

Electroweak Chiral Lagrangian for TC2 models

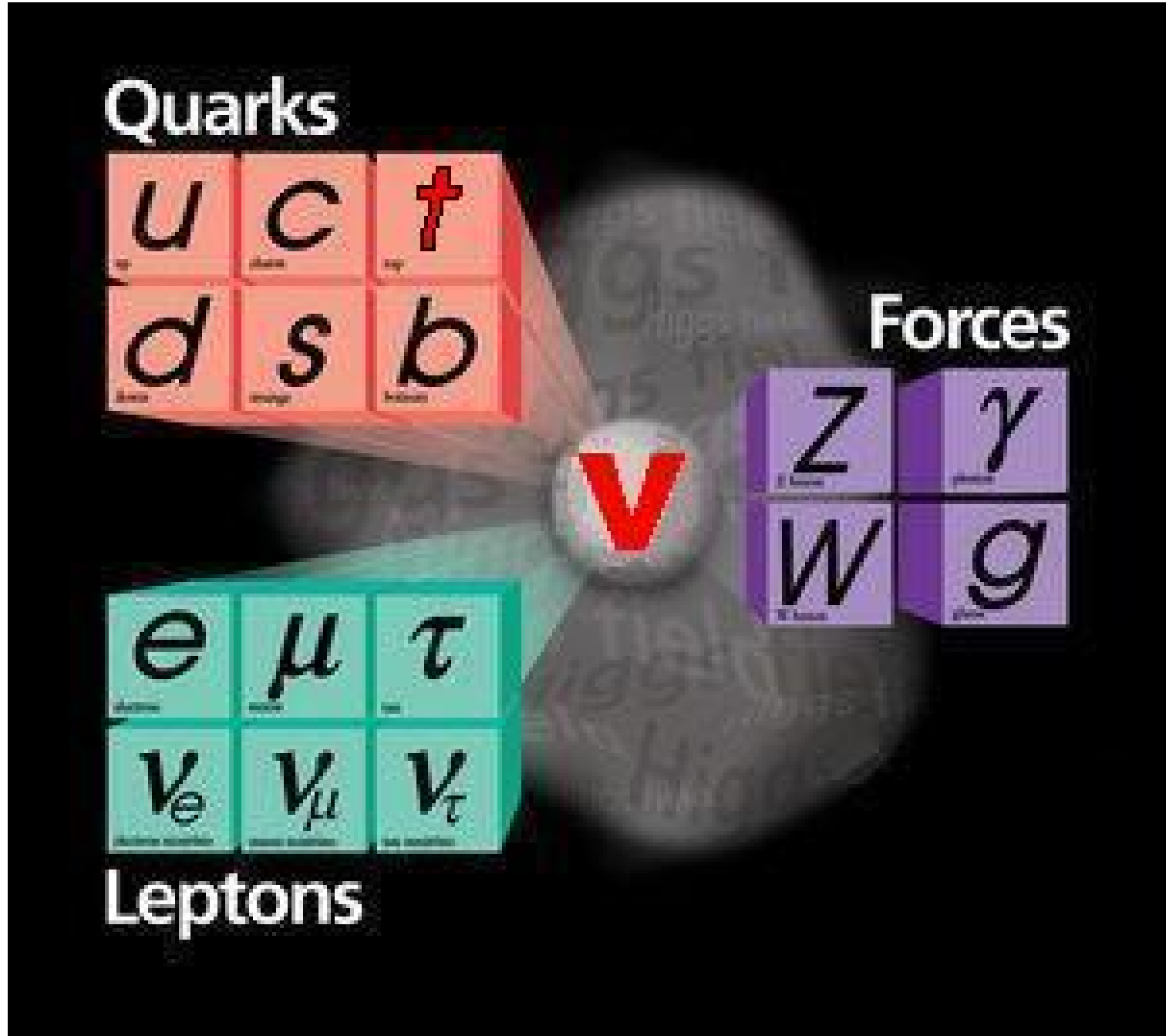
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Phys.Lett.B673(2009)63



Top Color Assisted Technicolor \equiv TC2 Models

- TC condensate provides M_W and M_Z
- ETC sector gives $m_{\text{light quark}}$, m_{lepton} and $m'_t \sim m_b$
- The majority of m_t is due to formation of $\langle \bar{t}t \rangle$
through the dynamics of an extended color gauge sector^{top color}
- Presence of an extended hyper-charge sector ensures that
the bottom and other light quarks do not also condensate

Classic topcolor

	$SU(3)_1$	$SU(3)_2$	$SU(2)_W$	$U(1)_1$	$U(1)_2$
I	...	SM	SM	...	SM
II	...	SM	SM	...	SM
III	SM	...	SM	SM	...

Flavor-universal topcolor

	$SU(3)_1$	$SU(3)_2$	$SU(2)_W$	$U(1)_1$	$U(1)_2$
I	SM	...	SM	...	SM
II	SM	...	SM	...	SM
III	SM	...	SM	SM	...

Hypercharge-universal topcolor

	$SU(3)_1$	$SU(3)_2$	$SU(2)_W$	$U(1)_1$	$U(1)_2$
I	...	SM	SM	SM	...
II	...	SM	SM	SM	...
III	SM	...	SM	SM	...

$$\mathbf{SU}(\mathbf{N})_{\text{TC}} \otimes \underline{\mathbf{SU}(\mathbf{3})_1 \otimes \mathbf{SU}(\mathbf{3})_2} \otimes \mathbf{SU}(\mathbf{2})_{\text{L}} \otimes \underline{\mathbf{U}(\mathbf{1})_1 \otimes \mathbf{U}(\mathbf{1})_2}$$



u

colorons

Z'



$$\mathbf{SU}(\mathbf{N})_{\text{TC}} \otimes \mathbf{SU}(\mathbf{3})_{\text{C}} \otimes \underline{\mathbf{SU}(\mathbf{2})_{\text{L}} \otimes \mathbf{U}(\mathbf{1})_{\text{Y}}}$$



v

W[±], Z

EWCL



$$\mathbf{SU}(\mathbf{N})_{\text{TC}} \otimes \mathbf{SU}(\mathbf{3})_{\text{C}} \otimes \mathbf{U}(\mathbf{1})_{\text{em}}$$

Electro-weak Chiral Lagrangian for W^\pm, Z, γ

$$T = U\tau^3U^\dagger \quad V_\mu = (D_\mu U)U^\dagger \quad D_\mu U = \partial_\mu U + ig_2 W_\mu U - iUg_1 B_\mu \tau^3/2$$

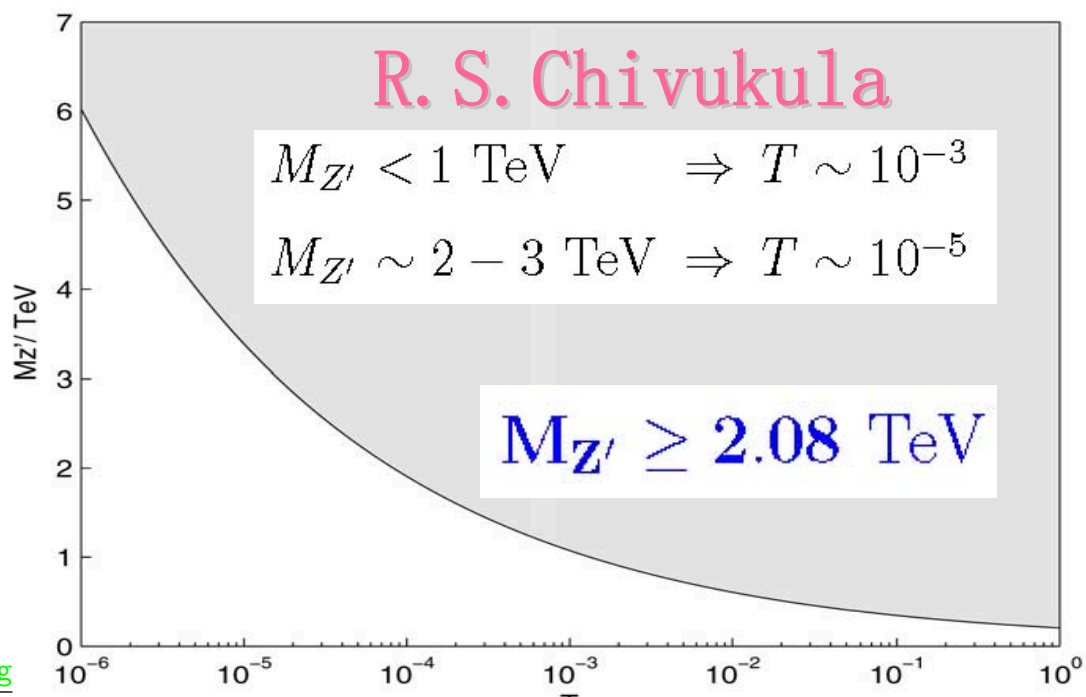
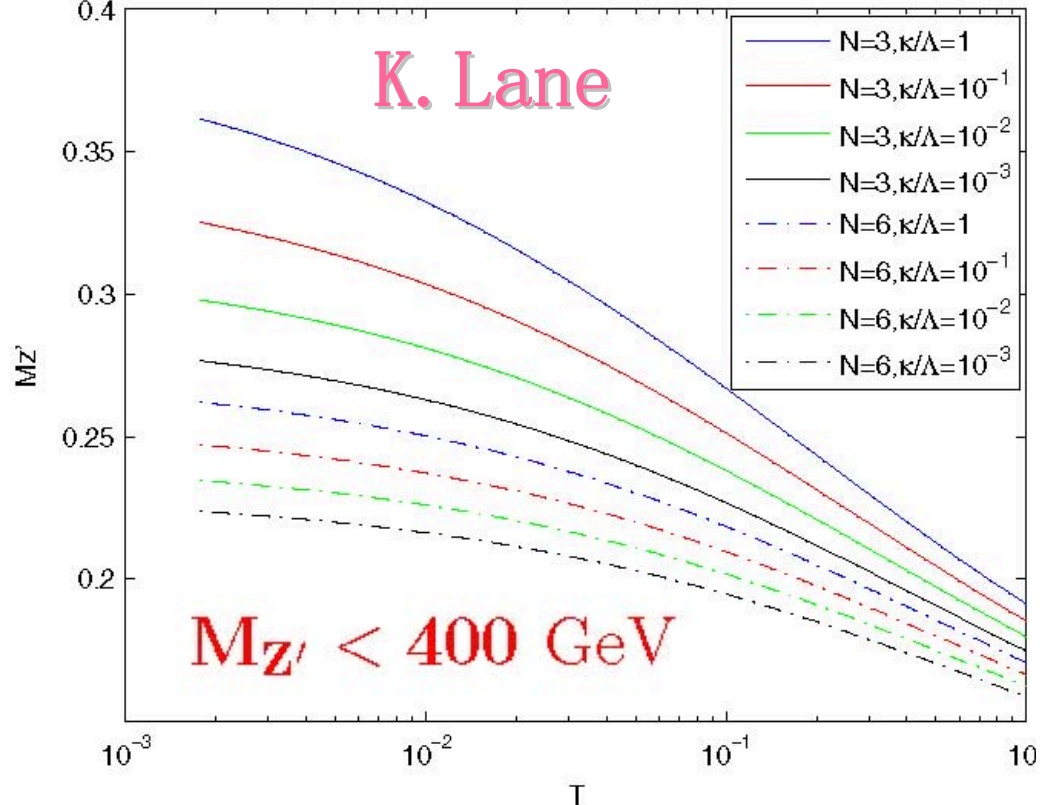
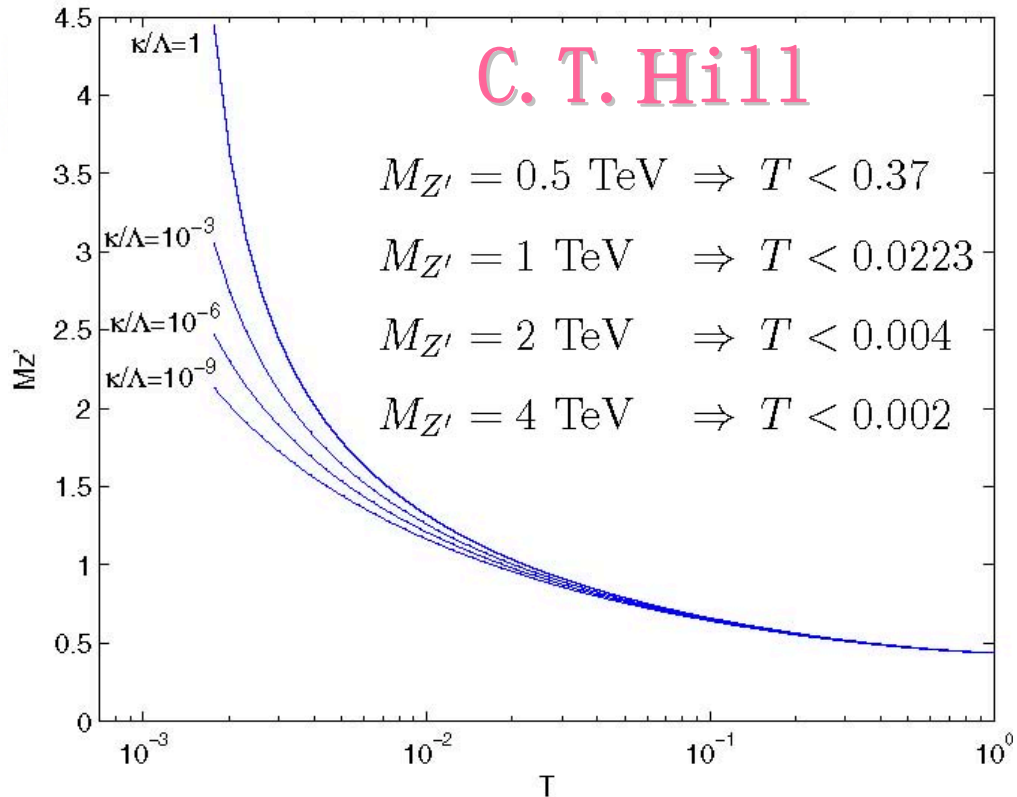
$$\begin{aligned} \mathcal{L}_{\text{EWCL}}^{\text{boson}} = & -\frac{f^2}{4}\text{tr}(V_\mu V^\mu) + \frac{f^2}{4}\beta_1[\text{tr}(TV_\mu)]^2 + \frac{1}{2}\alpha_1 g_2 g_1 B_{\mu\nu} \text{tr}(TW^{\mu\nu}) \\ & + \frac{i}{2}\alpha_2 g_1 B_{\mu\nu} \text{tr}(T[V^\mu, V^\nu]) + i\alpha_3 g_2 \text{tr}(W_{\mu\nu}[V^\mu, V^\nu]) + \alpha_4 [\text{tr}(V_\mu V_\nu)]^2 + \alpha_5 [\text{tr}(V_\mu V^\mu)]^2 \\ & + \alpha_6 \text{tr}(V_\mu V_\nu) \text{tr}(TV^\mu) \text{tr}(TV^\nu) + \alpha_7 \text{tr}(V_\mu V^\mu) \text{tr}(TV_\nu) \text{tr}(TV^\nu) + \frac{1}{4}\alpha_8 g_2^2 [\text{tr}(TW_{\mu\nu})]^2 \\ & + \frac{i}{2}\alpha_9 g_2 \text{tr}(TW_{\mu\nu}) \text{tr}(T[V^\mu, V^\nu]) + \frac{1}{2}\alpha_{10} [\text{tr}(TV_\mu) \text{tr}(TV_\nu)]^2 \\ & + \alpha_{11} g_2 \epsilon^{\mu\nu\rho\lambda} \text{tr}(TV_\mu) \text{tr}(V_\nu W_{\rho\lambda}) + 2\alpha_{12} \text{tr}(TV_\mu) \text{tr}(V_\nu W^{\mu\nu}) + \frac{1}{4}\alpha_{13} g_2 g_1 \epsilon^{\mu\nu\rho\sigma} B_{\mu\nu} \text{tr}(TW_{\rho\sigma}) \\ & + \frac{1}{8}\alpha_{14} g_2^2 \epsilon^{\mu\nu\rho\sigma} \text{tr}(TW_{\mu\nu}) \text{tr}(TW_{\rho\sigma}) - \frac{1}{4}B_{\mu\nu} B^{\mu\nu} - \frac{1}{2}\text{tr}(W_{\mu\nu} W^{\mu\nu}) + O(p^6) \end{aligned}$$

$$S = -16\pi\alpha_1, \quad \underline{\alpha T = 2\beta_1}, \quad U = -16\pi\alpha_8$$

- **C:** Topcolor assisted technicolor C.T.Hill, Phys.Lett.B345(1995)483^{formulation}
- **C:** Natural Topcolor-assisted technicolor K.Lane, E.Eichten, Phys.Lett.B352(1995)382^{ETC}
- **F:** New strong interactions at the Tevatron?
R.S.Chivukula, A.G.Cohen, E.H.Simmons, Phys.Lett.B380(1996)92
- **C:** Symmetry breaking and generational mixing in top-color-assisted technicolor K.Lane, Phys.Rev.D54(1996)2204
- **F:** A heavy top quark from flavor-universal colorons
M.B.Popovic, E.H.Simmons, Phys.Rev.D58(1998)095007
- **F:** A new model of topcolor-assisted technicolor
K.Lane, Phys.Lett.B433(1998)96
- **H:** Hypercharge-universal topcolor F.Braam, M.Flossdorf, R.S.Chivukula, S.D.Chiera, E.H.Simmons, Phys.Rev.D77,(2008)055005^{Hypercharge effects}

TC2 contribution to EWCL coefficients

- Pure TC contributions one or three doublet TC model result
- Z' contributions
- Ordinary quarks and leptons contributions not investigated
- Colorons make no contributions at the leading order
- ETC effects are small
- WTC effects not investigated
- αT is positive and bounded above: $\frac{1}{25}$ Hill $\frac{9}{40}$ Lane $\frac{9}{34}$ Chivukula

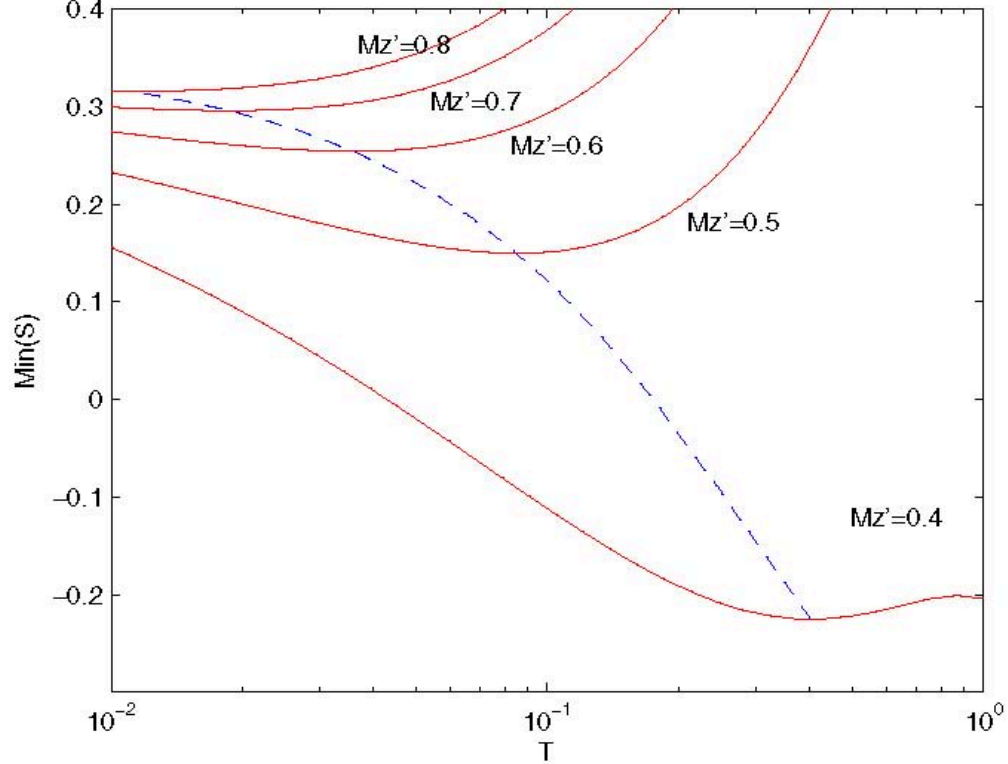
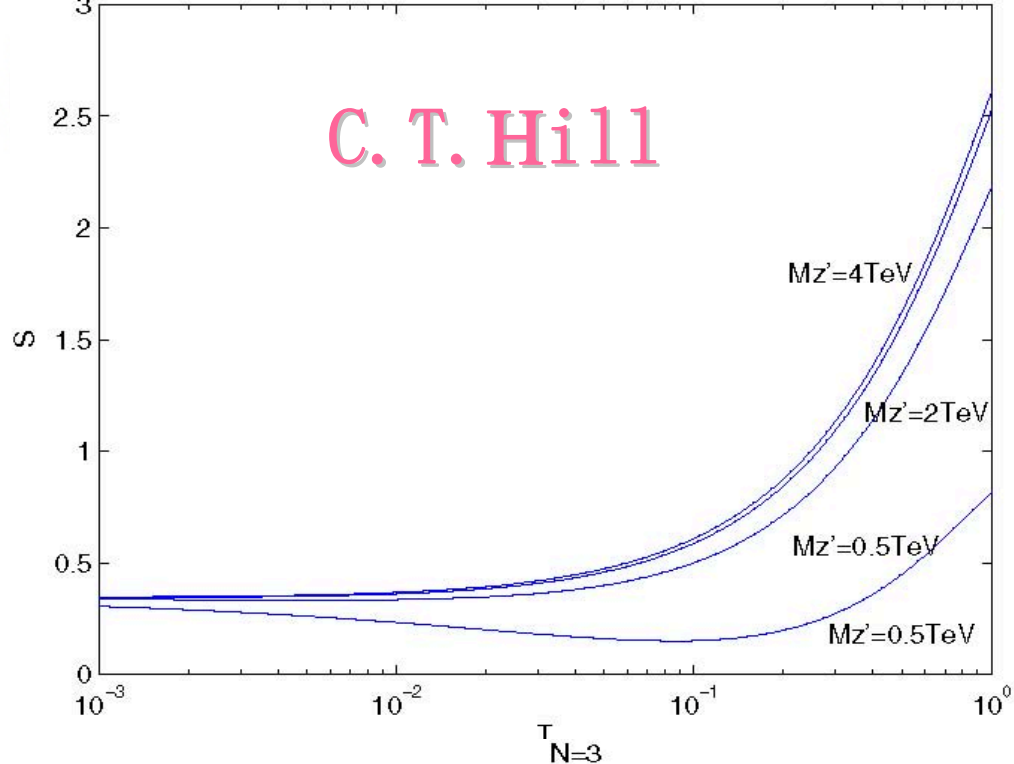


$M_{Z'} = 0.2 \text{ TeV}, N = 3 \Rightarrow T < 0.74$
 $M_{Z'} = 0.2 \text{ TeV}, N = 6 \Rightarrow T < 0.25$
 $M_{Z'} = 0.3 \text{ TeV}, N = 3 \Rightarrow T < 0.0035$

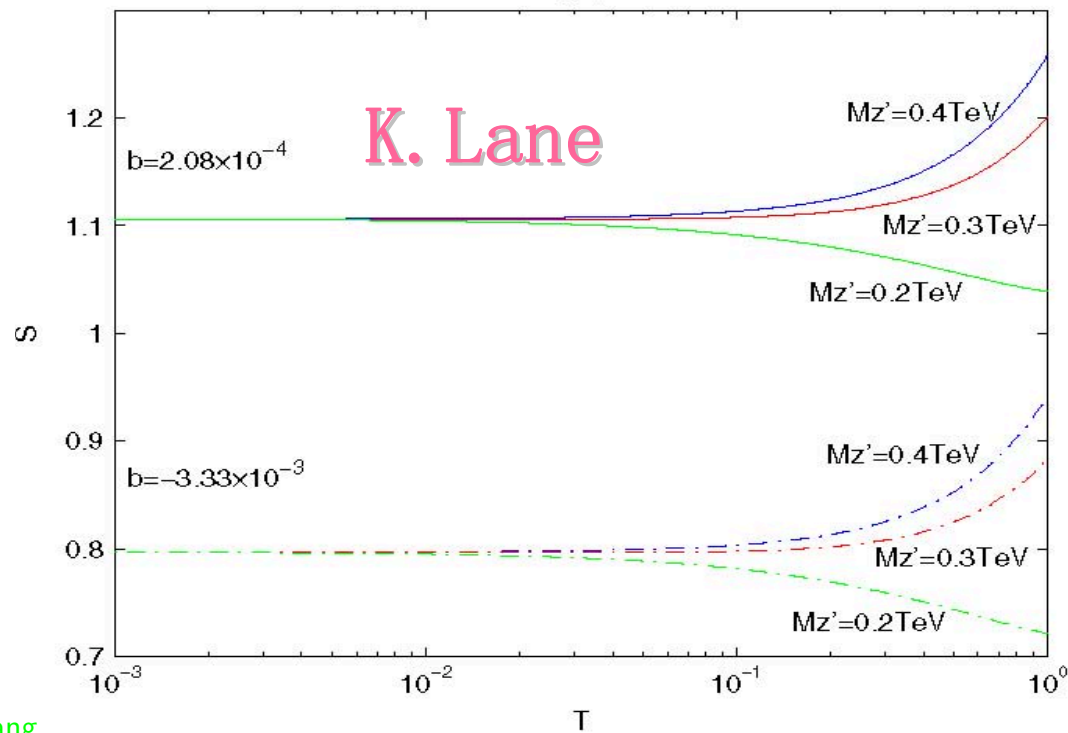
Three kinds of
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 Technicolor Models



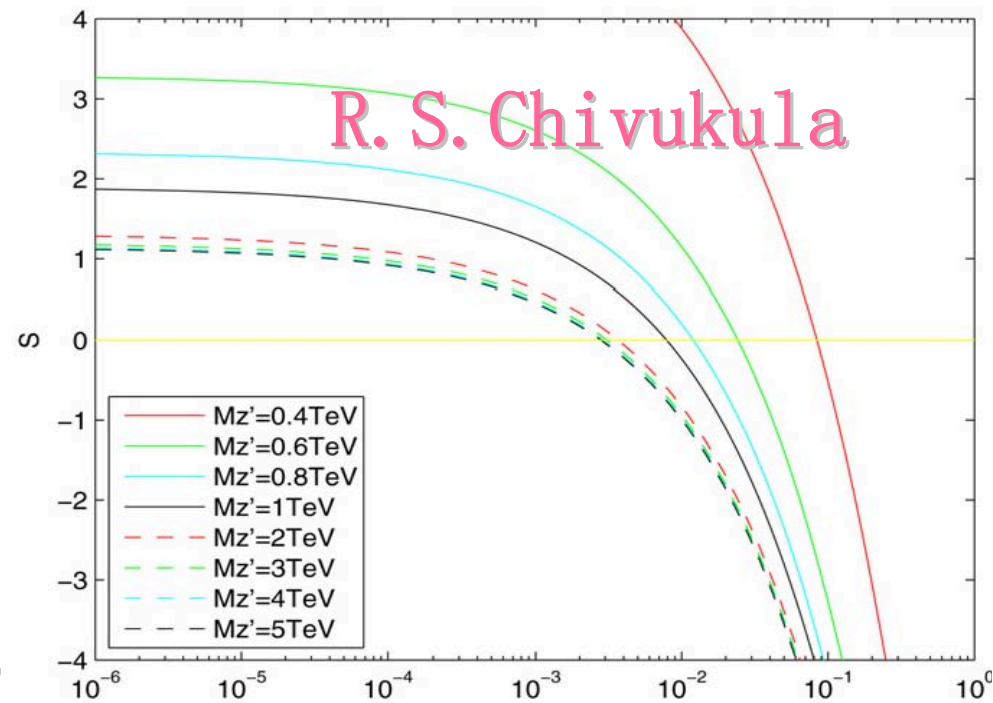
C. T. Hill

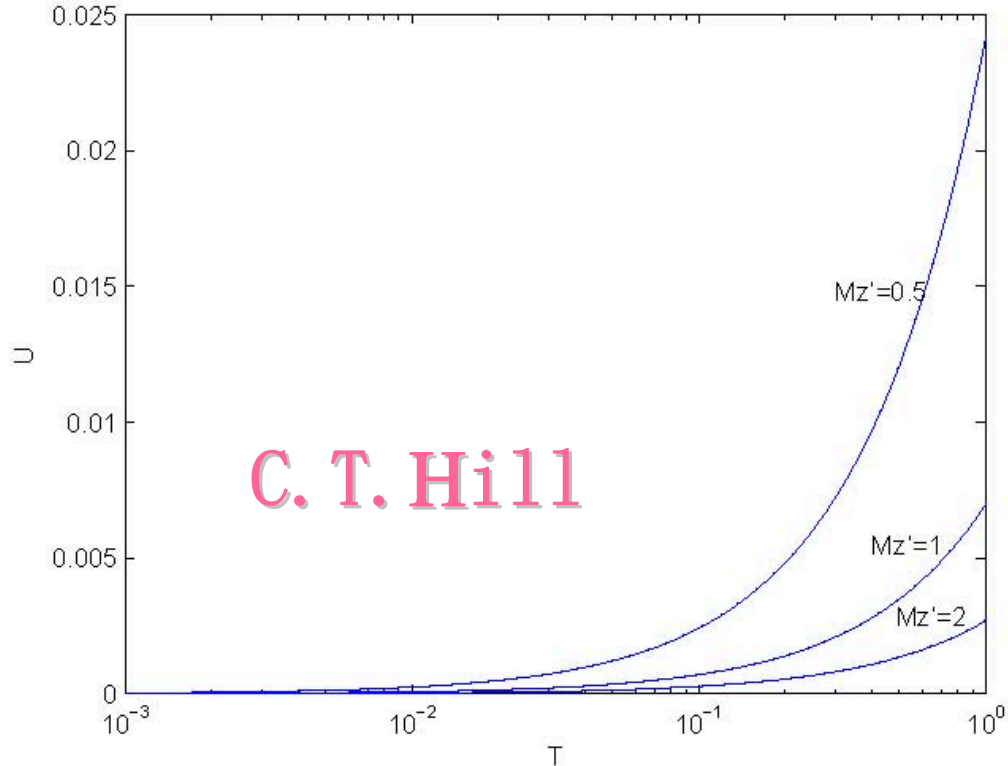


K. Lane

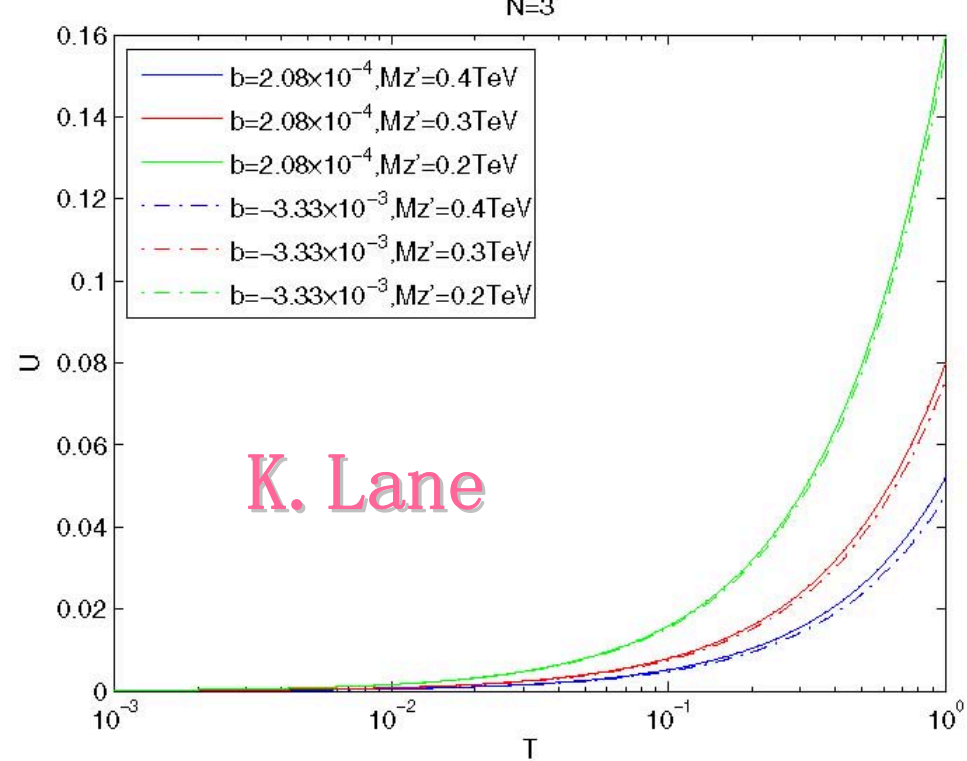


R. S. Chivukula

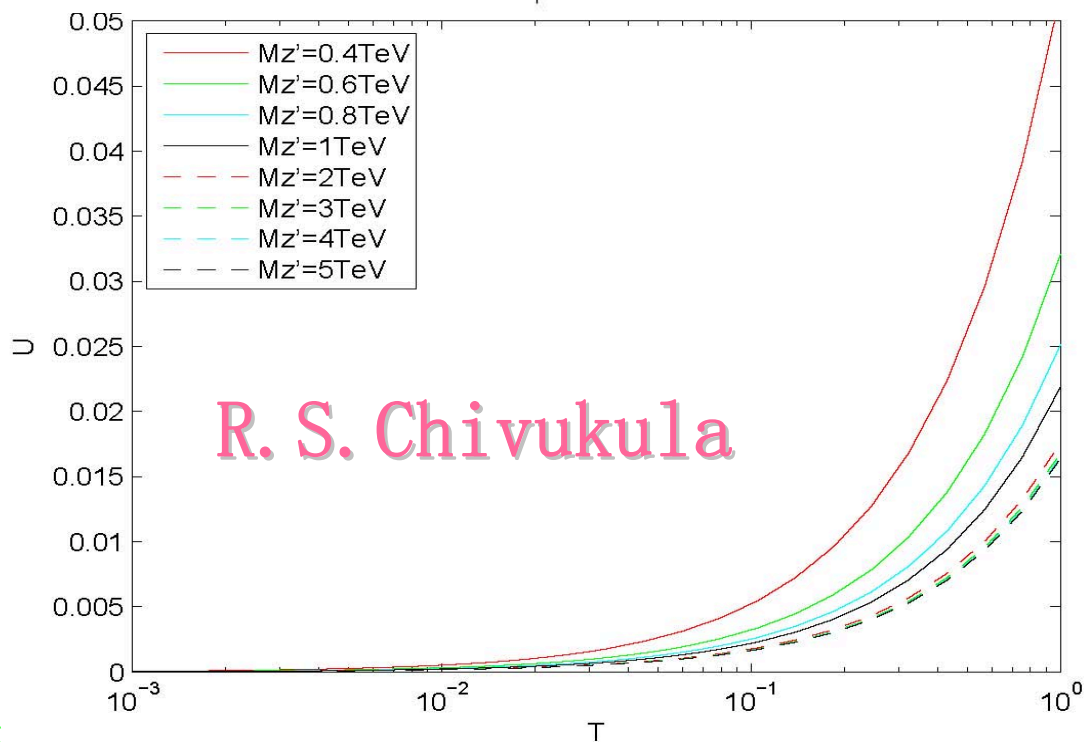




C. T. Hill

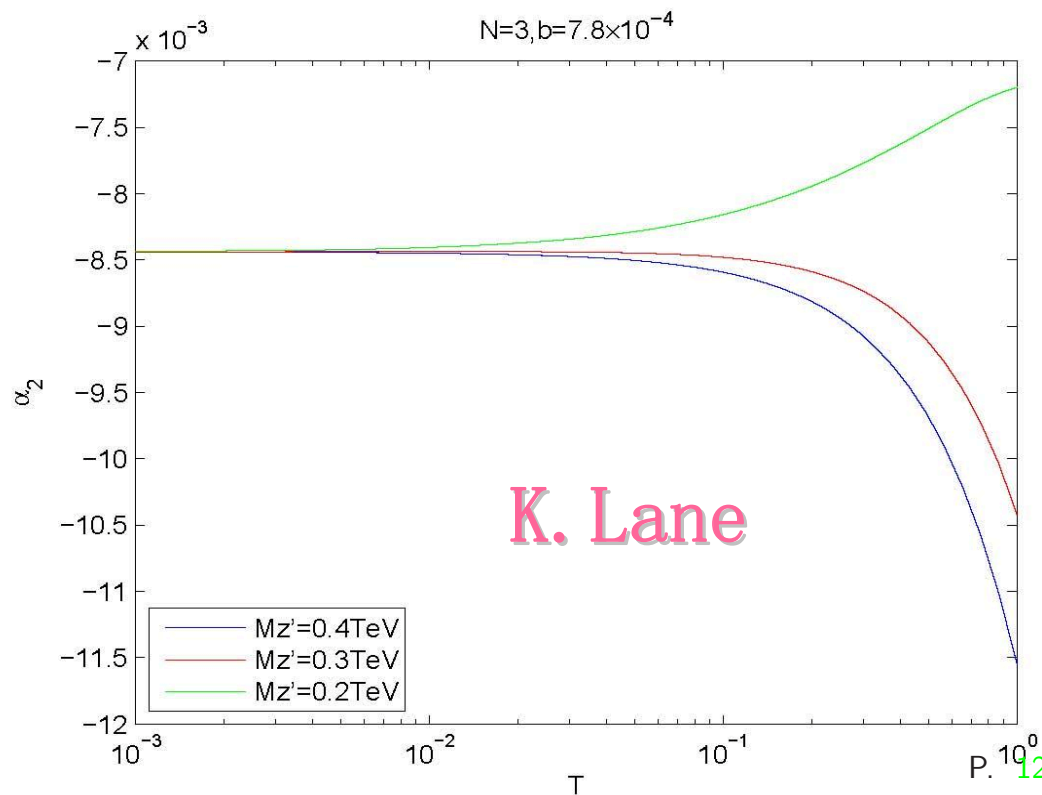
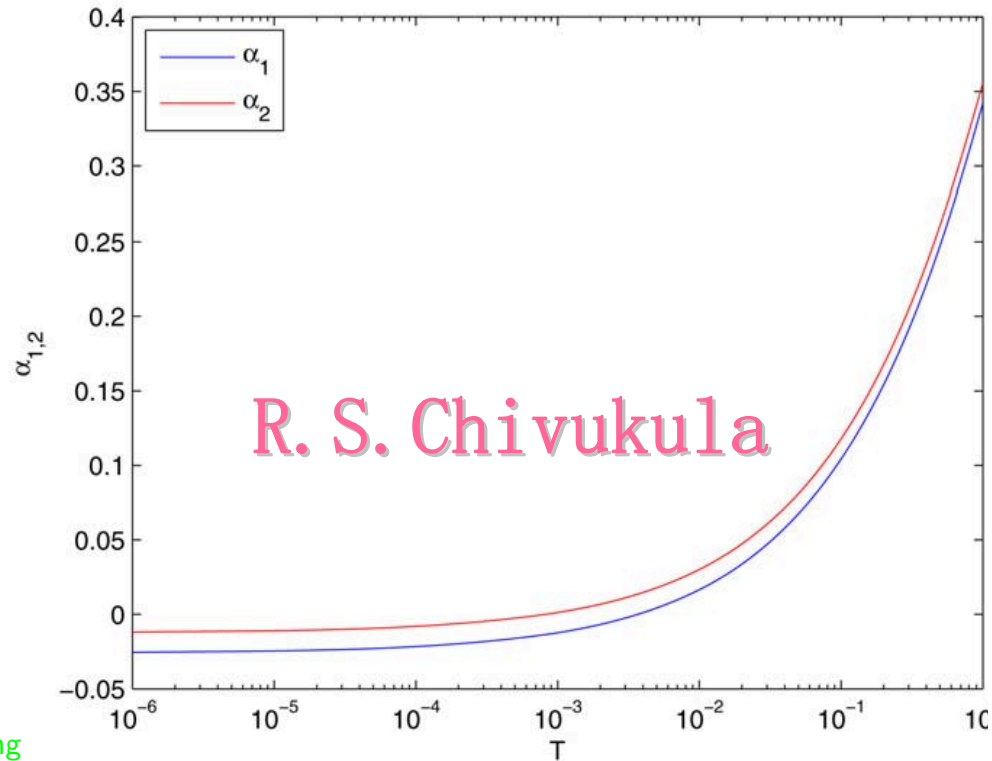
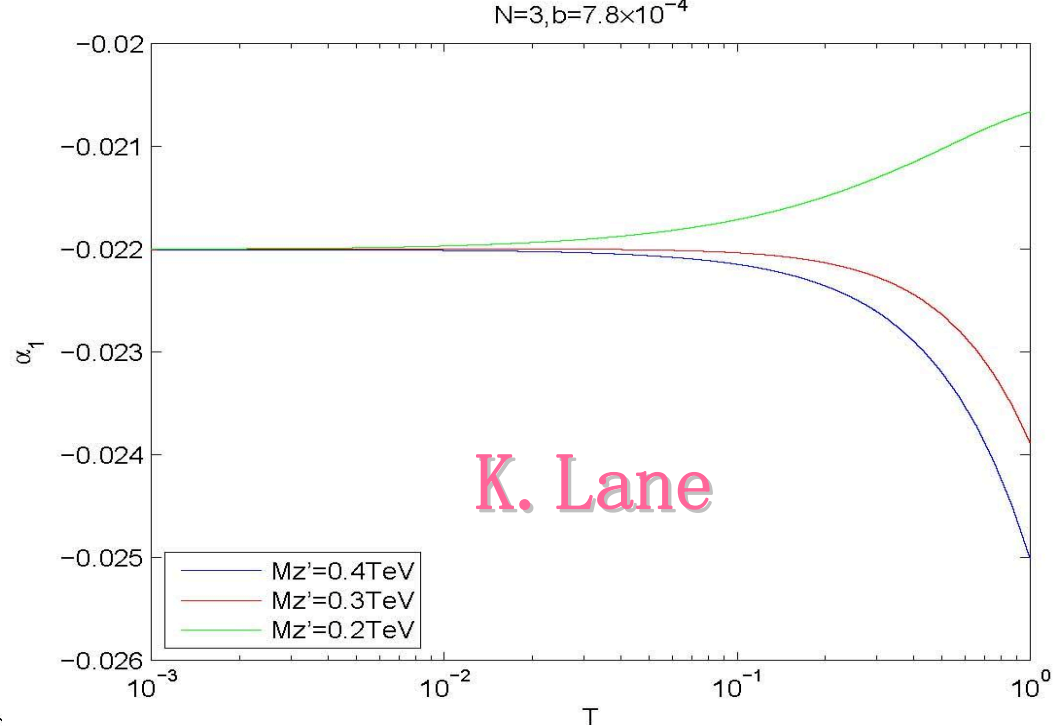
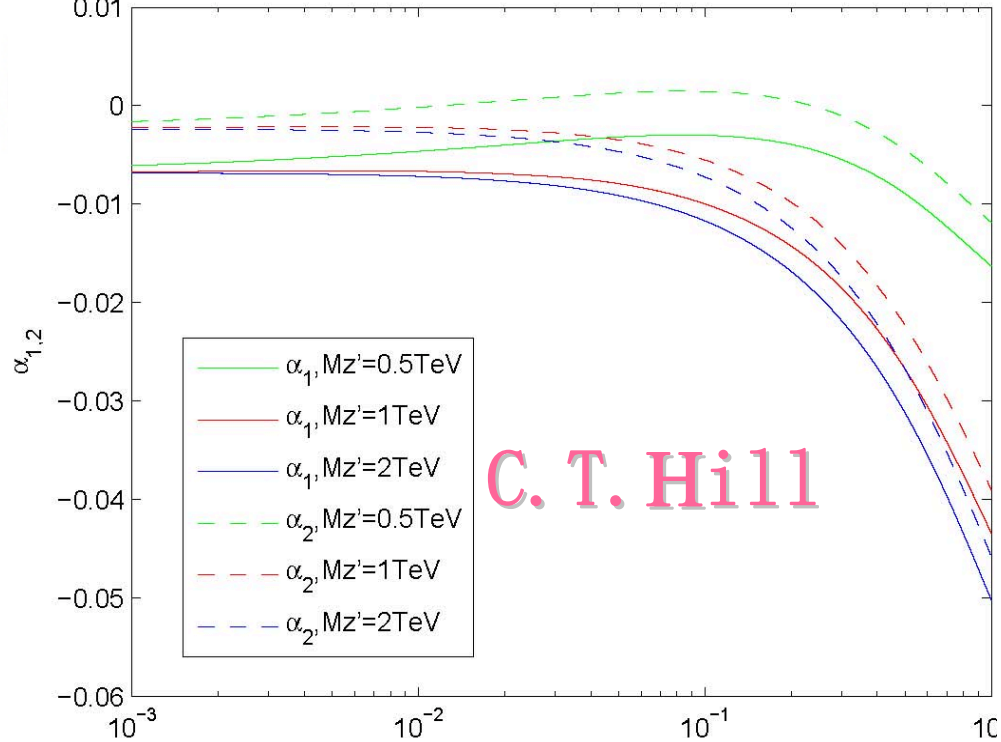


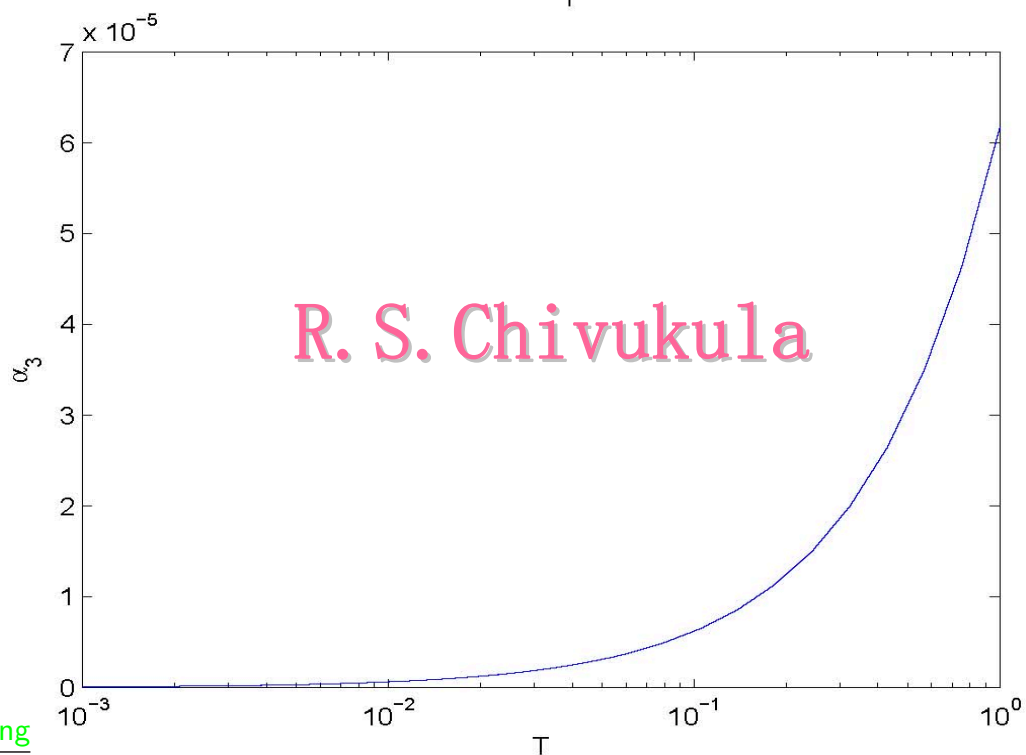
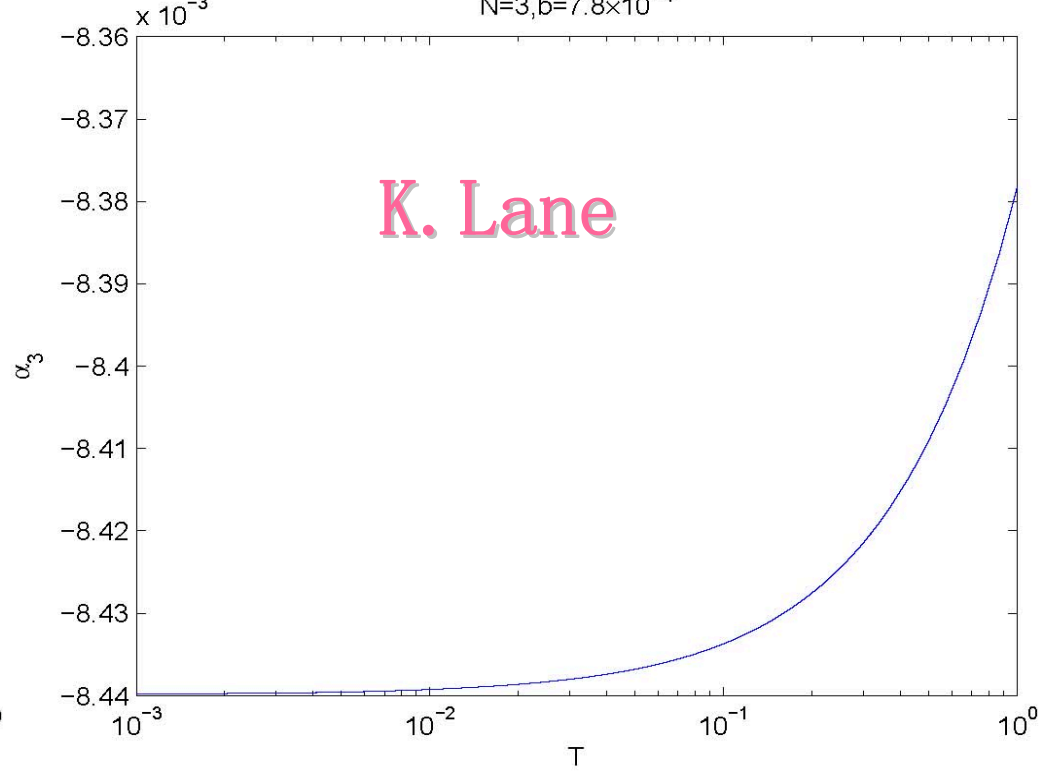
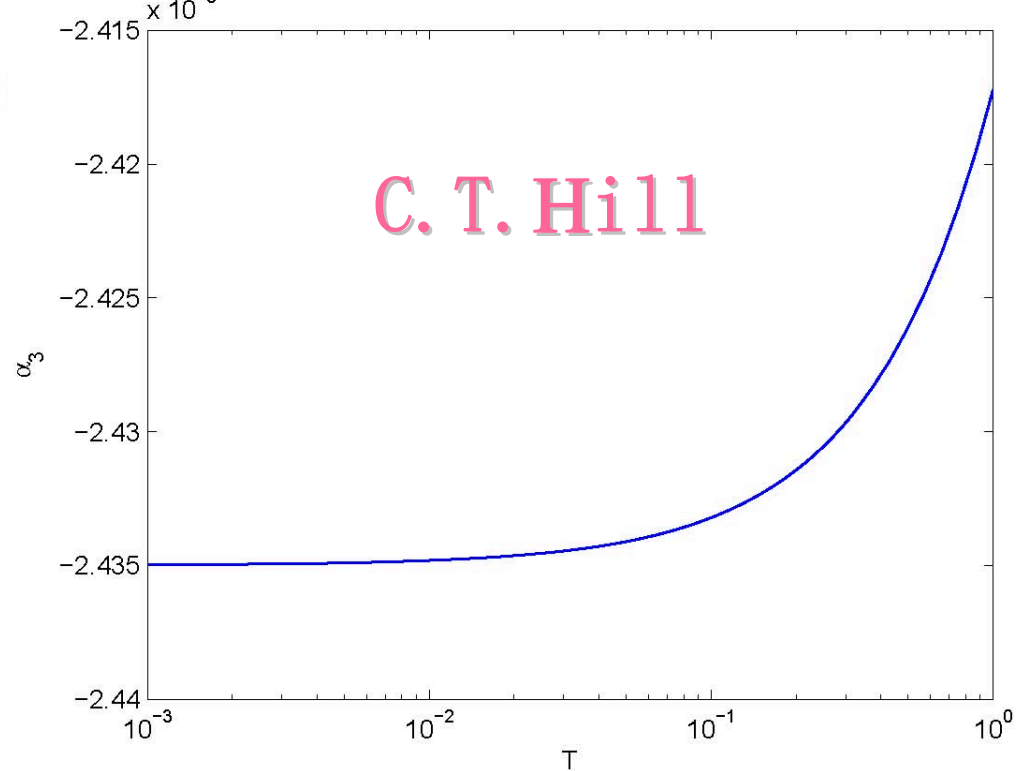
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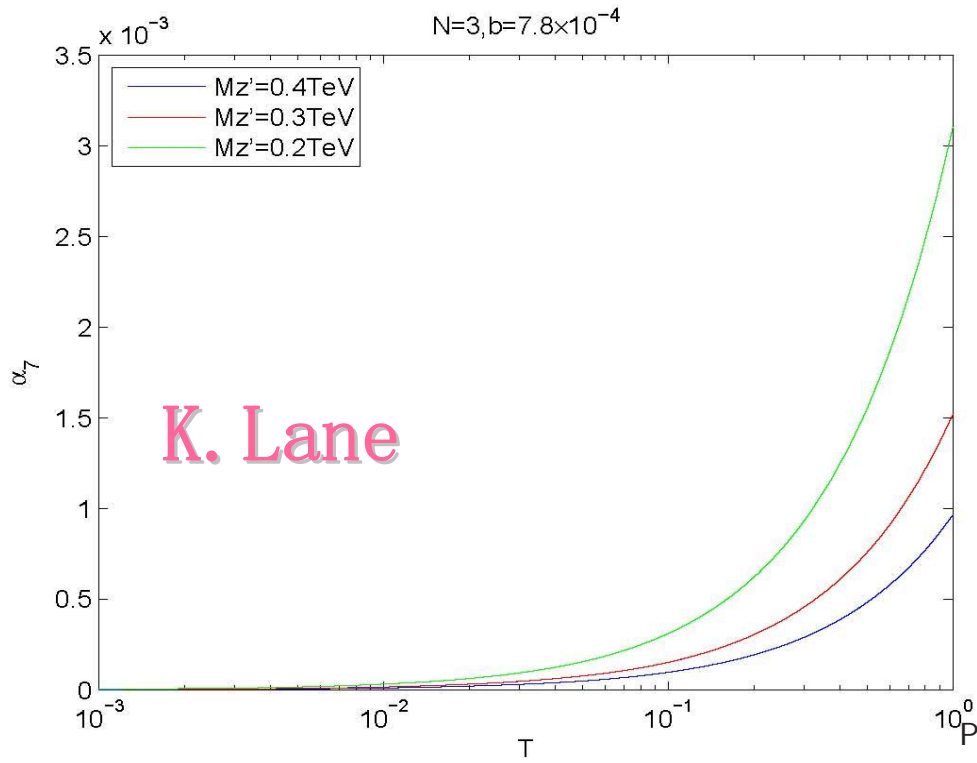
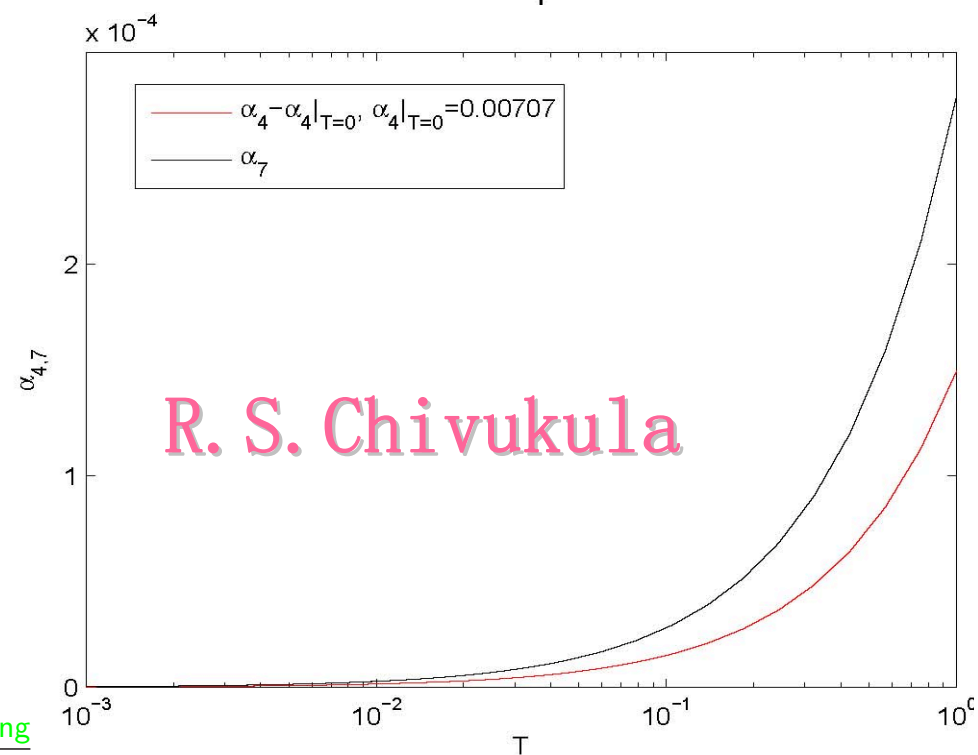
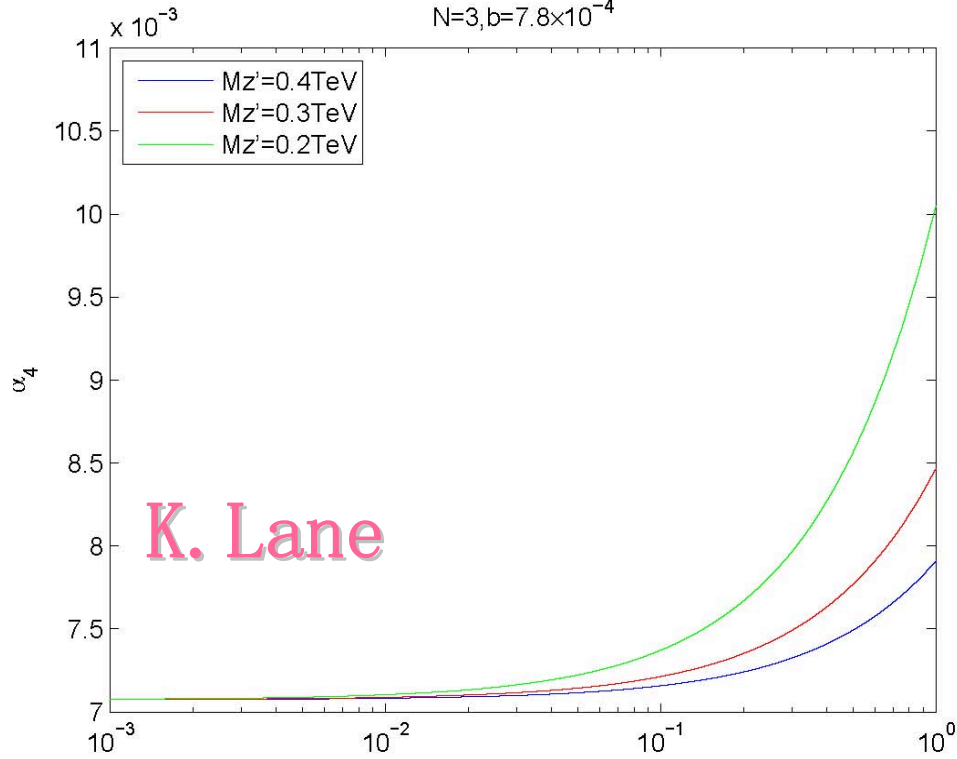
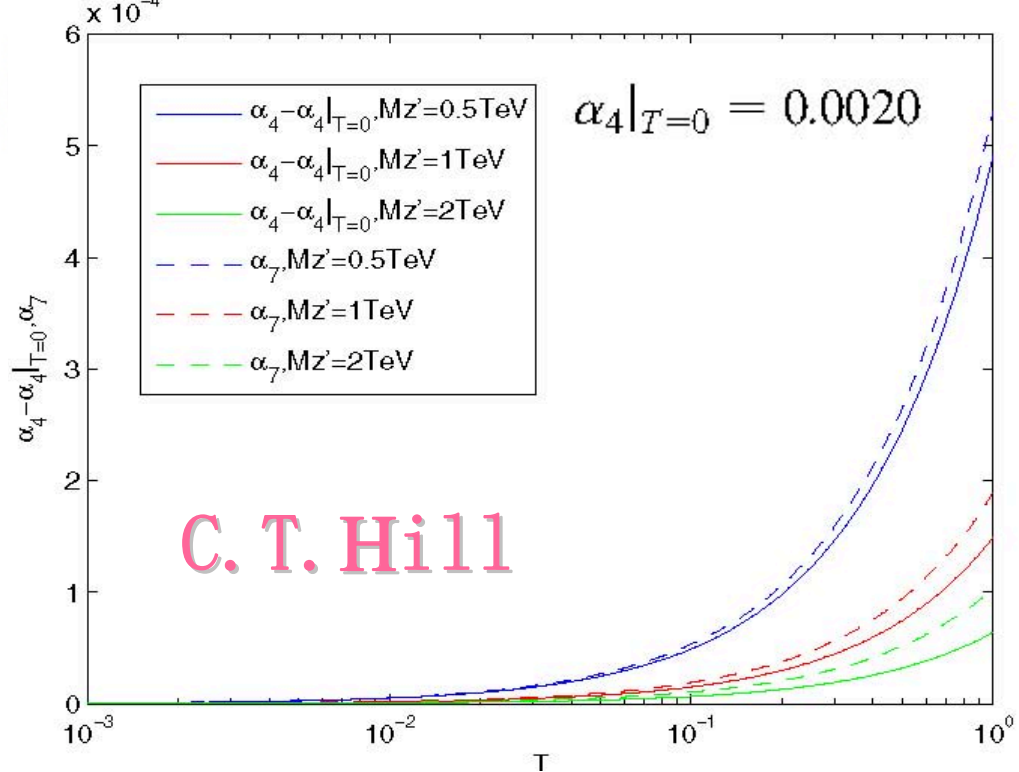
R. S. Chivukula

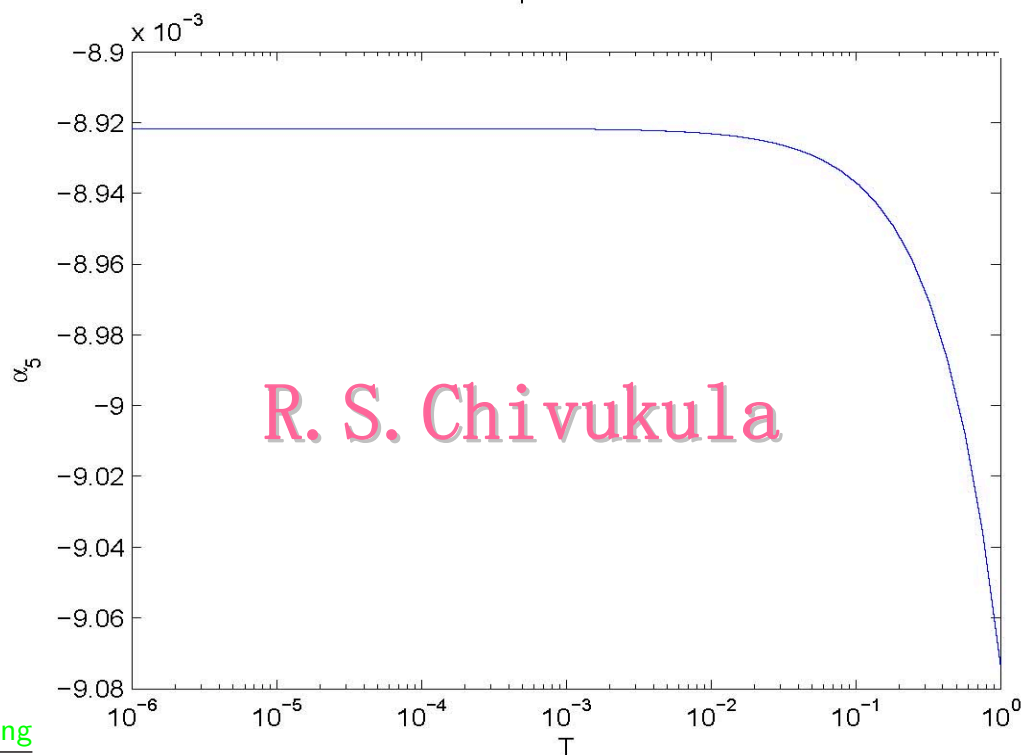
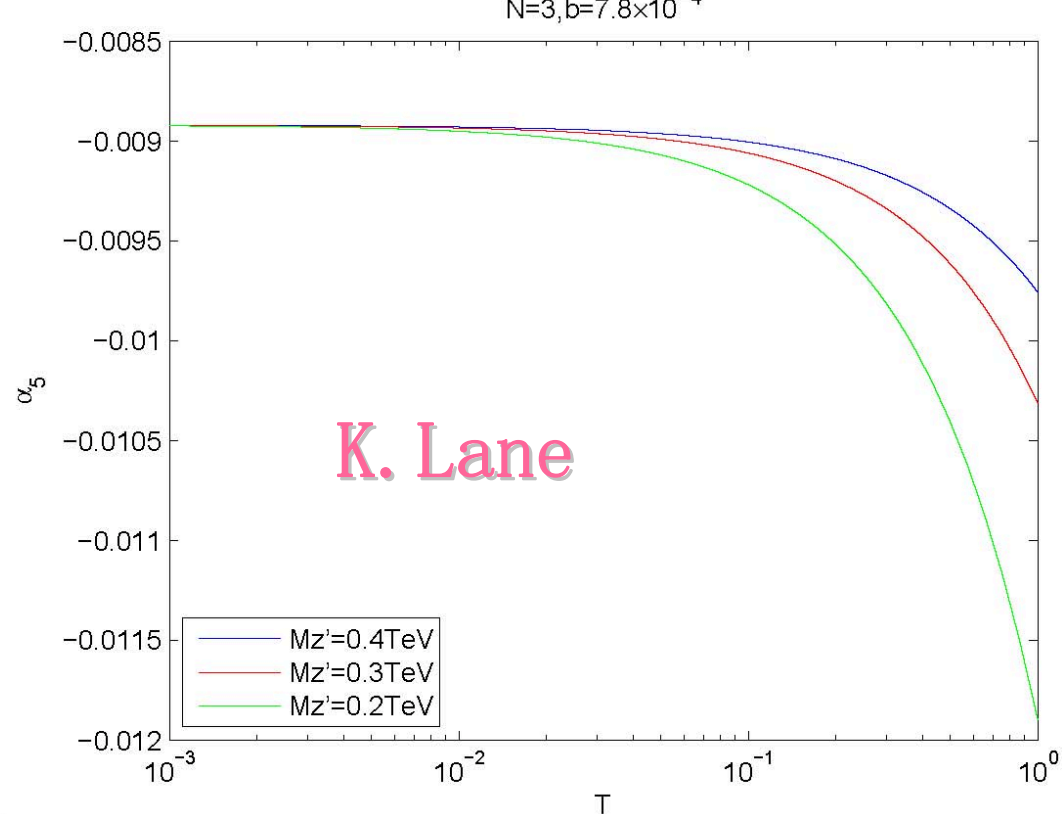
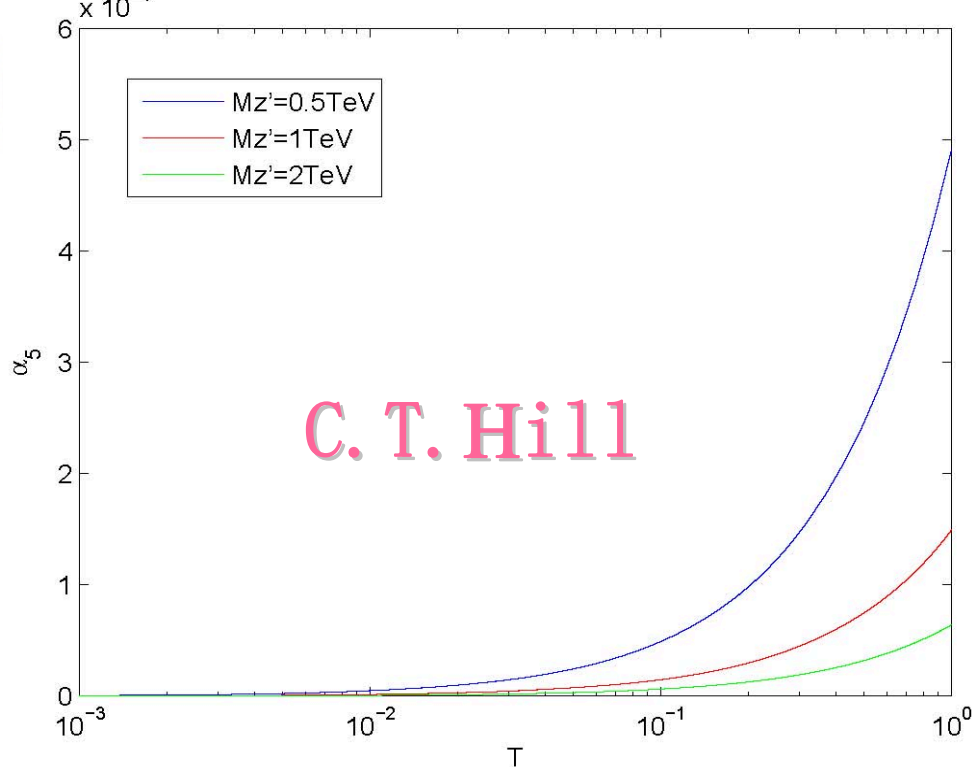
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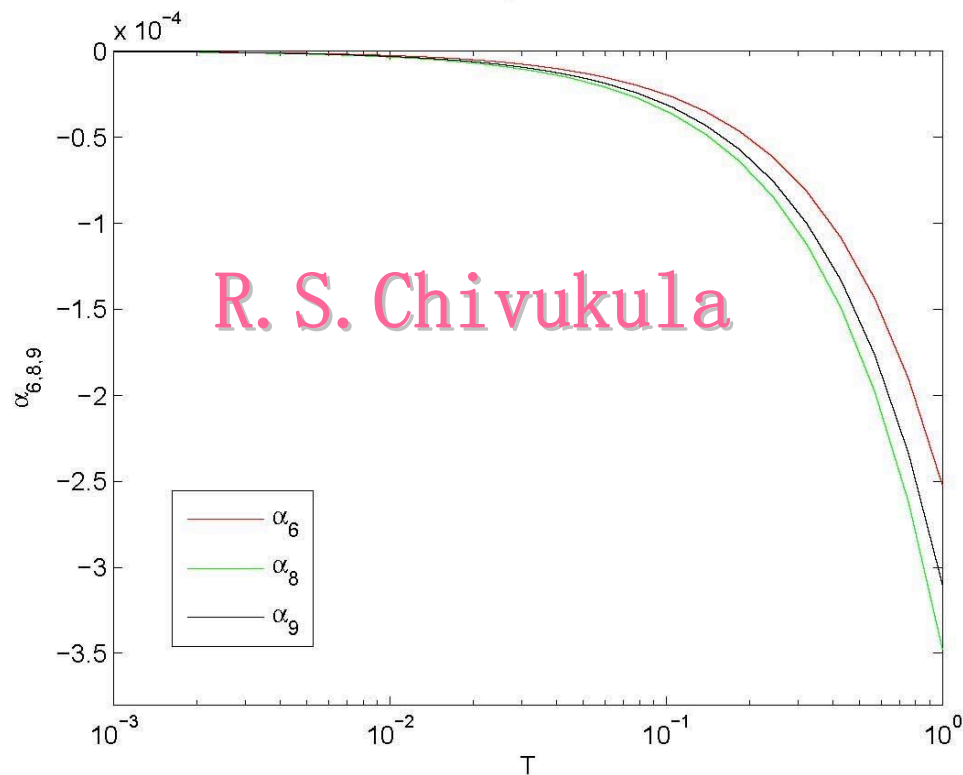
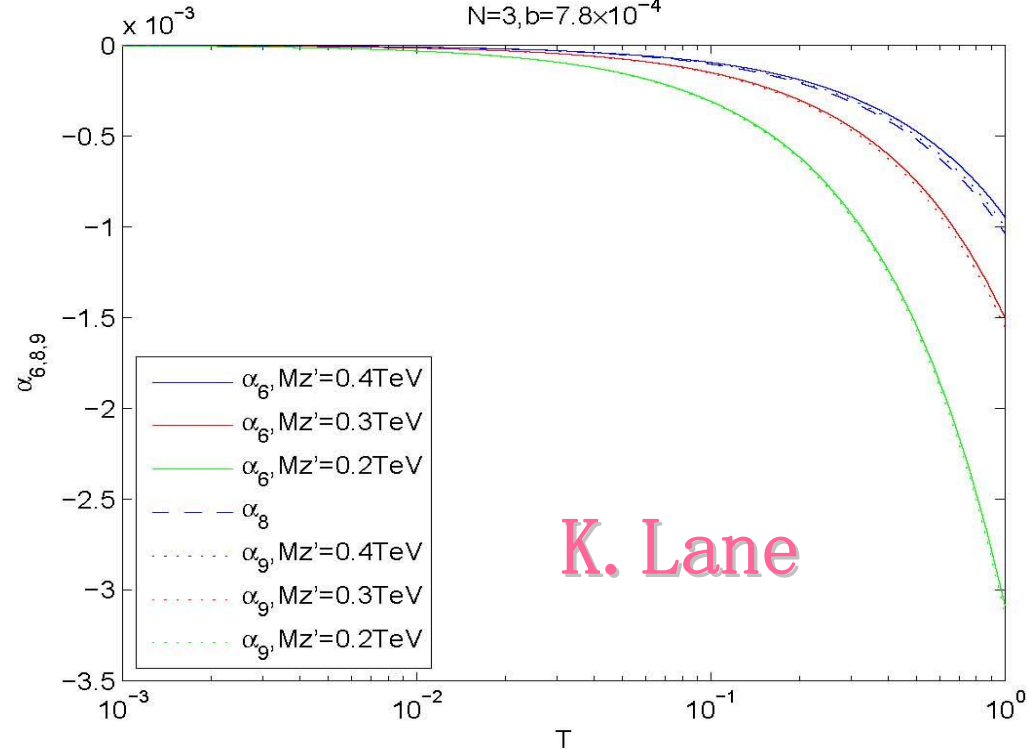
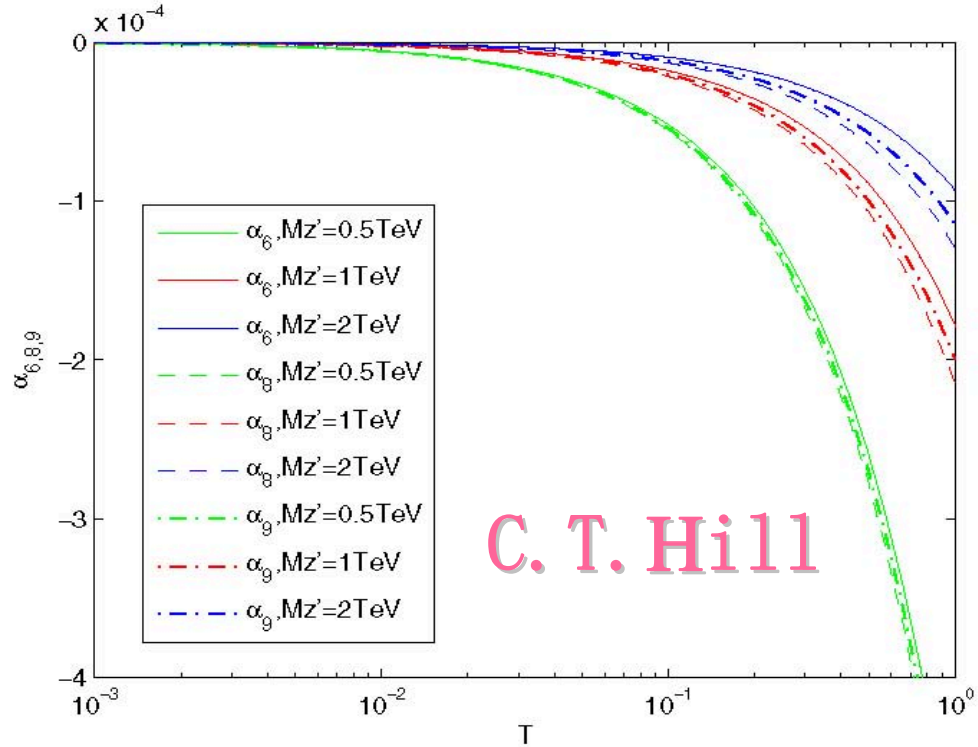


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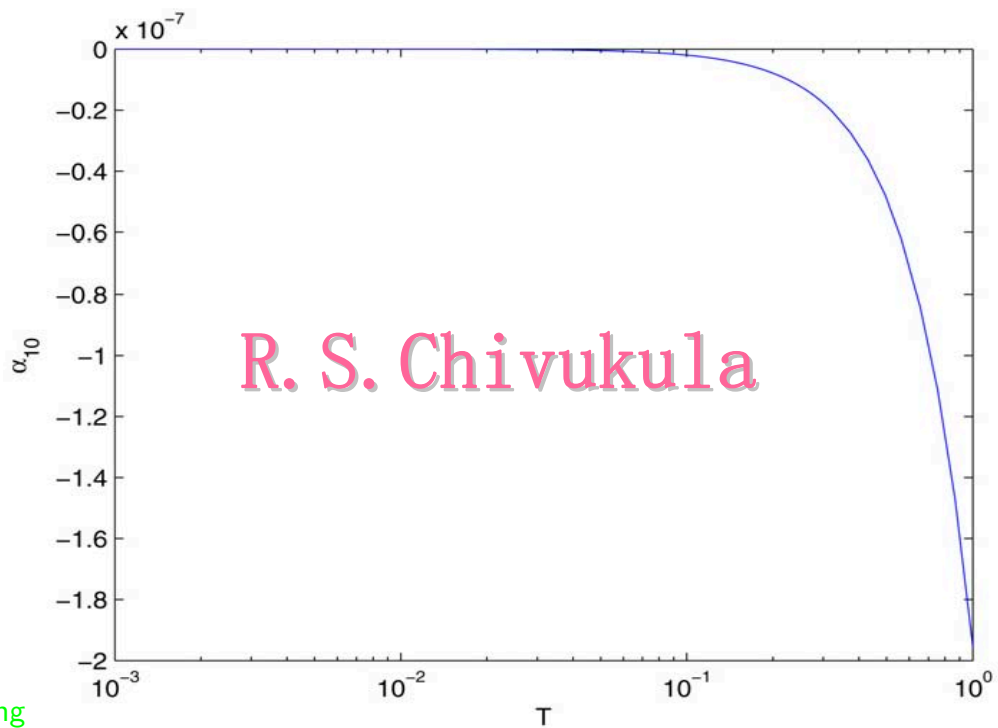
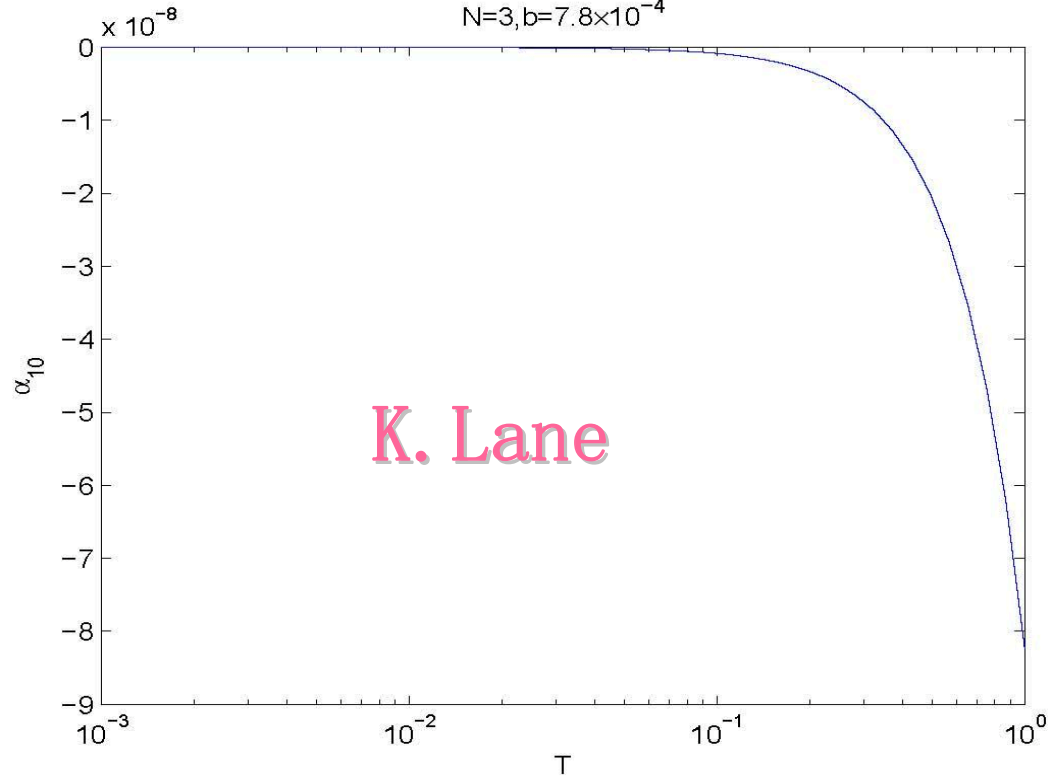
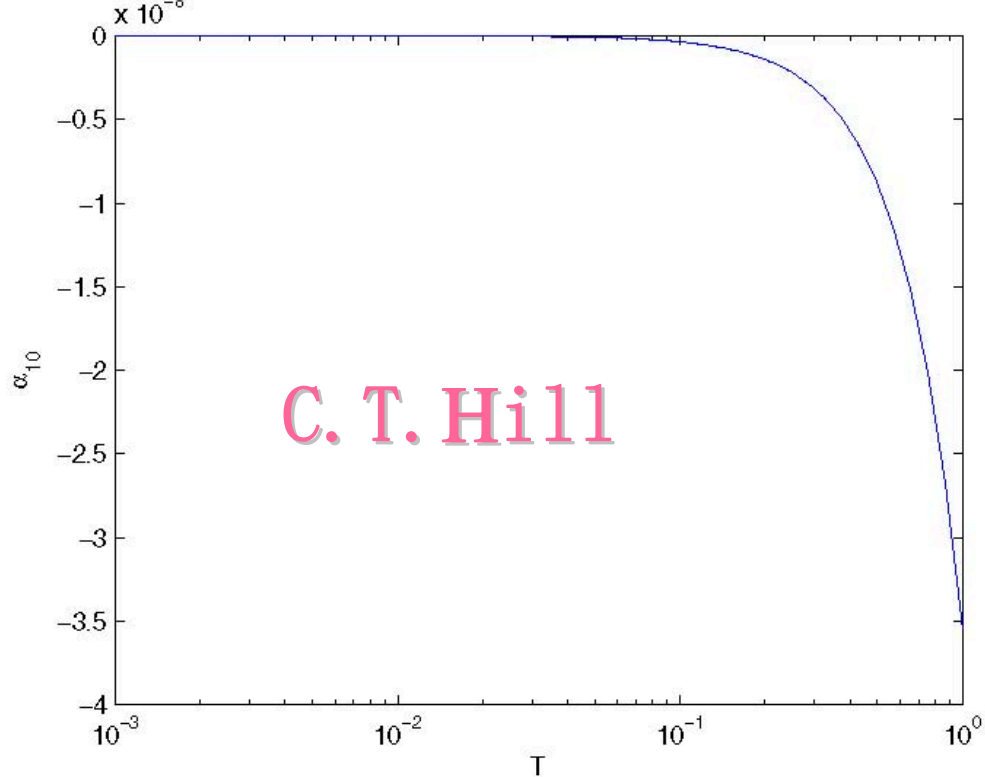




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TC2 model contributions to EWCL coefficients

Thanks!

