4G MODEL OF FITTING RMS RADIUS OF PROTON

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3 Assumptions of 4G model of final unification

- **There exists a characteristic electroweak fermion of rest energy, M_{wf} = 584.725 GeV/c^2. It can be considered as the zygote of all elementary particles.**
- **There exists a strong interaction elementary charge (e_s) in such a way that, its squared ratio with normal elementary charge is close to reciprocal of the strong coupling constant.**
- **Each atomic interaction is associated with a characteristic gravitational coupling constant.**

Characteristic electroweak fermion

- **Mass ratio of pions and weak bosons is 0.0016.**
- **Same ratio can be applied to the mass ratio of proton and assumed electroweak fermion.**

$$k \cong \left[\frac{\sqrt{(m_\pi)^0 (m_\pi)^\pm}}{\sqrt{(m_z)^0 (m_w)^\pm}} \right] \cong 0.0016$$

$$\cong \left[\frac{m_p}{M_{wf}} \cong \frac{938.272 \text{ MeV}/c^2}{584.725 \text{ GeV}/c^2} \right]$$

Understanding TeV photons with 585 GeV charged electroweak fermions

- Considering the proposed electroweak fermion of rest energy, 585 GeV, astrophysical emission of TeV photons can be understood in 3 ways.

1. Annihilation of 585 GeV

2. Inverse Compton Scattering of 585 GeV

3. Synchrotron radiation of 585 GeV

➢ **Seshavatharam U. V. S, Gunavardhana Naidu T, Lakshminarayana S., AIP Conf. proceedings. (In press). ICAMSER-2021, Chitkara University, India.**

Logic behind large atomic gravitational constants

When mass of any elementary particle is extremely small/negligible compared to macroscopic bodies, highly curved microscopic space-time can be addressed with large gravitational constants and magnitude of elementary gravitational constant seems to increase with decreasing mass and increasing interaction range. Corresponding relations are:

$$G_x m_x^2 \approx \hbar c \qquad \frac{G_x m_x}{c^2} \approx \frac{\hbar}{m_x c}$$

Three atomic gravitational constants

- Gravitational constant associated with Electromagnetic Interaction

$$G_e \cong 2.374335 \times 10^{37}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$

- Gravitational constant associated with Strong Interaction

$$G_s \cong 3.329561 \times 10^{28}\text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$

- Gravitational constant associated with Weak Interaction

$$G_w \cong 2.909745 \times 10^{22}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$

Interaction range in 4G model

- Weak, strong and electromagnetic interaction ranges can be expressed as,

$$L_w \cong \frac{2G_w M_{wf}}{c^2} \cong 6.75 \times 10^{-19}\,\mathrm{m}$$

$$L_s \cong \frac{2G_s m_p}{c^2} \cong 1.24 \times 10^{-15}\,\mathrm{m}$$

$$L_e \cong \frac{2G_e m_e}{c^2} \cong 4.81 \times 10^{-10}\,\mathrm{m}$$

Three important results in 4G model

- **Newtonian Gravitational Constant**

$$G_N \cong \frac{G_w^{21} G_e^{10}}{G_s^{30}} \cong \frac{16\pi^4}{\alpha^2}\left(\frac{m_e}{m_p}\right)^{14}\left(\frac{\hbar c}{m_p^2}\right) \cong 6.679855 \times 10^{-11}\ \text{m}^3\text{kg}^{-1}\text{sec}^{-2}$$

- **Product of Reduced Planck's constant and speed of light**

$$\hbar c \cong G_w M_{wf}^2$$

- **Fermi's weak coupling constant**

$$G_F \cong G_w M_{wf}^2 R_w^2 \cong 1.4402105 \times 10^{-62}\ \text{J.m}^3$$

$$\text{where, } R_w \cong \left(2 G_w M_{wf} / c^2\right)$$

Strong coupling constant in 4G Model

- **Strong coupling constant can be defined as,**

$$\frac{e_s^2}{e^2} \cong \left(\frac{G_s m_p^3}{G_e m_e^3}\right) \cong \left(\frac{G_s m_p^2}{\hbar c}\right)^2 \cong \frac{1}{\alpha_s}$$

$$\frac{e}{e_s} \cong \left(\frac{\hbar c}{G_s m_p^2}\right) \cong \left(\frac{G_w M_{wf}^2}{G_s m_p^2}\right) \cong \sqrt{\alpha_s} \approx \frac{1}{3}$$

$$\alpha_s \cong 0.1151937,$$

$$e_s \cong 2.9463591 e \approx 3e$$

$$\frac{1}{\alpha_s} \cong \left(\frac{G_s^{10}}{G_e^4 G_w^6}\right) \cong 0.1152$$

Magnetic moment of Proton

- Considering the proposed strong nuclear charge, magnetic moment of proton can be expressed as,

$$\mu_p \cong \frac{e_s \hbar}{2m_p} \cong \frac{eG_s m_p}{2c} \cong 1.49 \times 10^{-26} \text{ J/Tesla}$$

- Experimental value is 1.41×10^{-26} J/Tesla

Magnetic moment of Electron

- Considering the proposed strong nuclear charge, magnetic moment of proton can be expressed as,

$$\mu_e \cong \frac{e\hbar}{2m_e} \cong \sqrt{\left(\frac{eG_s m_p}{2c}\right)\left(\frac{eG_e m_e}{2c}\right)}$$

$$\cong 9.27\times 10^{-24}\ \text{J/Tesla}$$

Proton-Neutron stability relation

- **Current nuclear stability relation**

$$Z \cong \frac{A}{2.0 + \left(a_c / 2a_a\right) A^{2/3}} \cong \frac{A}{2.0 + 0.0153 A^{2/3}}$$

$$\text{where } a_c \approx 0.71 \text{ MeV and } a_a \approx 23.2 \text{ MeV}$$

- **Proposed relation**

$$A_s \cong 2Z + k\left(2Z\right)^2 \cong 2Z + 0.0064Z^2$$

$$\text{Let, } kx^2 + x - A_s \cong 0, \quad \text{where } x = 2Z$$

$$k = \left(\frac{e_s}{m_p}\right) \div \left(\frac{e}{m_e}\right) \cong \frac{G_s m_p m_e}{\hbar c} \cong 0.001605$$

4 Term nuclear binding energy relation

- **Four term single energy formula for Z=3 to 120 and N>=Z,**

$$BE \cong \left\{ A - \left[1 + \left(0.0016 \left(\frac{Z^2 + A^2}{2} \right) \right) \right] - A^{1/3} - \frac{\left(A_s - A \right)^2}{A_s} \right\} \left(10.1 \text{ MeV} \right)$$

- **Binding energy coefficient**

$$\frac{1}{2} \left[\left(2m_u c^2 + m_d c^2 \right) + \left(m_u c^2 + 2m_d c^2 \right) \right] \cong 10.1 \text{ MeV}$$

where $\left(m_u , m_d \right)$ reprsent Up and Down quark masses

Binding energy coefficient

- **Binding energy coefficient can be expressed as follows:**

$$\text{Let}, B_0 \cong -\frac{1}{\alpha_s}\left(\frac{e^2}{4\pi\varepsilon_0 R_0}\right) \cong -\left(\frac{e_s^2}{4\pi\varepsilon_0 R_0}\right) \cong 10.08 \text{ MeV}$$

$$\text{where, } \alpha_s \cong 0.1152 \text{ and } \mathrm{R}_0 \cong 1.24 \text{ fermi}$$

$$\left\{\frac{1}{\alpha_s} \cong \left(\frac{e_s}{e}\right)^2 \cong \left(\frac{G_s m_p^2}{\hbar c}\right)^2, \; R_0 \cong \frac{2G_s m_p}{c^2} \cong 1.24 \text{ fermi}\right\}$$

$$\therefore B_0 \cong -\frac{1}{2}\left(\frac{e e_s}{4\pi\varepsilon_0 \hbar c}\right)\left(m_p c^2\right)$$

$$\cong -\frac{1}{2}\sqrt{\left(\frac{e^2}{4\pi\varepsilon_0 \hbar c}\right)\left(\frac{e_s^2}{4\pi\varepsilon_0 \hbar c}\right)}\left(m_p c^2\right) \cong 10.09 \text{ MeV}$$

Nuclear energy potential

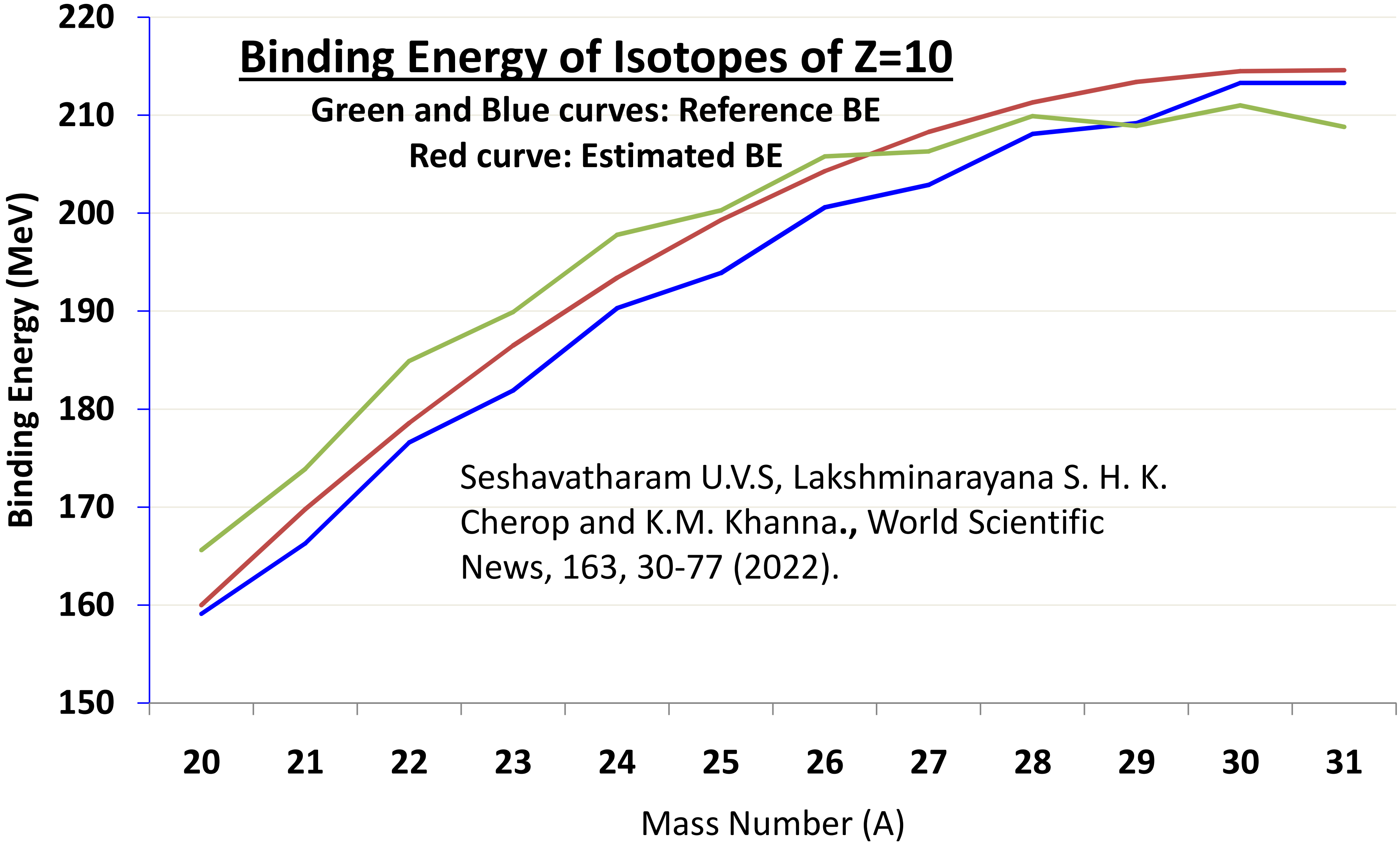
- Based on proposed strong nuclear charge, nuclear potential energy can be,

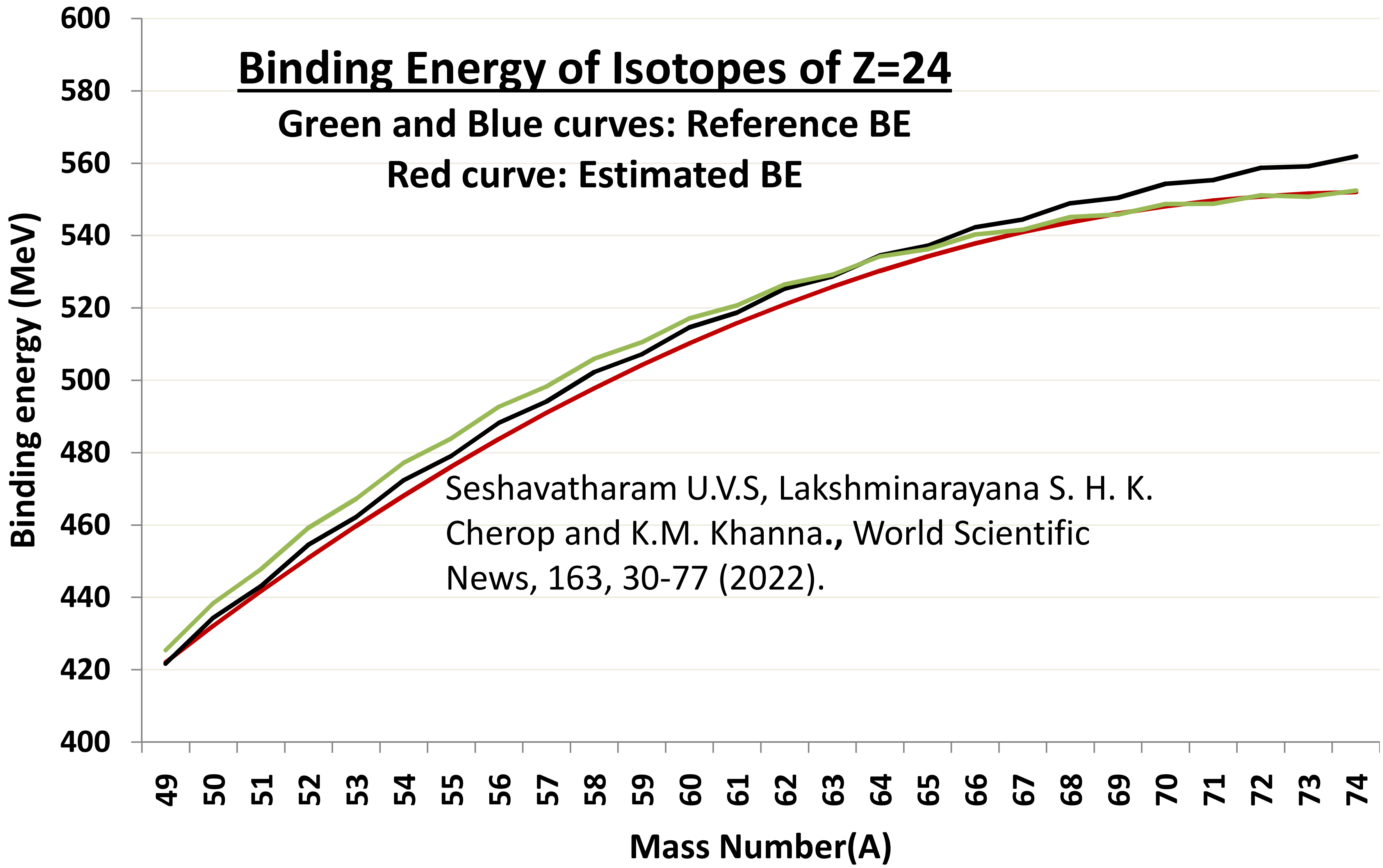
$$P.E \cong -\sqrt{\left(\frac{e_s^2}{4\pi\varepsilon_0\left(\hbar/m_p c\right)}\right)\left(\frac{e^2}{4\pi\varepsilon_0\left(\hbar/m_p c\right)}\right)} \cong -20.2 \text{ MeV}$$

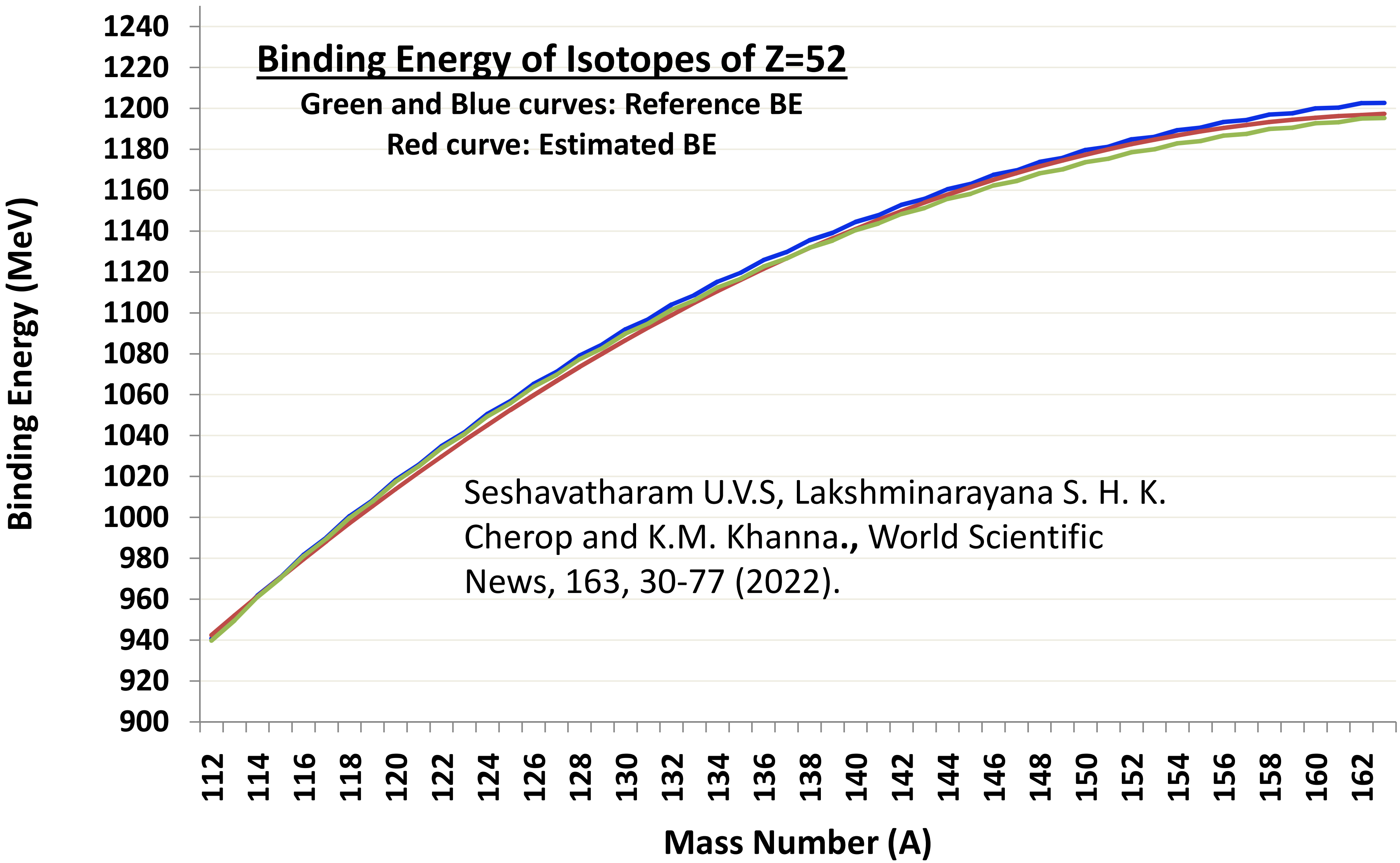
- Nuclear kinetic energy can be,

$$K.E \cong \frac{1}{2}\sqrt{\left(\frac{e_s^2}{4\pi\varepsilon_0\left(\hbar/m_p c\right)}\right)\left(\frac{e^2}{4\pi\varepsilon_0\left(\hbar/m_p c\right)}\right)}$$

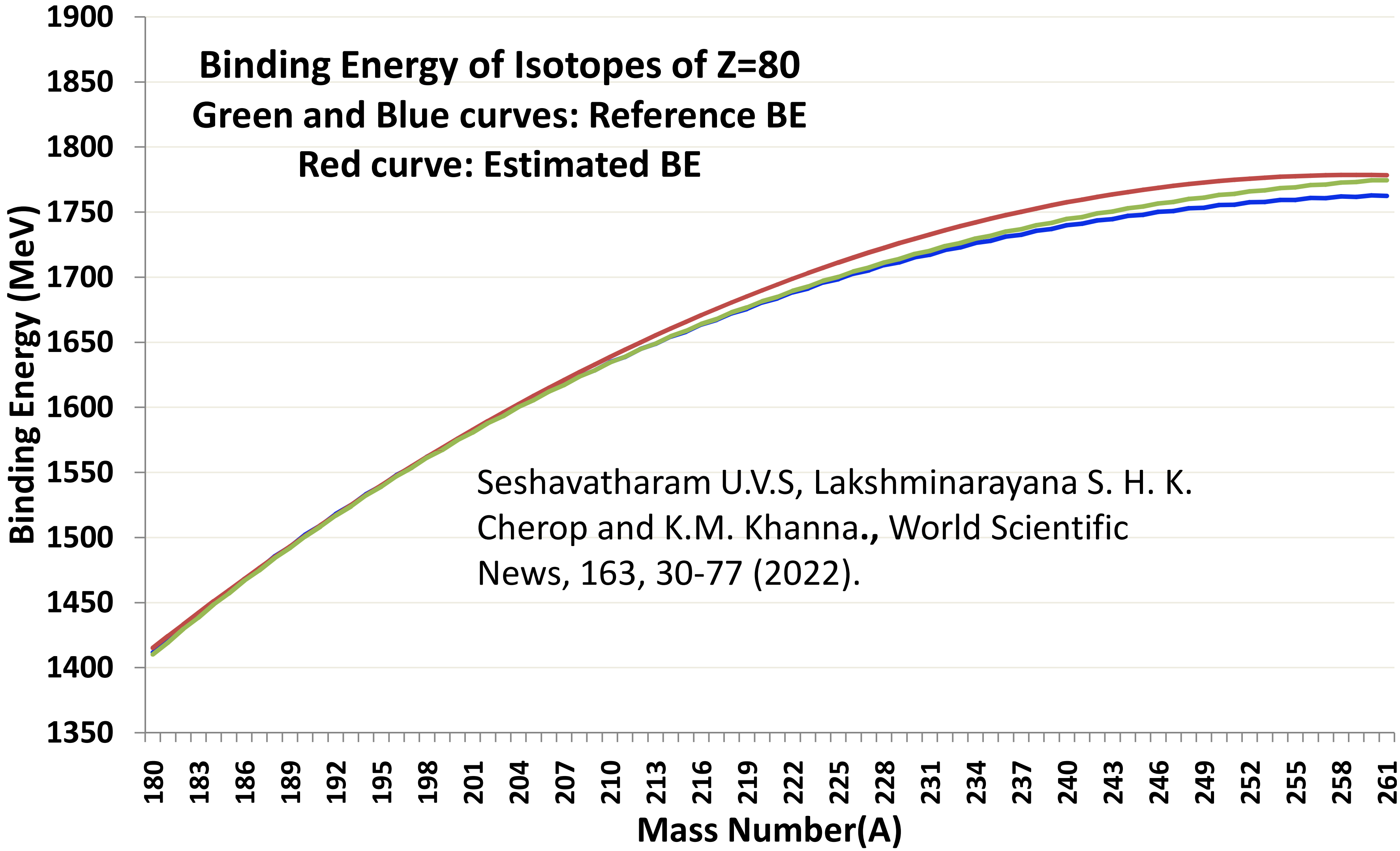
- Total energy can be, $T.E \cong -\sqrt{\left(\frac{e_s^2}{8\pi\varepsilon_0\left(\hbar/m_p c\right)}\right)\left(\frac{e^2}{8\pi\varepsilon_0\left(\hbar/m_p c\right)}\right)} \cong 10.1 \text{ MeV}$

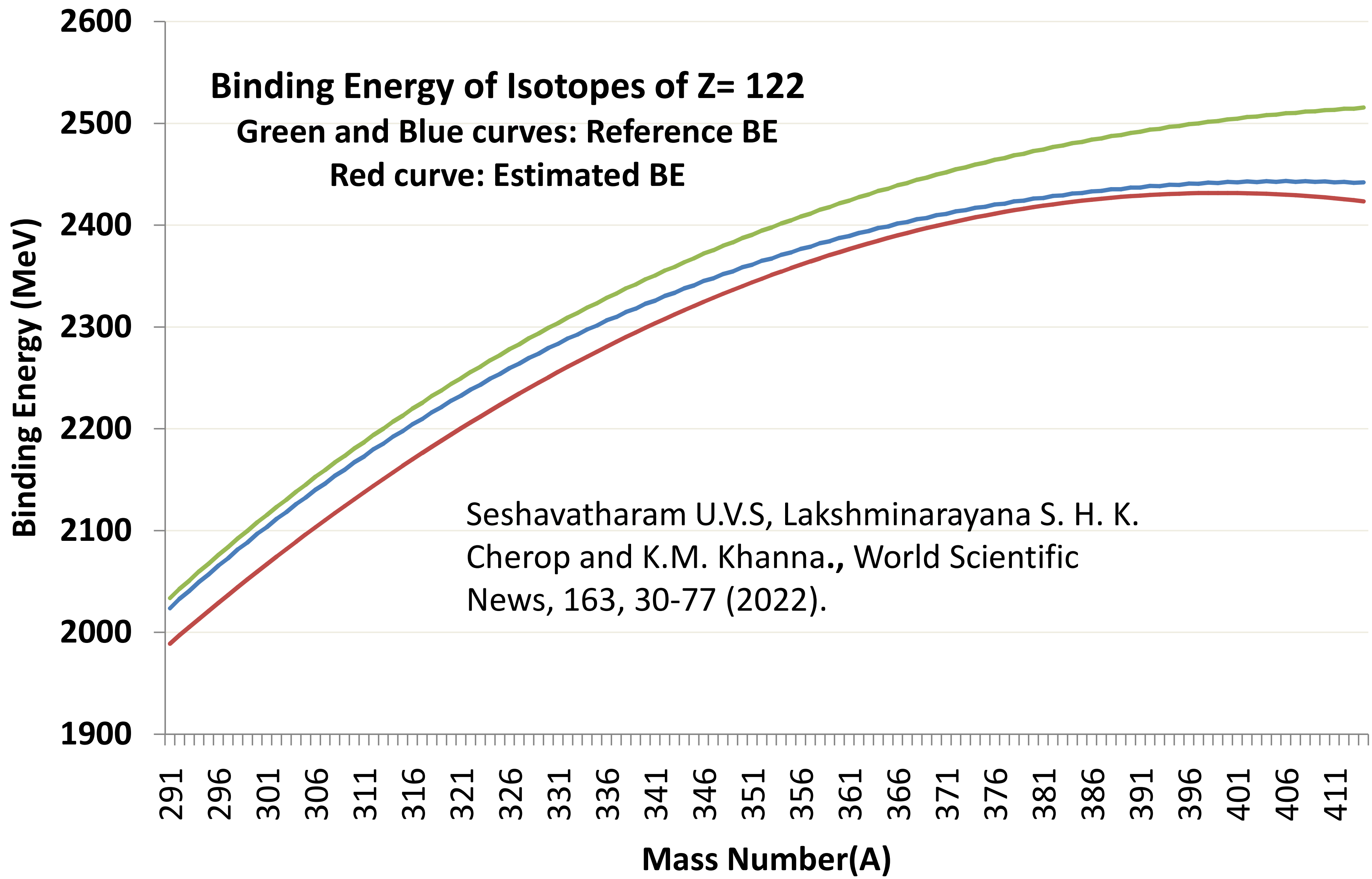

Binding Energy of Isotopes of Z=10
Green and Blue curves: Reference BE
Red curve: Estimated BE
Seshavatharam U.V.S, Lakshminarayana S. H. K.
Cherop and K.M. Khanna., World Scientific
News, 163, 30-77 (2022).
Binding Energy (MeV)
220
210
200
190
180
170
160
150
20
21
22
23
24
25
26
27
28
29
30
31
Mass Number (A)


Binding Energy of Isotopes of Z=24
Green and Blue curves: Reference BE
Red curve: Estimated BE
Seshavatharam U.V.S, Lakshminarayana S. H. K.
Cherop and K.M. Khanna., World Scientific
News, 163, 30-77 (2022).
Binding energy (MeV)
600
580
560
540
520
500
480
460
440
420
400
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
Mass Number(A)



Binding Energy of Isotopes of Z=52
Green and Blue curves: Reference BE
Red curve: Estimated BE
Seshavatharam U.V.S, Lakshminarayana S. H. K.
Cherop and K.M. Khanna., World Scientific
News, 163, 30-77 (2022).
Binding Energy (MeV)
Mass Number (A)
1240
1220
1200
1180
1160
1140
1120
1100
1080
1060
1040
1020
1000
980
960
940
920
900
112
114
116
118
120
122
124
126
128
130
132
134
136
138
140
142
144
146
148
150
152
154
156
158
160
162


Binding Energy of Isotopes of Z=80
Green and Blue curves: Reference BE
Red curve: Estimated BE
Seshavatharam U.V.S, Lakshminarayana S. H. K.
Cherop and K.M. Khanna., World Scientific
News, 163, 30-77 (2022).
Binding Energy (MeV)
1900
1850
1800
1750
1700
1650
1600
1550
1500
1450
1400
1350
180
183
186
189
192
195
198
201
204
207
210
213
216
219
222
225
228
231
234
237
240
243
246
249
252
255
258
261
Mass Number(A)


Binding Energy of Isotopes of Z= 122
Green and Blue curves: Reference BE
Red curve: Estimated BE
Seshavatharam U.V.S, Lakshminarayana S. H. K.
Cherop and K.M. Khanna., World Scientific
News, 163, 30-77 (2022).
Binding Energy (MeV)
2600
2500
2400
2300
2200
2100
2000
1900
291
296
301
306
311
316
321
326
331
336
341
346
351
356
361
366
371
376
381
386
391
396
401
406
411
Mass Number(A)

5 Term nuclear binding energy relation

- **Five term formula for Z>=3 and N<Z,**

$$BE \cong \left\{ \begin{array}{c} A - \left[1 + \left(0.0016 \left(\dfrac{Z^2 + A^2}{2} \right) \right) \right] - A^{1/3} \\ -\dfrac{\left(A_s - A\right)^2}{A_s} - \overline{\left(\dfrac{N\left(Z - N\right)}{A} \right)} \end{array} \right\} \left(10.1\ \mathrm{MeV}\right)$$

- We are working in this direction.

Nuclear charge radii

- Medium and heavy nuclear charge radii can be understood with the simple relation.

$$R_{(Z.N)} \cong \left(Z^{\frac{1}{3}} + \left(\sqrt{ZN}\right)^{\frac{1}{3}} \right) \left[\frac{G_s m_p}{c^2} \cong 0.62 \text{ fm} \right]$$

- **Reference Relation**

$$R_{(Z.N)} \cong \left\{ 1 + \left[0.015 \frac{\left(N - \left(N/Z\right)\right)}{Z} \right] \right\} Z^{\frac{1}{3}} \times 1.245 \text{ fm}$$

Root mean square radius of proton

- Root mean square radius of proton can be fitted with,

$$\hbar \cong \left[\left(\frac{e_s^2}{4\pi\varepsilon_0 c}\right)\left(m_p R_p c\right)^2\right]^{\frac{1}{3}}$$

$$R_p \cong \sqrt{\left(\frac{4\pi\varepsilon_0\hbar^2}{e_s^2 m_p}\right)\left(\frac{\hbar}{m_p c}\right)} \cong \sqrt{\frac{4\pi\varepsilon_0\hbar^3}{e_s^2 m_p^2 c}} \cong \sqrt{\frac{\alpha_s}{\alpha}}\left(\frac{\hbar}{m_p c}\right) \cong 0.835 \text{ fm}$$

Conclusion

- It seems possible to study nuclear physics with 4G model in a unified approach.
- TeV photons coming from astrophysical objects can be studied with 585 GeV weak fermion.
- Characteristic astrophysical mass limits can be estimated with 4G model.
- Quark charge can be studied with strong nuclear charge.
- There is a scope for understanding nuclear binding energy with strong and weak interactions.
- Root mean square radius of proton can be studied in a unified manner.

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Thank you for your kind attention

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