+'s) where small deviations arise from the lepton mass difference. The R(K) ratio has been determined previously by the B factories. The measured R(K) from LHCbs full Run 1 dataset :

$$R(K)_{LHCb} = 0.745 + 0.090/0.074(\text{stat.}) \pm 0.036(\text{syst.}) \quad (50)$$

is the most precise measurement of this quantity. It agrees well with the previous measurements in its di-lepton mass squared region and strengthens the claim for tensions in $b \to s$ transitions.

Branching ratio for the $B - - > X_s l\bar{l}$.

In the article "Scalar leptoquarks and the rare B meson decays" by:
Suchismita Sahoo, Rukmani Mohanta
arXiv:1501.05193v3 [hep-ph] 28 Apr 2015
School of Physics, University of Hyderabad, Hyderabad - 500 046, India.
We find therein:

$$
\begin{aligned}
BR(B \to X_s e\bar{e})|_{q^2 \in [1,6] GeV^2} &= (1.73 \pm 0.12) \times 10^{-6} (\text{SM prediction}) && (51)\\
&= (1.93 \pm 0.55) \times 10^{-6} (\text{Expt.}) && (52)\\
BR(B \to X_s e\bar{e})|_{q^2 > 14.2 GeV^2} &= (0.2 \pm 0.06) \times 10^{-6} (\text{SM prediction}) && (53)\\
&= (0.56 \pm 0.19) \times 10^{-6} (\text{Expt.}) && (54)
\end{aligned}
$$

Taking the braching ratio to $X_s e^+ e^-$ (a neutral current channel) as $2 * 10^{-6}$ and thinking of all the anomaly to be in the $X_s \mu \bar{\mu}$ cannel we obtain from the ratio $R(K)_{LHCb} = 0.745 + 0.090/0.074(\text{stat.}) \pm 0.036(\text{syst.})$ that the anomaly, which comes out negative, is $-(1 - 0.745) * 2 * 10^{-6} = -0.5 * 10^{-6}$ in branching ratio.
If we ignored that the above 0.33% were only for one resonance D^* rather than as these $-0.5 * 10^{-6}$ being for all the channels with the lepton pair, these two numbers could be compared.
$\frac{0.33\%}{-0.5*10^{-6}} = -7 * 10^3$.

Slightly Better Number for Main Amplitude Ratio

Taking it that the decay rates

$$BR(B \to D\tau\nu_{tau}) = 0.65\% \quad (55)$$
$$BR(B \to D^*\tau\nu_\tau) = 1.36\%, \quad (56)$$

the sum of the two channels become 2% and the 24% of that would be $BR(B \to X_c\tau\nu_\tau)$=0.5%. Comparing to the neutral current channel anlogous $BR(B \to X_s e^+ e^-) = 2 * 10^{-6}$ and using the same number for the analogous decay with muons as the lepton and the relative anomaly $R(K) - 1 = -0.25_5$ we get the ratio of the (absolute)anomalies $\frac{0.005}{-.25_5 * 2 * 10^{-6}} = -1 * 10^4$.

Interference or Not Does Not Matter by Accident.

The ratio of the experimentally found quite seperate anomalies maesured in their rates/branching ratios is

$$\frac{\text{“Anomalous rate } B \to X_c\tau\nu_\tau\text{”}}{\text{“Anomalous rate } B \to X_s\mu\nu_\mu\text{”}} = (-)1 * 10^4$$

while the ratio of the normal rates is:

$$\frac{BR(B \to X_c\tau\nu_\tau)}{BR(B \to X_s\mu\nu_\mu)} = \frac{2\%}{2 * 10^{-6}} = 1 * 10^4$$

corresponding to an amplitude ratio:

$$\frac{A(B \to X_c\tau\nu_\tau)}{A(B \to X_s\mu\nu_\mu)} = \sqrt{\frac{2\%}{2 * 10^{-6}}} = 1 * 10^2.$$

Charged Current Lepton Flavour Violation Anomaly

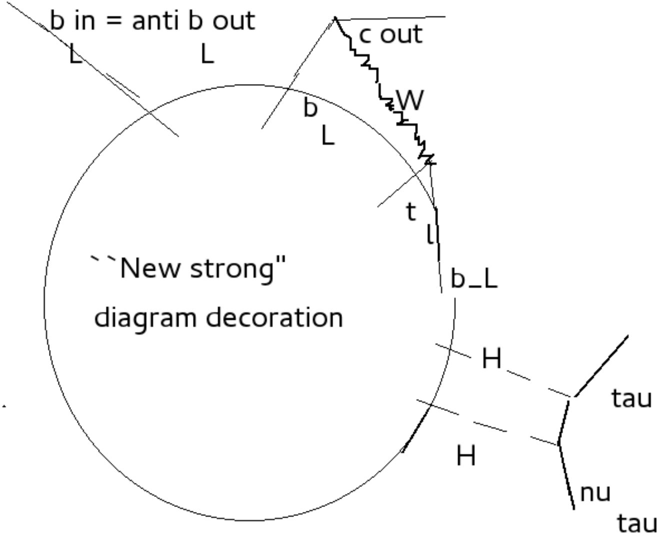
For charged current processes - which as is wellknown give much larger decay rates than the neutral one - there has been found also some tension or anomalies. In this case the anomalies are of the type of giving a bigger decay rate for $b \to c\tau\nu_\tau$ than the anlogous process with muon or electron instaaed of τ. It is thus a process only very weakly influenced by hadroninc interactions and pure lepton universality should sufficient accuracy. So if one chooses to study some ratio of decay rates of a B-meson between channels only deviating by the flavour of the lepton pair, then one should be pretty sure of the calculation by means of the Standard Model. There should be no essential strong interaction uncertainty.

Troubles with Charged Current Processes

At first we have some trouble in how to get our non-perturbative scheme produce a sufficiently large anomaly for the charged current case. In this case a b-quark-decay has to deliver most copiously a charmed quark c and then a pair say of leptons e.g. $\mu^- + \bar{\nu_\mu}$. But while we in the neutral current case needed form b to produce the s, or d, which can be considered with some amplitude to be contained in the weak-$SU(2)$ partner of the left top and thus being at least contained in one of the new strong interaction type particles, we have for the charmed quark left nor right any corresponding even partly presence in the by "new strong" interaction involved particles.
So there seems no way to produce charmed quark c except by more usual mechanisms like the Wbc-vertex.

How to Almost get the W-boson Insisde the New Strong Interaction?

Our intuitive feeling of the problem:
We feel that having to add a normal W-boson to the diagram family with our new strong interaction, which is already so small that it can only show up as hitherto unobserved anomalies, would make the whole anomalous process in question getting so small contribution from our new strong effects that there would be no chanse to "see" anything; especially we would not be able to explain in our non-perturbaltive scheme the lepton non-universality in $b \to cl\bar{\nu}_l$.
But now the idea:
Could we - partly or by talk at least - make the W-boson propagator part of the new strong interaction diagram ?


b in = anti b out
L
L
c out
W
b
L
t
l
b_L
``New strong"
diagram decoration
H
H
tau
nu
tau

Got the Loop Momentum of the "New Strong" Diagram Through the W-propagator.

On the foregoing figure we proposed to put the W-propagator - needed for making the charged quark c, we look for in the charged current process with b - in such a way that by loop integration for the proposed type of diagrams the loop momentum form the "new strong" part of the diagram also comes through the W-propagator. In this relatively complicated type of diagrams you can therefore speculate that you get large - may be of order 750 GeV - through the W-propagator also. This could make the large m_W usually supposed to make weak interactions weak not so relevant. The momentum through the W-propogator should simply be typically so large that a poor 80 GeV would not be important.
But is this diagram sketched on the figure a dominant one?

Comparing the Charged to Neutral Current Diargams for Anomaly

If we mannage to get the momenta from the inside the ellipse (New strong) part throuogh the W-propagator we almost have it as part of this new strong part and we migh estimate the size of the diagram as just comming from the ratio of the g_2 weak gauge coupling to the g_t (the coupling for our new strong). This is not so dramatic a difference and might not be very different from the V_{ts} which is present as a factor in the neutral current diagram.

Abstract:
We study some rare decays of B meson involving the quark level transition $b \to q l^+ l^-$ $(q = d, s)$ in the scalar leptoquark model. We constrain the leptoquark parameter space using the recently measured branching ratios of $B_{s,d} \to \mu^+\mu^-$ processes. Using such parameters, we obtain the branching ratios, direct CP violation parameters and isospin asymmetries in $B \to K\mu^+\mu^-$ and $B \to \pi\mu^+\mu^-$ processes. We also obtain the branching ratios for some lepton flavour violating decays $B \to l_i^+ l_j^-$. We find that the various anomalies associated with the isospin asymmetries of $B \to K\mu^+\mu^-$ process can be explained in the scalar leptoquark model.

The total branching fraction measured at B-factories for $B \to K l^+ l^-$ is $(0.45 \pm 0.04) \times 10^{-6}$ and for $B \to K(892) l^+ l^-$ is $(1.05 \pm 0.10) \times 10^{-6}$.

So far, among the possible processes, only LHCb searched for $B_s \rightarrow \bar{\tau}\tau$ [23]: $Br(B_s \rightarrow \tau\tau \;\; EXP \leq 6.8 \times 10^{-3}$; 1 and BABAR performed an analysis of $B \rightarrow K\tau\bar{\tau}$ [24]: 181802-1 $Br(B \rightarrow K\tau\bar{\tau}$ - $EXP \leq 2.25 \times 10^{-3}$: 2 Published by the American Physical Society

Decay Mode	Expt. (BELLE & BABAR)	Theory (SM)
BKl^+l^-	0.45 ± 0.04	0.35 ± 0.12
$B \to K^* e^+ e^-$	$0.17 \ +1.19/-0.16$	1.58 ± 0.49
$B \to K^* \mu^+ \mu^-$	$0.16 + \ 1.15/0.15$	1.19 ± 0.39
$BX_s \mu^+ \mu^-$	$0.97 \ +2.23/-0.98$	4.2 ± 0.7
$B \to X_s e^+ e^-$	$1.04 \ +4.91/-1.06$	4.2 ± 0.7
$BX_s l^+ l^-$	$0.76 \ +3.66/-0.77$	4.2 ± 0.7

Ahmed Ali (DESY, Hamburg) Precision Tests of the Standard Mod

The Ratio of the Anomalies in Charged Current to Neutral Current.

We are interested in the very specific ratio for which we have hopefully some tensions to compare:

- The charged current $b \to c\tau\bar{\nu_\tau}$
- The neutral current $b \to s\mu\bar{\mu}$.

Very crudely order of magnitudewise we predict for this ratio for the *amplitudes*

$$\frac{A(b \to c\tau\bar{\nu_\tau})}{A(b \to s\mu\bar{\mu})} = \frac{V_{bc}g_2^2 m_\tau^2}{V_{st}g_t^2 m_\mu^2}. \qquad (57)$$

Putting Numbers in Our Ratio of Amplitudes A

The $SU(2)$-weak gauge coupling g_2 is known experimentally in the relevant scale range to be given by a fine structure constant $\alpha_2 = 1/30$. Thus we have, combining with the 0.935 found from top mass:

$$g_2 = \sqrt{4\pi/30} = 0.41 \quad (58)$$

$$g_t = 0.93_5 \quad (59)$$

$$\frac{g_2}{g_t} = .38 \quad (60)$$

$$\frac{g_2^2}{g_t^2} = 0.14_5 \quad (61)$$

The V_{ts} and V_{bc} are mixing angles between second and third family, so if we totally ignored the first family, they would have to be equal.

Our amplitude Ratio Prediction:

Since

$$\frac{m_\tau}{m_\mu} = 16.8167 \pm 0.0015 \quad (62)$$

$$\frac{g_2^2}{g_t^2} = 0.14_5 \quad (63)$$

$$\frac{V_{ts}}{V_{bc}} \approx 1, \quad (64)$$

our amplitude ratio becomes

$$\frac{A(b \to c\tau\bar{\nu_\tau})}{A(b \to s\mu\bar{\mu})} = \frac{V_{bc} g_2^2 m_\tau^2}{V_{st} g_t^2 m_\mu^2} \quad (65)$$

$$= 0.14 * 16.82^2 \quad (66)$$

$$= 41 \quad (67)$$

Interference Case, Perdiction of Ratio of Anomalies for Charged Relative to Neutral Current:

We consider the two anomalous contributions to the decay amplitudes of B to respectively s plus muons relative to that to c and tau and its neutrino.

Supposing that these anomalies appear as interference terms with the main amplitudes $A_{main\, c\tau...}$ and $A_{main\, s\mu...}$ - the one from the Standard Model - the ratio of the anomalous contributions to the rates will be in the ratio of the anomaly-amplitudes multiplied by the ratio of the main ones:

$$\frac{\text{“anomalous rate”}(B \to c\tau\nu_\tau)}{\text{“anomalous rate”}(B \to s\mu\nu_\mu)} = -1 * 10^4|_{“exp”} =$$

$$\stackrel{=}{?} \frac{A_{main\, c\tau...}A_{anomalous\, c\tau...}}{A_{main\, s\mu...}A_{anomalous\, s\mu...}} = \frac{A_{main\, c\tau...}}{A_{main\, s\mu...}} * \frac{V_{bc}g_2^2 m_\tau^2}{V_{st}g_t^2 m_\mu^2}|_{“our\ theory”} =$$

$$100 * 41|_{“our\ theory”} = 4000|_{“our\ theory”}.$$

Our Estimate is Order of Magnitudewise.

Since our diagrams for the two anomalous processes are different diagrams only related by being of the similar non-perturbative character, we can *only* expect the realtion between them to be an order of magnitude relation, and neither the sign nor a factor $41/100$ makes any difference. So the agreement $-10000|_{\text{``}exp''}$ with $4000|_{\text{``}our\ theory''}$ is perfect!

Square of Anomaly Term Dominating Not Perfect

If as in our model/theory the anomalous effect is strongly dependent on the Higgs coupling and thus the lepton mass, it is needed to assume that the anomaly is mainly there for the heavier of the leptons involved. Thus for relating a muon and an electron channel the muon channel must carry the anomaly. In this way $R(K)$ smaller than unity cannot be accepted in our model if simply the square of the anomaly amplitude dominated. We have to take the interference case to get the right sign of the effect!
Were it not for this sign problem, then actually the dominance of the anomalous term squared would only have been away from perfect agreement by yet a factor $41/100$, and that would still have been very good agreement; but the sign forces us to take the interference.

Can we Relate the Order of Magnitude to Our Earlier Bound State Speculations?

Immediately one would say that as we have earlier speculated - and still find some theoretical evidence for - a bound state of say 6 top + 6 anti top in the mass range about the place of the once so famous statistical fluctuation at 750 GeV, it would be natural to speculate that we should be able to estimate the absolute order of magnitude size of the anolmaly effect from this mass number 750 GeV.

Conclusion

We have proposed - and claim it was very successfully - that the anomalies seen in B-meson decays both in neutral current channels $b \to s\bar{l}l$ and to charged current channels $b \to c\bar{l}\nu_l$ (or charged conjugate etc. related channels) relative to the exact Standard Model can be interpreted as due to Standard Model **Non-perturbative effects**. Our argumentation and fitting were like this:

- The non-perturbative effects shall come from the fact, that properly counted, the top-quark-yukawa-coupling g_t is indeed to be counted as "effectively strong".
- Thus we take it, that huge - high order Feynman diagrams - cannot be ignored, provided they have almost only vertices corresponding to the top-yukawa coupling.

Conclusion (continued)

- In the bulk of such diagrams we can of course only have the three propagators:
  - The Higgs doublet,
  - The righthanded top components,
  - The doublet composed of the left handed top and the left handed superposition of the d, s, and mainly b quarks being in doublet with the top.
- We have earlier speculated that this "strong g_t" gives rise to bound states of 6 top + 6 anti tops.

Conclusion (yet continued)

Most importantly we want to conclude that it is possible that the two types of anomalies beingmore and more found are indeed due to the proposed non-perturbative effects in Standard Model, provided we allow the overall scale of these non-perturbative effects to be fitted. Indeed:

- We predict the “anomalous effect ” to have respectively the b and the s quark or in the other anomaly the b and the c quark be left handed. I.e. only the left handed quarks should be coupled to the anomaly. This is most important for suggesting that the anomaly tends to be C_9.
- The lepton pair couples via a couple of Higgs-propagators and is thus in amplitude proportional to the square of the yukawa coupling/ or square of the (charged)lepton mass.

Conclusion (yet, yet continued)

But the in our opinion most impressive success of our non-perturbative model is that with an only slightly speculative estimation we obtain **the ratio of the anomaly in the neutral current process b→ s and in the seemingly rather unrelated charged current process b → c.**
We relate this ratio of the two anaomalies to the ratio of the lepton mass ratio of m_τ to m_μ, in fact the ratio of the anomalous part of the branching fraction into $c\tau\nu_\tau$ is predicted crudely to be larger than corresponding branching fraction into the neutral current (and thus rare) channel $s\mu\bar{\mu}$ by a factor being crudely the square root of the corresponding Standard Model calculated branching ratios multiplied by the square of the ratio of the tau-lepton mass to the muon-one.

Conclusion (yet, yet, yet continued)

The crux of the matter is of course that the anomalous parts of the **amplitudes** for the two processes with anomalies $B \to X_s \bar{\mu}\mu$ and $B \to X_c \tau \bar{\nu}_\tau$ apart from a smaller correction is in the ratio $\left(\frac{m_\tau}{m_\mu}\right)^2$. (The "smaller correction" is the ratio $(g_2/g_t)^2$.)

One of us thanks the Niels Bohr Institute for being allowed to staying as emeritus, and to COST, which is supposed to sponsor his trip to Tallin, where it is the idea to deliver the present talk.