A Doubly Sinister $SU(3) \times SU(2)^2 \times U(1)$ Model With See-Saw Dirac Neutrinos No Strong CP Problem And A Most Unusual Candidate For Dark Matter

By

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[Research Not yet Complete]

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DOUBLED FERMIONS:

3 FAMILIES of ORDINARY FERMIONS. 3×16 LEFT-HANDED FIELDS TRANSF'G UNDER $SU(3) \times SU(2) \times U(1)$

+

3 FAMILIES of TERA-FERMIONS 3×16 Left HANDED FERMIONS TRANSFORMING The Same Way UNDER $SU(3) \times SU(2)' \times U(1)$

+

A DISCRETE SYMMETRY LINKING the two

OUR CP SYMMETRY = CONVENTIONAL CP + INTERCHANGE of ORDINARY ↔ TERA

$$h = (2,1)$$
$$h' = (1,2)$$

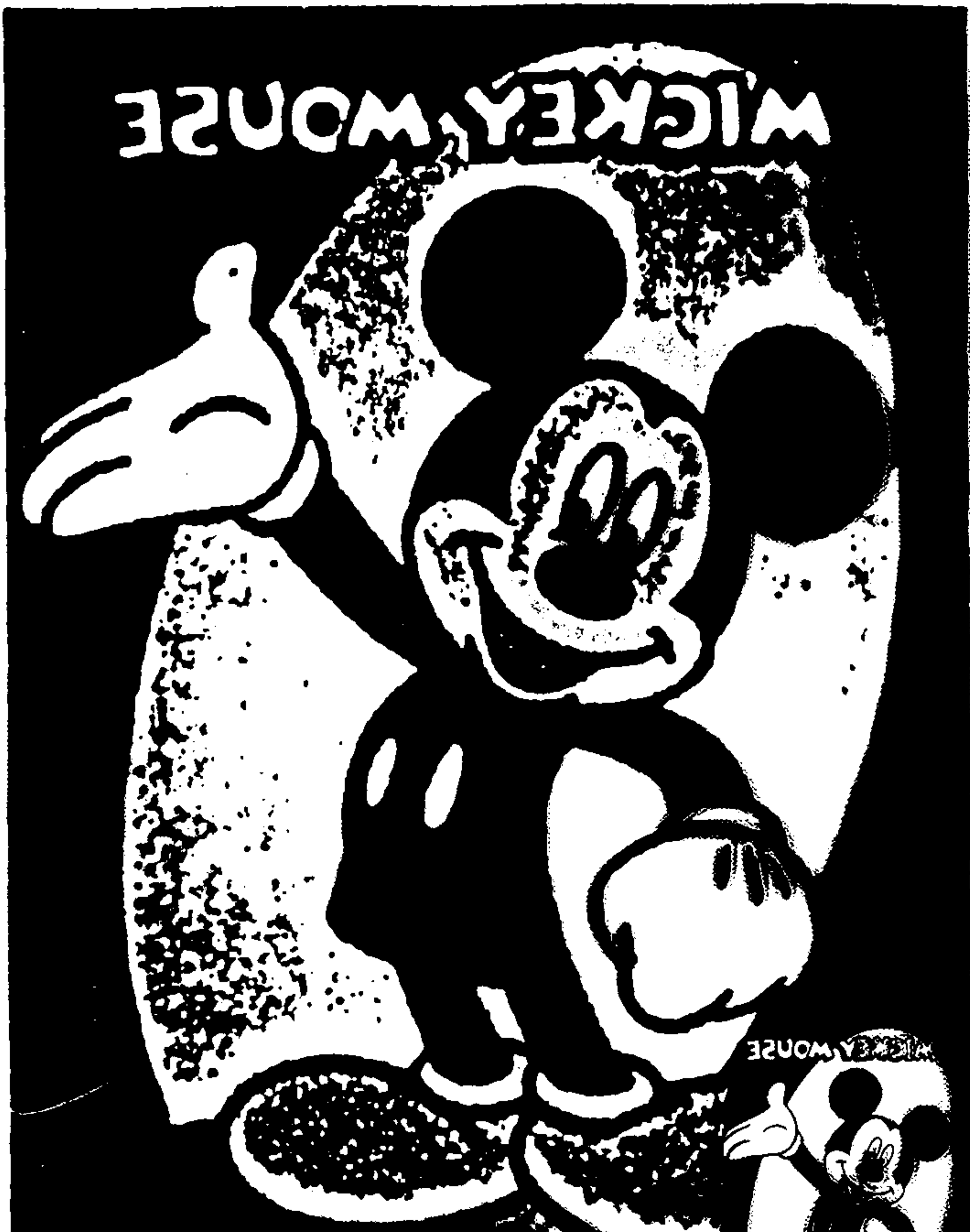
BUT DUE TO SOFT BREAKING ~~of~~ OUR CP SYMMETRY

$$\langle h' \rangle \gg \langle h \rangle$$
$$\langle h' \rangle = S \langle h \rangle$$

SO ORDINARY MASSES ARE $\lambda_{ij} \langle h \rangle$

AND TERA MASSES ARE

$$S \lambda^{*}_{ij} \langle h \rangle$$


MICKEY MOUSE
MICKEY MOUSE

LL MASSES

$$v\left(\bar{u}\lambda(1+\gamma_5)u\right) + \zeta v\left(\bar{U}\lambda^*(1+\gamma_5)U\right)$$

RL MASSES

$$v\left(\bar{u}\lambda(1+\gamma_5)u\right) + \zeta v\left(\bar{U}\lambda(1-\gamma_5)U\right)$$

EITHER WAY

$$\text{Arg}\,\text{DET}\,M = 0$$

LL VS LR

Soft CP VIOLATION

Soft PARITY VIOLATION

TERA LL	ORDINARY	TERA LR
(U, D)	(u, d)	$(\bar{U}, \bar{D})$
$\bar{U}$	$\bar{u}$	U
$\bar{D}$	$\bar{d}$	D
(ν', E^-)	(ν, e^-)	$(\bar{\nu}', E^+)$
E^+	e^+	E^-
$\bar{N}$	$\bar{n}$	N

UNDESIRABLE YUKAWA couplings that DESTABILIZE TERAFERMIONS

----- VERY UNDESIRABLE BARE MASS TERMS that wd. SCREW UP the THEORY.

BAD CONNECTIONS EASILY SUPPRESSED BY DISCRETE SYMMETRY OR GLOBAL $B-L+B'-L'$

EITHER Model

Solves the <u>Strong CP Problem</u>

The value of ArgDet M is   LL is NICER.

Conventional: 6-Loop finite + 7 loop divergent, with divergence cancelled by logS.

And by the way... S has got to be very LARGE BECAUSE

$$M(E) = S \times M(e)$$

AND $M(E) < 100$ GeV by expt?

$$\therefore S > 2 \times 10^5$$

We will put $S = 10^6$ for example

So $M(E) \sim 0.5$ TeV

$M(U) \sim 5$ TeV

$M(D) \sim 10$ TeV

HOW LL YIELDS A DIRAC SEESAW for ν MASS

$$\sigma(\bar{n}\lambda\nu) = (\bar{n}\, m\, \nu)$$

$$S\sigma(\nu'\bar{\lambda}\bar{N}) = S(\bar{n}'\bar{m}\bar{N})$$

$$\bar{n} M \bar{N}$$

$$(\nu', \bar{n}) \begin{bmatrix} 0 & m \\ S\bar{m} & M \end{bmatrix} \begin{pmatrix} \nu \\ \bar{N} \end{pmatrix}$$

$$\text{So } m_\nu = S\, m\, M^{-1} m^{+}$$

(reflecting CONSERVATION of LEPTON NUMBER, duly defined.)

$m \sim$ GeV
$S \sim 10^{6}$ $\Rightarrow M \sim 10^{17}$ GeV (UNITY SCALE)

NEUTRINO COUNTING

for $S \sim 10^6$, the RIGHT-HANDED PARTNERS to ν_e, ν_μ, ν_τ (MOSTLY $\bar{\nu}$'s) DROP out of EQUILIB AT

$$T \sim S^{1/3} \times 1\,\text{MeV} \sim 100\,\text{TeV}$$

So Lots of ENTROPY IS DUMPED between them + RECOMBINATION.

Upshot

$$N_\nu \cong 3.15$$

STABLE TERAHADRONS

for $S \sim 10^6$ $\quad m(U) \sim 5$ TeV

$m(D) \sim 10$ TeV

ALL STABLE TERAHADRONS ARE UISH:

$(U\bar{u})^0$

$(Uud)^+$

$(UUd)^+$ ← Bound by 50 GeV!

$(UU\bar{u}\bar{u})^0$

$(UUU)^{++}$ ← Best Bound of ALL: TERA Δ^{++}

SO TERA-MATTER CAN BE DARK MATTER IF THERE'S A TERABARYONIC ASYMMETRY.

Let it be

THE FATE of the U's
et al.

All these exchange reactions have geometric (LARGE) cross sections + are VERY EXOTHERMIC.

∴ ALMOST ALL U's END UP AS $(UUU)^{++}$ [TERA Δ^{++}] during the PERIOD

$$GeV > T > MeV$$

III

Meanwhile, Teracharge Neutrality $\to 2N(E) = 3N(U)$

What happens to those ~ 500 GeV <u>STABLE</u> TERAELECTRONS?

E^-

$\bar{E} + P \to \bar{E}P + \gamma$ (RECOMBINATION at $T < 20$ keV)

Then — very effectively —

$$(UUU)^{++} + \bar{E}P \to (UUU)\bar{E} + P$$

$$(UUU)\bar{E} + \bar{E}P \to (UUU)\bar{E}\bar{E} + P$$

<u>FINALLY</u>: ALMOST ALL TERAFERMIONS BECOME TERAHELIUM $(UUU)^{++}\bar{E}\bar{E}$

OUR CANDIDATE FOR DARK MATTER.

Meanwhile, Teracharge Neutrality 112

Suggesting $2(N_E) = 3N_U$, what

happens to these Stable Teraelectrons

$\bar{E}$ (with $M \sim 0.5$ TeV)? They

Recombine efficiently to $\bar{E}P$

States at $T < 10$ KeV. Then,

They engage in large cross-section

Exchange reactions

$$(UUU) + \bar{E}P \rightarrow (UUU)\bar{E} + P$$

$$(UUU)\bar{E} + \bar{E}P \rightarrow (UUU)\bar{E}\bar{E} + P$$

Most all Terafermions end up as Terahelium

$$(UUU)^{++} \bar{E}\bar{E}$$

TERA HELIUM DETECTION VIA 13

the TERA-ATOM.

3) Through the Magnetic Moment of the TERANUCLEUS

→ MAG. MOMENT — charge scattering DOMINATES. CROSS-SECTION + MASS ARE COMPATIBLE WITH [NEGATIVE] DATA FOR

$S \sim 10^6$ OR $M \sim 10\,\text{TeV}$

TERA HELIUM IS AN ACCEPTABLE DARK MATTER CANDIDATE.

WHAT About the Survivors?

Some TERAS Survive in other forms. Perhaps 10^{-5} of them:

$$\bar{E}p,\ (Uud)^+,\ (UUd)^+\ (UudE)^0$$

etc.

These would form — or lead to the formation — of superheavy isotopes of familiar elements, with masses .5 – 15 TeV. No such things have been seen to extreme precision. Maybe...

Reprocessing or Sequestering During Structure formation Can Solve this problem...

And God knows where superheavy H or He would find itself today,