ppp. 1.

RELATION BETWEEN FINESTRUCTURE CONSTANT AT PLANCK-SCALE FROM MULTIPLE POINT PRINCIPLE.

MAIN ASSUMPTION:
MANY VACUA WITH SAME (i.e. ≈0) COSMOLOGICAL CONSTANT.

DEVELOPMENT WITH DON BENNETT & L.V. LAPERASHILI
OF WORKS ALSO WITH RYZHIKH
(AND RELATED TO WORK WITH C. DAS AND C.D. FROGGATT)

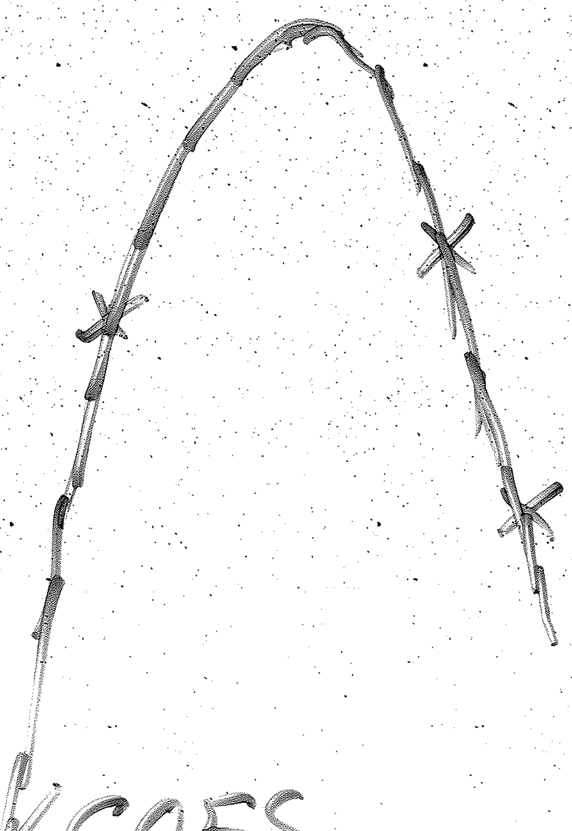
I AM H.B. NIELSEN.

SINCE SO MANY AT-
TEMPTS TO AVOID
FINE TUNING EVEN
SEEM TO NEED NEW
PHYSICS SOON, WE MAY
GIVE UP, AND
ADMIT: THERE
IS FINETUNING!
"MULTIPLE POINT PRIN-
CIPLE" IS A MODEL FOR
HOW GOD DID FINETUNE
NAMELY SLIGHTLY EXTENDING
THAT COSMOLOGICAL CONSTANT IS SMALL

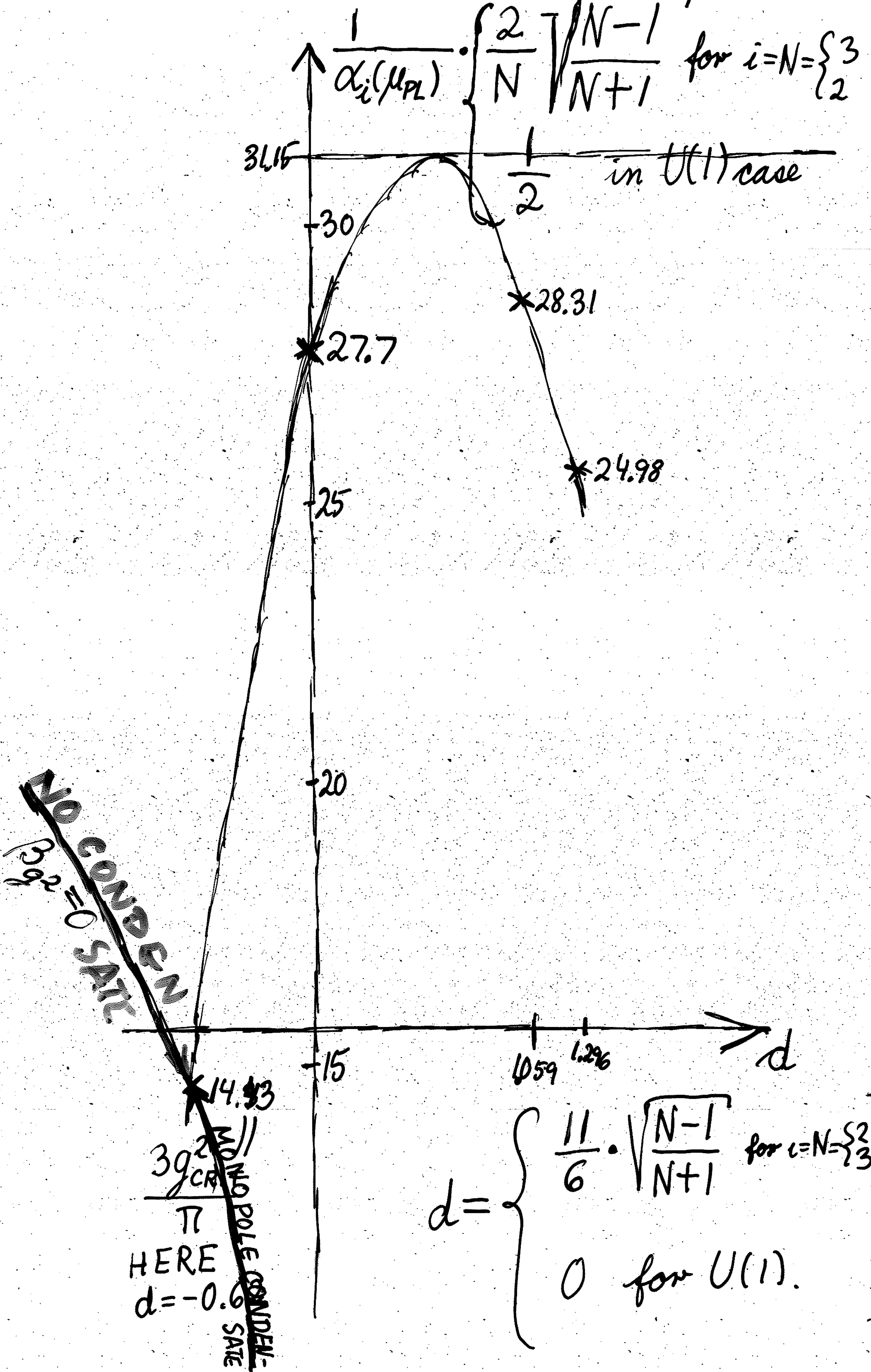
nyn. 2.

MAIN POINT:

EXPERIMENTALLY RATHER SUCCESSFULL RELATION BETWEEN THE THREE FINE STRUCTURE CONSTANTS OF THE STANDARD MODEL $\alpha_1, \alpha_2, \alpha_s$ EXTRAPOLATED TO THE PLANCK-SCALE:



GOES THROUGH "4TH POINT"



$$d = \begin{cases} \frac{11}{6} \cdot \sqrt{\frac{N-1}{N+1}} & \text{for } i=N=\begin{cases}2\\3\end{cases} \\ 0 & \text{for } U(1). \end{cases}$$

THE $\frac{g^2}{\pi}$ WHERE g IS THE MONOPOLE CHARGE IS RELATED BY OUR EXTENSION OF THE DIRAC CONSISTENCY RELATION FOR MONOPOLES AND CHARGES SIMPLY

$$\frac{g_i^2}{\pi} \underset{\text{DIRAC GENERALIZED}}{=} \begin{cases} \frac{2}{N}\sqrt{\frac{N-1}{N+1}} \cdot \frac{1}{\alpha_i} & \text{FOR } SU(N)/Z_N \text{ GROUP } i=N \\ \frac{1}{\alpha_1} & \text{IN } U(1) \text{ CASE.} \end{cases}$$

HERE WE "CHEATED" ON OUR PLOT WITH 1/2.

THE "FOURTH POINT" HAS APART FROM THE FACTOR 3 JUST THE PHASE TRANSITION VALUE g^2_{crit}/π BETWEEN CONDENSATION OF MONOPOLES AND NO CONDENSATION.

пуп. 2.3.

SUMMARY OF THE MAIN MESSAGE, THE $\frac{3g^2}{\pi}$ VERSUS d PLOT:

$\left(d \,\hat{=}\, \frac{d}{dt} g^2(\mu) \Big|_{\text{DUE TO NON-ABELIANNESS}} \right.$

d IS GROUP CHARACTERISTIC)

1) THE THREE POINTS ARE <u>EXPERIMENTAL</u> DATA TRANSFORMED BY RATHER SIMPLE β-FUNCTION RUNNING TO THE PLANCK SCALE AND SOME <u>SIMPLE</u> SQUAREROOTS AND TRIVIAL FACTORS, MAKING IT INTO g^2/π.

2) THE "<u>FOURTH POINT</u>" MARK THE PHASE <u>TRANSITION</u> <u>BETWEEN</u> <u>PHASES</u> WITH AND WITHOUT CONDENSATION OF MONOPOLES AS CALCULATED IN AN APPROXIMATION USING β-FUNCTIONS TO TWO LOOP APPROXIMATION. THIS IS UNDER FURTHER SPECIFYING $\beta_{g^2} = \frac{g^4}{48\pi^2} + \frac{g^6}{(16\pi^2)^2} + d = 0$

nnp.3.

REALLY WE HAVE AN

OLD MODEL PREDICTING IN PRINCIPLE ALL THREE FINE STRUCTURE CONSTANTS BASED ON:

0) NEW PHYSICS BEFORE ALMOST PLANCK SCALE DON'T DISTURB.

1) THE MULTIPLE POINT PRINCIPLE" SAYING: MANY VACUUM STATES HAVE THE SAME ENERGY DENSITY (~ COSMOLOGICAL CONSTANT $\Lambda_{j\text{TH VAC}}$; $\Lambda_{j\text{TH VAC}} \approx \Lambda_{k\text{TH VAC}}$)

2) THE GAUGE GROUPS U(1), SU(2), AND SU(3) APPEAR AS DIAGONAL SUBGROUPS OF RESPECTIVELY $U(1) \subseteq U(1)\times U(1)\times U(1)$, $SU(2) \subseteq SU(2)\times SU(2)\times SU(2)$, AND $SU(3) \subseteq SU(3)\times SU(3)\times SU(3)$.

THE NEWER DEVELOPMENT OF THE OLD MODEL USING LATTICE PHASE TRANSITIONS:

1) NOW USE MAGNETIC MONOPOLE CONDENSATION IN THE DESCRIPTION OF THE PHASES. (HOPEFULLY AVOID TOTALLY TO USE LATTICE MONTECARLO CALCULATIONS, AS WE USED IN OLD MODEL)

2) NOW LOOK FOR IF SOME COMBINATION OF / RELATION BETWEEN THE 3 FINESTRUCTURE CONSTANTS COULD BE MORE EASILY AND/OR ACCURATELY PREDICTED FROM THE (OLD) MODEL.

3) GIVE UP SOME SUSPICIOUS CORRECTIONS (WE MAY HAVE INVENTED TO GET AGREEMENT

упр. 5.

TO HAVE IN MIND ABOUT MAGNETIC MONOPOLES (FROM CONSIDERATION OF THE LATTICE YANG-MILLS THEORY, SAY):

- ABELIAN DIRAC RELATION BETWEEN THE (ELEMENTARY) MAGNETIC CHARGE g AND THE ELECTRIC ONE e:

$$ge = 2\pi \cdot n$$

WHERE n IS AN INTEGER (BUT WE SHALL TEND TO ASSUME THE SIMPLEST CASE $n = \pm 1$ BEING REALIZED)

- WE - RYZHIKH, LAPERASHVILI & I - PROPOSE NONABELIAN GENERALISATION TO $SU(N)/Z_N$: $\alpha_N^{-1} = \frac{N}{3}\sqrt{\frac{N+1}{N-1}} \cdot g^2/\pi$.

стр. 6.

BECAUSE OF THE RE-
LATIONS - OF DIRAC TYPE -

$$\frac{1}{\alpha_{U(1)}} = \frac{g^2_{U(1)}}{\pi}$$

$$\frac{1}{\alpha_{SU(N)/Z_N}} = \frac{N}{2} \cdot \sqrt{\frac{N+1}{N-1}} \cdot \frac{g^2_{SU(N)/Z_N}}{\pi}$$

YOU NEED, IF THEY ARE
FULLFILLED FOR RUNNING
COUPLING SCALE FOR
SCALE THAT:
A MAGNETIC MONOPOLE
BETA-FUNCTION, β_{g^2} SAY,
MUST "INHERIT" A TERM
COMMING FROM THE FAMOUS
ASSYMPTOTIC FREEDOM CAUSING TERM
IN THE $\alpha_{SU(N)/Z_N}$ RUNNING β_N.

app. 7. (t IS LOG OF SCALE μ^2)

FROM β_N PURE YANG MILLS CONTRIBUTION

$$\beta_N \Big|_{\substack{\text{NON-}\\ \frac{1}{\alpha_N}\ \text{ABELIAN-}\\ \text{NESS}}} = \frac{d(\alpha_N^{-1})}{dt} \Big|_{\substack{\text{NON-}\\ \text{ABELIAN-}\\ \text{NESS}}}$$

$$= \frac{b_N}{4\pi} = \frac{1}{4\pi} \cdot \frac{11}{3} \cdot N$$

WE DERIVE TO KEEP THE RELATION

$$\frac{1}{\alpha_N(\mu)} = \frac{N}{2} \cdot \sqrt{\frac{N+1}{N-1}} \cdot \frac{g_N^2(\mu)}{\pi}$$

AT ALL SCALES, THAT THERE BE A CONTRIBUTION

$$\frac{d}{dt}\left(\frac{g_N^2(\mu)}{\pi}\right)\Big|_{\text{NONABELIANNESS}} = \frac{1}{4\pi} \cdot \frac{11}{3} N \cdot \frac{2}{N} \sqrt{\frac{N-1}{N+1}}$$

WE WRITE THE CONTRIBUTION TO THE "RUNNING" (OR BETA-FUNCTION) FOR $\frac{g^2}{\pi}$ (THE SQUARED MONOPOLE CHARGE DIVIDED BY π) AS

$$\beta_{\frac{g^2}{\pi}}\Big|_{\text{NON-ABELIANNESS}} = \frac{d}{dt}\left(\frac{g^2(\mu)}{\pi}\right)\Big|_{\text{NON-ABELIANNESS.}} =$$

$$= \frac{11}{6\pi}\sqrt{\frac{N-1}{N+1}} = \frac{d}{\pi}$$

WHERE THEN DEFINED THE QUANTITY d FOR SU(N)-OR RATHER SU(N)/Z_N-GROUPS BY

$$d \hat{=} \frac{11}{6}\cdot\sqrt{\frac{N-1}{N+1}}.$$

REMEMBER ABOUT OUR QUANTITY d:

d IS A GROUP-CHARACTERISTIC (GROUP-DEPENDENT) QUANTITY DEFINED BY

$$d = \frac{d}{dt}\left(g^2_{SU(N)/Z_N}(\mu)\right)\Big|_{\text{NONABELIANNESS}} = \begin{cases} \frac{11}{6}\cdot\sqrt{\frac{N-1}{N+1}} & (\text{FOR } SU(N)) \\ 0 & \text{FOR } U(1) \end{cases}$$

i.e. d IS A MEASURE FOR THE BETA-FUNCTION RUNNING RATE <u>FOR THE MONOPOLE</u> DUE TO NONABELIANNESS.

рурп. 10.

A MAGNETIC MONOPOLE CHARGE g_N IS – AT SAY THE PLANCK SCALE $\mu = 1.2 \cdot 10^{19}$ GeV – DEFINABLE FROM REPLACEMENT FOR THE DIRAC RELATION $eg = 2\pi$ (TIMES INTEGER, WHICH WE GUESS $= \pm 1$) BY OUR SIMPLE FORMULA

$$\frac{g_N^2}{\pi} = \frac{2}{N} \sqrt{\frac{N-1}{N+1}} \cdot \frac{1}{\alpha_N}$$

pyyp. 11.

TO AT LEAST INCLUDE THE DIAGONAL SUBGROUP MODEL (SOMETIMES CALLED ANTI-G.U.T.) WE ALLOW SAY SU(N) AS A DIAGO-NAL SUBGROUP OF N_{gen} CROSS PRODUCT FACTORS

$$SU(N) \underset{\substack{\text{DIAGO-}\\\text{NAL SUB-}\\\text{GROUP OF}}}{\subseteq} \overbrace{SU(N) \times \ldots \times SU(N)}^{N_{gen}\ \text{FACTORS}}$$

$$= SU(N)^{N_{gen}}$$

$$SU(N)|_{\text{DIAGONAL SUBG.}} = \{ \overbrace{(u, u, \ldots, u)}^{\substack{\text{ORDERED}\\ N_{gen}\text{-SET}}} \mid u \in SU(N) \}$$

CRUCIAL THAT TO FIRST APPROXIMATION THE INVERSE FINE STRUCTURE CONSTANT FOR A DIAGONAL SUBGROUP $\frac{1}{\alpha_{N\,DIAG}}$

IS GIVEN ADDITIVELY FROM THE INVERSE FINE-STRUCTURE CONSTANTS $\frac{1}{\alpha_{N,j}}$ FOR THE VARIOUS FACTORS IN $\overbrace{SU(N)\times SU(N)\times\ldots\times SU(N)}^{N_{gen}}$

$$\frac{1}{\alpha_{N\,DIAG}} = \sum_{j=1}^{N_{gen}} \frac{1}{\alpha_{Nj}}$$

стр.13.

FOR EACH OF THE FAMILY GAUGE GROUP FINE STRUCTURE CONSTANTS α_{Nj} OR α_{ij} (j RUNNING THROUGH N_{gen} (=PRESUMABLY 3) FAMILIES) WE CAN IMAGINE (ASSUME) A MONOPOLE WITH g_{Nj} GIVEN BY

$$\frac{g_{Nj}^2}{\pi} = \frac{1}{\alpha_{Nj}} \cdot \frac{2}{N}\sqrt{\frac{N-1}{N+1}}$$

$$SU(N) \subseteq \overbrace{SU(N) \times \ldots \times SU(N)}^{N_{gen}}$$

THE FAMILY GAUGE GROUPS

$$\frac{1}{\alpha_N} = \sum_{j=1}^{N_{gen}} \frac{1}{\alpha_{Nj}} = \frac{N}{2}\sqrt{\frac{N+1}{N-1}} \cdot \sum_{j=1}^{N_{gen}} \frac{g_{Nj}^2}{\pi} = \frac{N_{gen}\, g_{N\,AV.}^2}{\pi} \frac{N}{2}\sqrt{\frac{N+1}{N-1}}$$

IF WE CONSIDER g^2_{NAV} THE AVERAGE OVER THE MONOPOLE CHARGES SQUARED FOR THE N_{gen} SU(N)-RELATED "FAMILY-GAUGE GROUPS", i.e. $N_{gen}\, g^2_{NAV} = \sum_{j=1}^{N_{gen}} g^2_{Nj}$, THEN WE HAVE

$$\frac{1}{\alpha_N} = \sum_{j=1}^{N_{gen}} \frac{1}{\alpha_{Nj}} = \frac{N_{gen}\, g^2_{NAV}}{\pi}$$

THE OBSERVABLE INVERSE FINESTRUCTURE CONSTANT IN STANDARD MODEL

FROM BREAKING TO THE DIAGONAL SUBGROUP $SU(N) \underset{\text{BREAKING}}{\subseteq} SU(N) \times \ldots \times SU(N)$

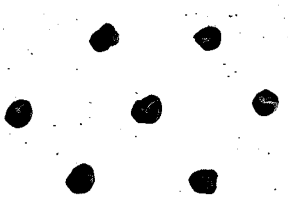
(WE GUESS/ASSUME $N_{gen} = 3$, SO THAT EACH FAMILY OF QUARKS AND LEPTONS JUST GETS ITS OWN GAUGE-FAMILY).

pyy. 15.

"CHEATS" BY INTEGER FACTORS, WE MUST ADMIT:

1) THE "FOURTH POINT" (THE PHASE TRANSITION RELATED ONE) HAD ITS $\frac{N_{gen}\, g^2_{NAV}}{\pi}$ JUST 3 TIMES AS BIG AS THE TRUE $\frac{g^2_{CRIT}}{\pi}$ (FROM TWO LOOP-BETA FUNCTIONS)

2) THE EXTRA $\frac{1}{2}$ PUT IN AS A FACTOR MULTIPLYING $\frac{1}{\alpha_{U(1)}}$. OUR EXCUSE IS THE "HEXAGONAL PATTERN"



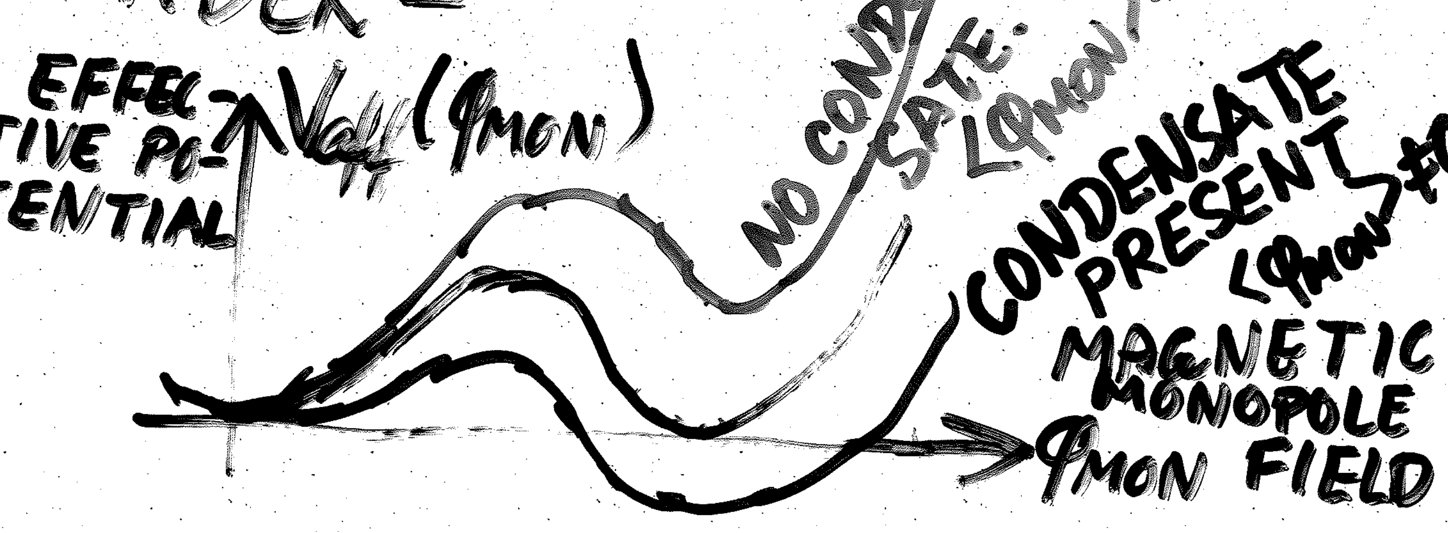
YOU ASSUME MONOPOLES WITH CHARGES COMBINED FROM SEVERAL (FAMILY-) U(1)'s.

rjyp 16?

THE PHASE DIAGRAM WERE ESTIMATED BY USING AN EFFECTIVE POTIAL

$$V_{eff}(\varphi_{MON}) = \Lambda + m^2_{RUN}(\varphi_{MON})|\varphi_{MON}|^2 + \frac{\lambda_{RUN}(\varphi_{MON})}{4}|\varphi_{MON}|^4$$

AND LOOKING FOR TWO DEGENERATE MINIMA – IT BEING THEN THE PHASE BORDER –



трн. 17.

REASONS WHY WE ARE VERY HAPPY FOR OUR "MULTIPLE POINT PRINCIPLE" SAYING MANY DEGENERATE VACUA:

1) WE GET A PROMISSING HIGGS MASS PREDICTION IN PURE STANDARD MODEL ALL THE WAY TO PLANCK SCALE:

$$m_{\text{HIGGS W.S.}} = 135\ \text{GeV}/c^2 \ \text{(STABILITY)}$$

$$m_{\text{HIGGS W.S.}} = 121\ \text{GeV}/c^2 \ \text{(META STABILITY)}$$

2) INVOLVING A BOUND STATE OF 6 TOP + 6 ANTI-TOP QUARKS WE GET $g_t = 1.35$ PREDICTION FOR THE TOP-YUKAWA, WHICH EXPERIMENTALLY IS 0.95.

3) WE "SOLVE" THE PROBLEM OF $\mu_{\text{PLANCK}} \gg m_{\text{HIGGS W.S.}}$ (ALMOST "HIERARCHY-PROBLEM") 4) θ-PROBLEM?

pppc. 1 pppk. 18

CONCLUSION

WE PLOTTED ONE POINT CORRESPONDING TO EACH OF THE THREE GROUPS U(1), SU(2), AND SU(3) IN THE S.M. INTO A PLOT WITH THE COORDINATES:

ABSCISSA d: A GROUPDEPENDENT PARAMETER PROPORTIONAL TO THE CONTRIBUTION TO THE BETA-FUNCTION β_{g^2} FOR THE MONOPOLE (MAGNETIC) CHARGE g COMMING FROM THE NONABELIANNESS COUPLING OF THE GAUGE PARTICLES TO EACH OTHER $\beta_{g^2}\Big|_{\text{FROM YANG MILLS}} \propto d$.

ORDINATE $\frac{N_{gen}\, g^2}{\pi}$: A QUANTITY RELATED BY SIMPLE FACTORS TO $\frac{1}{\alpha_i}$ THE INVERSE FINESTRUCTURE CONS pppc2 nnn19.

CONCLUSION CONTINUED:

FITTING THE THREE
POINTS CORRESPONDING
TO THE THREE STAN-
DARD MODEL GROUPS
U(1), SU(2), AND SU(3), BY
A PARABOLA IN THE
$\left(d, \frac{N_{gen}\, g^2}{\pi}\right)$-PLOT LEADS
TO THE PARABOLA PAS-
SING RATHER ACCURATE-
LY THROUGH "THE FOURTH
POINT", WHICH IS CALCU-
LATED (TO TWO LOOP) FROM
PHASE TRANSITION POINT
OF VIEW FOR A SCALAR
MONOPOLE (HIGGS ANALOGOUS)
FIELD. WE HAVE A NOT
SO COMPLICATED MODEL
BEHIND.

pypc.3. pppn 26

CONCLUSION YET CONTI-NUED:

OUR MODEL BEYOND STANDARD IS JUST STANDARD MODEL MUCH FURTHER THAN ALMOST ANYBODY ELSE'S MODEL:

- SEE-SAW SCALE PHYSICS SUPPOSED NOT MUCH DI-STURBING.
- IN OUR PHASE FURTHER THAN SEE-SAW RELATED
ONLY AT ABOUT A FAC-
TOR $\sqrt{40}$ BELOW THE
PLANCK SCALE: FAMILIES
OF ALSO GAUGE GROUPS.
- BUT LOGICALLY ADDED PRINCIPLE: MANY VACUA WITH SAME ENERGY DENSITY (COSMOLOGICAL C.)

ursc. 4. nyy 21.

GENERAL CONCLUSION:

AN OLD MODEL WITH $U(1) \times SU(2) \times SU(3) \subseteq U(1)^6 \times \times SU(2)^3 \times SU(3)^3 \subseteq$ "EVEN MORE COMPLICATED BUT NOT MODELLED" WHICH GAVE CRUDELY - OR IMPROVED BY SUSPICIOUS CORRECTIONS - ALL 3 FINE STRUCTURE CONSTANTS $\alpha_1, \alpha_2, \alpha_S$ IN AGREEMENT WITH EXPERIMENT, HAD A SINGLE RELATION EXTRACTED SO AS TO DELIVER A RATHER SIMPLE AND WELL-FITTING RELATION BETWEEN THE THREE FINESTRUCTURE CONSTANTS AT PLAN рис.5 стр.22

CONCLUSIONS ABOUT ADMISSIONS OF WEAKNESSES OF MODEL:

- THE PLANCK SCALE OF ENERGY MUST BE USED; OTHERWISE WE LOOSE A PARAMETER BEING PREDICTED.
- A SUSPICIOUS FACTOR $\frac{1}{2}$ PUT ON $\frac{1}{\alpha_1}$ (THE U(1) INVERSE FINESTRUCTURE CONSTANT). BUT WE HAVE A MODEL SUGGESTING THIS FACTOR 1/2.
- WE NEED THE STANDARD MODEL GAUGE GROUPS TRIPLED ($N_{gen}=3$) CLOSE TO THE PLANCK SCALE (e.g $\sqrt{40}$ BELOW): $U(1)\times SU(2)\times SU(3) \subseteq (U(1)\times SU(2)\times SU(3))^3$