On a Singular Solution in Higgs Field (6)

- A long time behavior of the candidate for dark energy

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Contents

We have recently discussed the calculated mass correction for SM Higgs boson (H^0), and also the degenerates into a candidate of dark matter and dark energy from ur-Higgs boson (ur-H^0) and excited ur-H^0 respectively

In this talk, we'll review and discuss with;

1. Short review

- Corrected Higgs mass (125.28 GeV/c^2) formula for the excited states, and its multiwall-fullerene representation of glueballs, having ρ mesons inside, as an excited state of ur-H^0

- Almost of ur-H^0 degenerate into the hybrid molecules of a glueball and pseudo-scalar mesons as a candidate of dark matter; and the excited ur-H^0 degenerate into the quasi-crystals of fullerene consists of σ mesons and some ω mesons, as the candidate of dark energy

2. A long time behavior of the candidate for dark energy

- Gradual disruption of dark energy of almost non-mass fullerene into smaller ones consist of several σ mesons by collisions

- The working force to expand the volume of universe is thought to be the result of these fullerenes' mutual repulsive strong force between respective ω mesons

- The observed accelerating expansion of the universe would be explained with the scale factor (a) in Robertson-Walker metric by describing a long time disruption-behavior

- The accelerating expansion will continue until number of ω meson in the disrupted fullerene becomes around one or zero; then the expansion slows down and at last the contraction of universe begins after equilibrium by central gravity

- A certain decay route into dark energy from dark matter

== Short review ==

- corrected Higgs mass formula with the respective mesons' masses of excited states: (K.K: BORMIO 2013)

$$M_{(\mathrm{H}^0)^*} \equiv \sum_{M_i} \left[3\chi_{c^0}(1\mathrm{p}),\ \rho_3(1990)\overline{\rho_3}(1990) + 4\left\{ \left(B_S{}^* \overline{B}_S{}^* \right) \left(B_C{}^* \overline{B}_C{}^* \right) \left(D_S{}^{*+} D_S{}^{*-} \right) \right\} \right]$$

$$\cong 125.28\ \mathrm{GeV/c^2}.$$

- Its multiwall-fullerene representation of glueballs, having ρ mesons inside, as an excited state of the ur-H^0

$$M_{(\mathrm{H}^0)^*} \equiv \sum_{M_i} \left[40 \times \mathrm{f}_6(3100) \right] \cong \sum_{M_i} \left[6 \times \left\{ \left(\mathrm{GB}_{40} \right) + \rho(770) \right\} \right]$$

$$= \sum_{M_i} \left[6 \times \left(\mathrm{GB}_{40} \right) + 3\rho(770)\overline{\rho}(770) \right].$$

- Higgs mass **originally** derived from an asymptotic solution in Higgs field and its mass formula by mesons' masses of truncated-octahedron

(K.K: TAMJ 57(2009) 217; 58(2010) 61)

Higgs Mass Formula

$$\varphi \sim \varepsilon^2 v,\ (\ \varepsilon \to 0) : \text{Asymptotic singular solution}$$

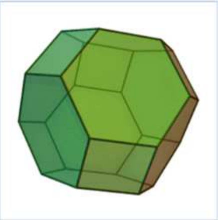
Thus from EOM, **Higgs field mass formula** is

$$\varphi(\varepsilon_\lambda) = 0,$$

$$m_\varphi^{\ 2} = 2\left\{\left(\sqrt{W_\mu^{\ +} W^{-\mu}}\right)^2 \Big/ (2\varepsilon_\lambda/g)^2\right\} + \left\{(Z_\mu)^2 \Big/ (2\varepsilon_\lambda/G)^2\right\},$$

where $\varepsilon_\lambda \equiv \varepsilon$, infinitesimal Grassmann number

$$\mathrm{M}_{\mathrm{H}^0} = \frac{2M_W}{\sqrt{1+\cos^2\theta_W}} = \frac{2M_W M_Z}{\sqrt{M_W^{\ 2} + M_Z^{\ 2}}} = 120.611\ \ \mathrm{GeV/c^2}$$

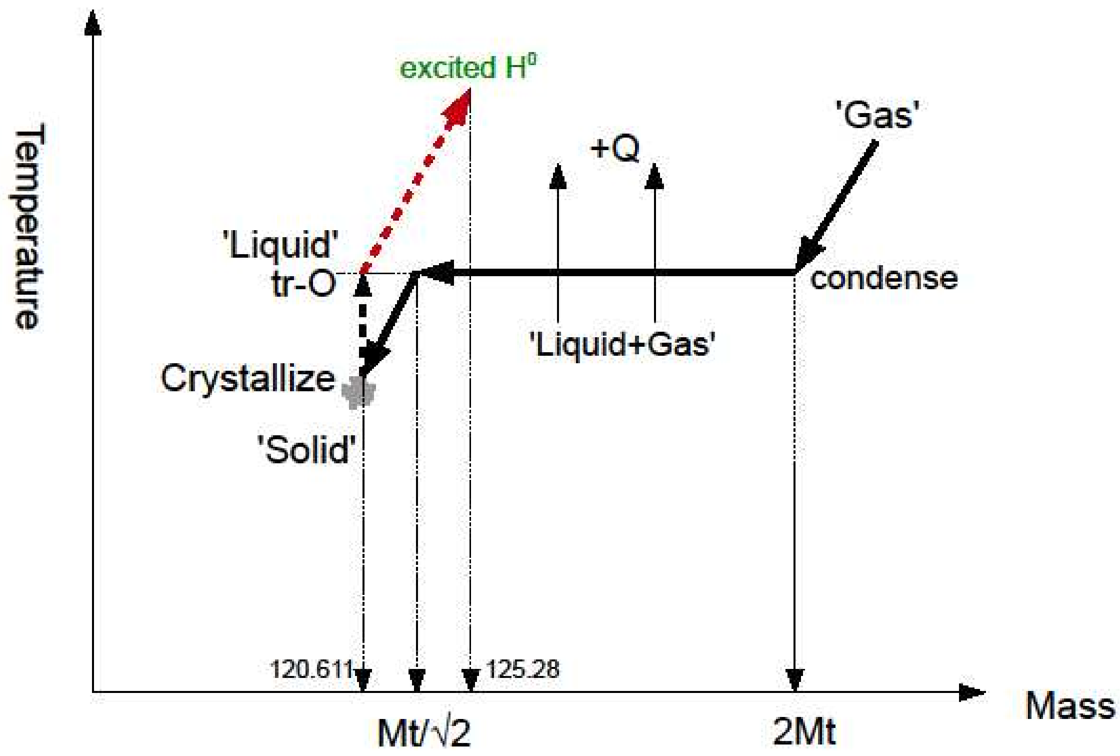


truncated-Octahedron (tr-O)

$$M_{\mathrm{H}^0}(3\eta_{c,\dots(\text{exper. values})}) \equiv \sum_{M_i}\left[3\eta_c,\ 10\pi^+\pi^- + \underline{4\left\{\left(B_S^{\ 0}\overline{B}_S^{\ 0}\right)\left(B_C^{\ +}B_C^{\ -}\right)\left(D_S^{\ +}D_S^{\ -}\right)\right\}}\right]$$

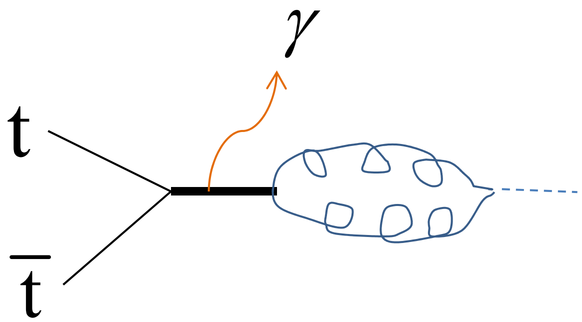
Phase transition diagram -- from (tt_bar)* to Higgs boson

K.K: JPSA 3 (2013) 114

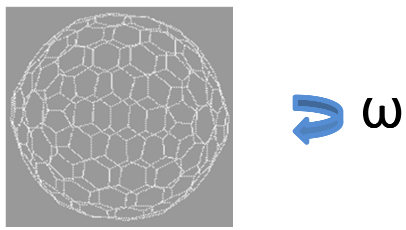


- Degenerate into the candidate of dark matter

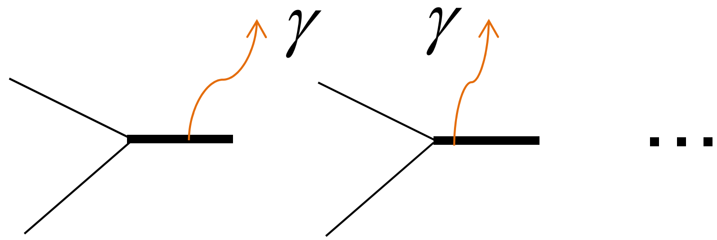
Only ($1/N_e$) of these ur-Higgs bosons can be transformed finally to the H^0 with corrected mass (125.28 GeV/c^2) through multi-photon resonances of its component by irradiated γ-rays from neighbors.



$$\sum_{i=1}^{240} (\mathrm{GB})_i - \textit{fullerene}: \ \text{ur-H}^0$$

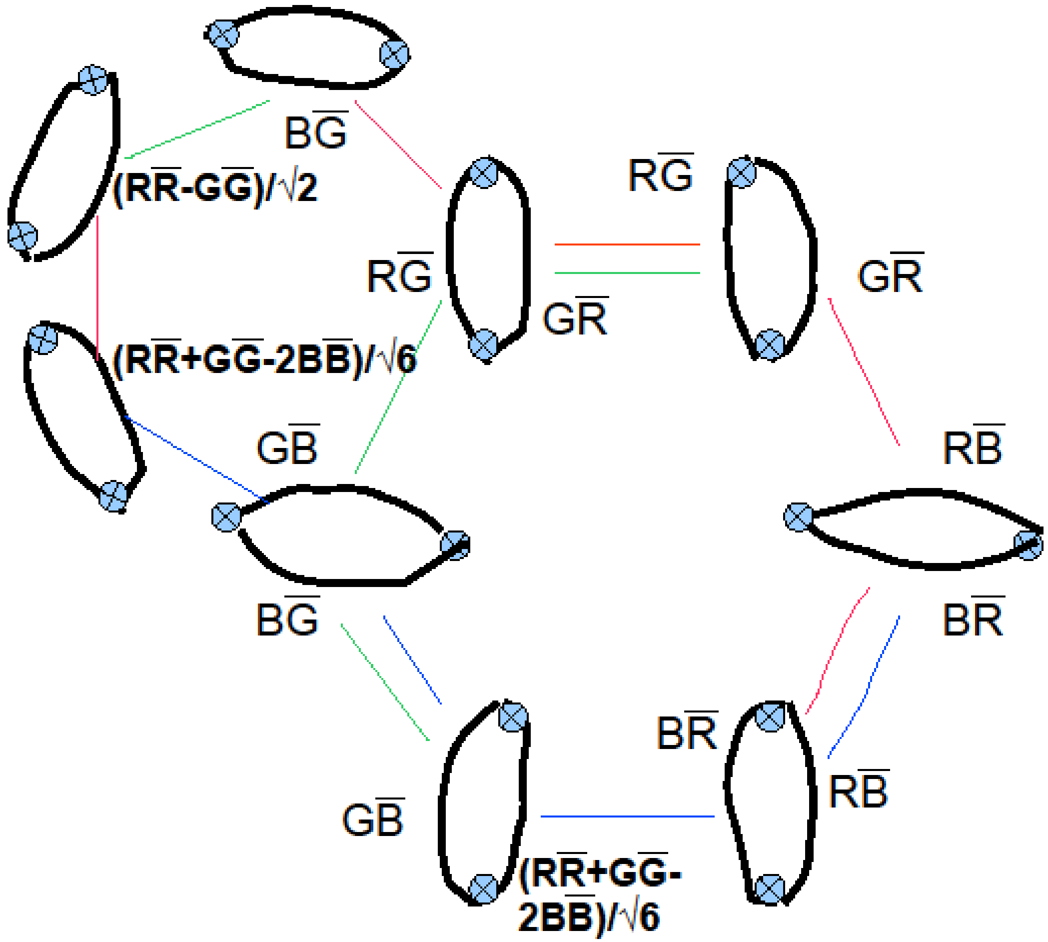


$$N_e = \Delta m \bullet c^2 / E_\gamma = 9.483$$



A hexagon and a pentagon on GB_{240} (= ur-Higgs)

Each glueball feels the color of neighbor glueball, and is supposed to have color valence of 4 (four).

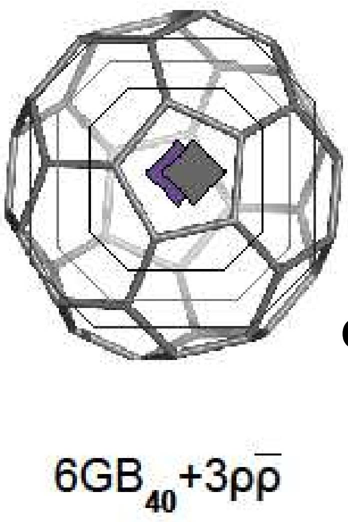


- Degenerate into the candidate of dark energy

(K.K: EPS HEP 2013)

excited ur-H^0 of multi-wall | developed fullerene

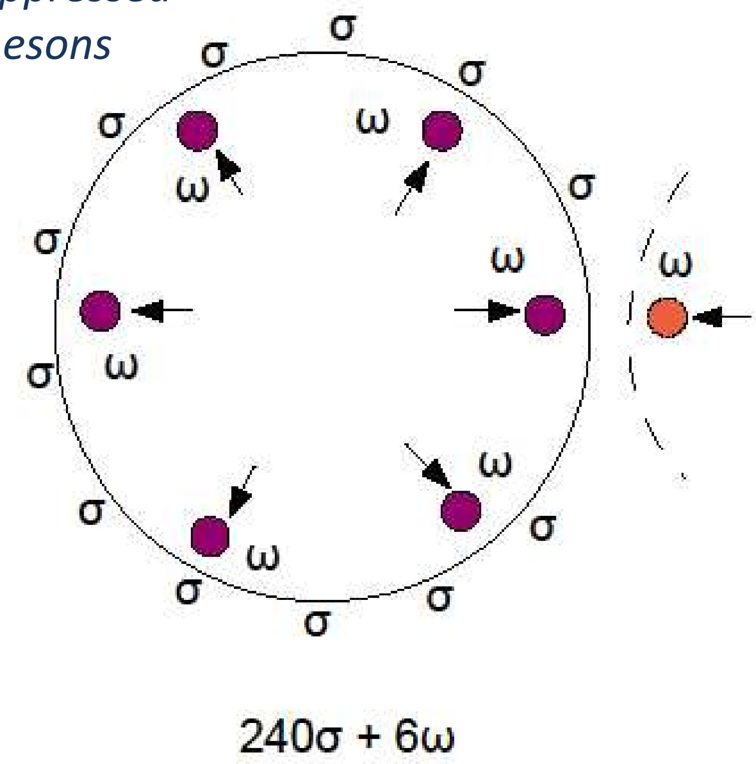
$\rho \rightarrow \pi^+\pi^-$ / e^+e^- decays will be suppressed by the outer-walls made of σ mesons



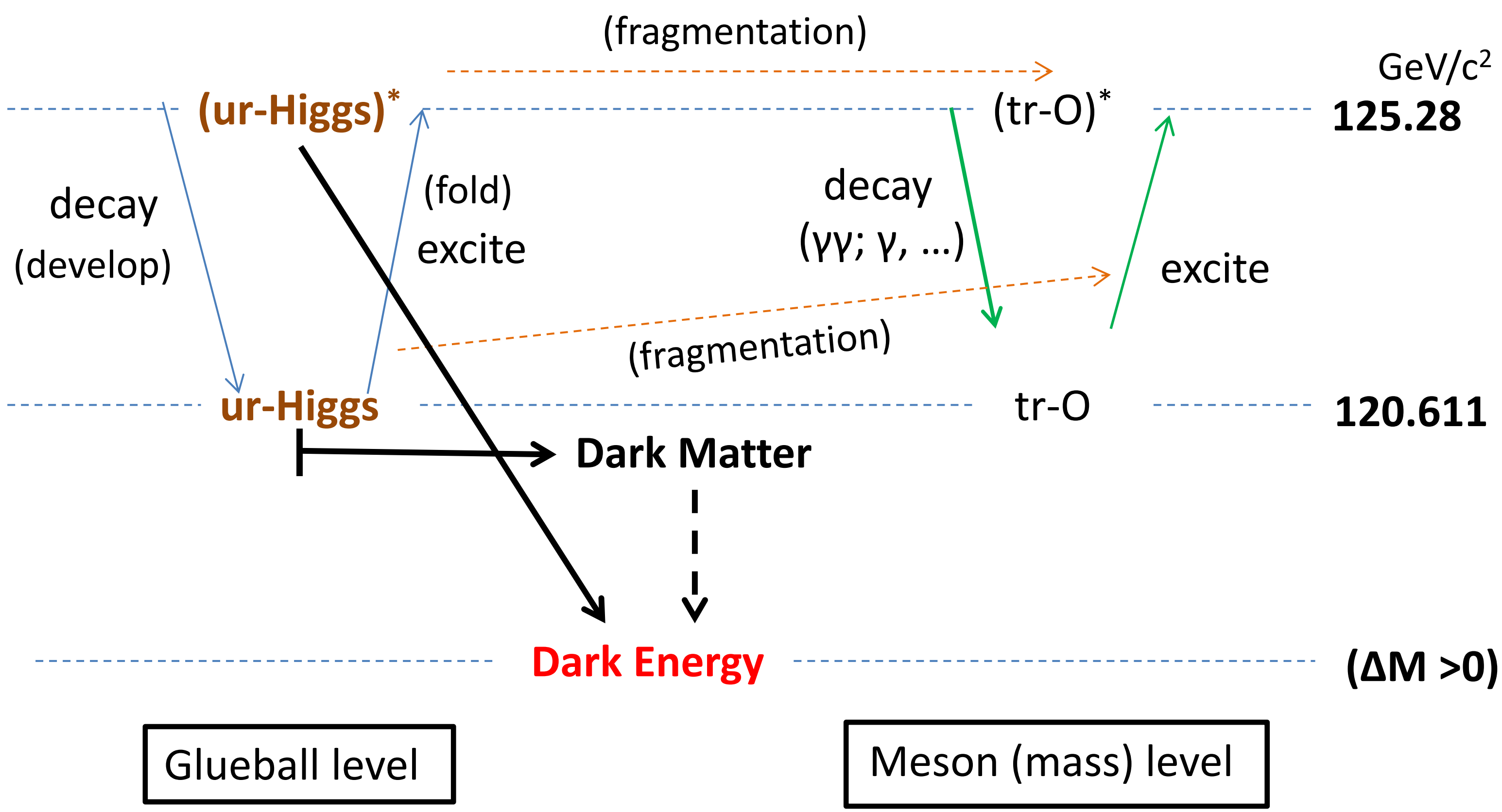
ρ→ω

(develop)

GB ⇒ σ meson



Overview of degenerate ur-Higgs



The content ratios

Although all rates of the candidates are obtained now, more over, we should refine these values as follows.

In order to take account of mass contribution from QGP, such as *totally equivalent* top quark, we re-calculate the rate of Atom;

$$R_{(\mathrm{Atom})} \cong R_{(\mathrm{Atom})}{}' \times \frac{M_{\mathrm{t}} + \left\{ M_b + M_c + M_s + n^* (gluon) \right\}}{M_{\mathrm{t}}}$$

$$\cong 0.03728 \times \frac{171.266 + \left\{ 4.65 + 1.275 + 0.095 + 137.036 \times \left(0.50255/2 \right) \right\}}{171.266}$$

$$= 0.04609, \quad \text{where we put } n^* \equiv 1/\alpha.$$

$$R_{(\mathrm{DM})} \equiv R_{(\mathrm{DM})}{}' = 0.2357,$$

$$\therefore \; R_{(\text{dark energy})} = 1 - \left(R_{(\mathrm{Atom})} + R_{(\mathrm{DM})} \right) = 0.7182$$

all of which are completely in accordance with the result of WMAP (9 Years).

Comparison to observations

- WMAP: content of matter, dark matter and dark energy

	Atom	Dark Matter	Dark Energy
WMAP (9 Years)	0.0463 ± 0.0024	0.233 ± 0.023	**0.721 ± 0.025**
This calculation	0.04609	0.2357	**0.7182**

- **Fermi-LAT: mass of dark matter**

Fermi-LAT	This calculation	
$129.8 \pm 2.4^{+7}_{-13}$	≈ 120.611	GeV/c^2

And … **- CDMS-II WIMP mass:** **8.6** GeV/c^2

$14 \times (\text{WIMP mass}) \cong$ This calc. (**120.611**; possible ancestor of ***the WIMP mass***)

2. A long time behavior of the candidate for dark energy

Finite nucleus by mean-field theory of σ-ω model

$$\sigma = \sigma(r), \quad \omega_\mu = \delta_{\mu,0}\omega(\mathrm{r})$$

By inserting into Dirac equation.

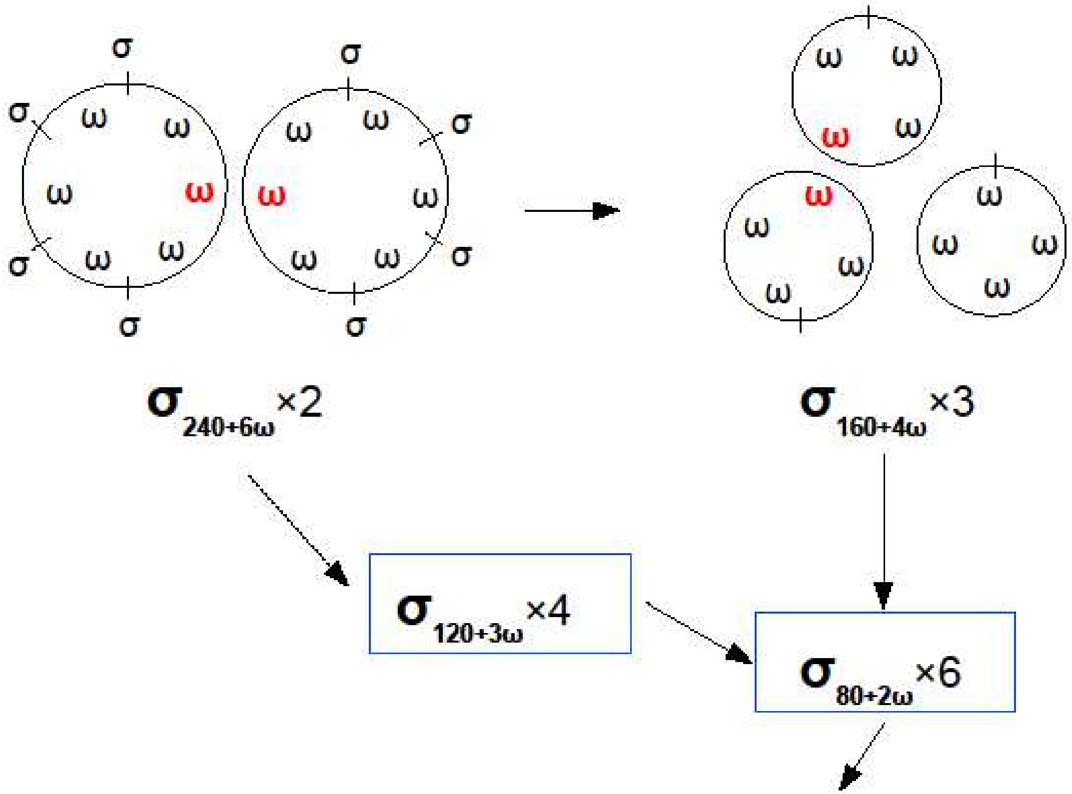
$$\left(i\gamma_\mu \partial^\mu - m - U(r) - \gamma^0 V(r)\right)\psi(x) = 0,$$

$$\text{where} \quad U(r) \equiv g_\sigma \sigma(r), \; V(r) \equiv g_\omega \omega(r).$$

We shall regard the developed fullerene as a finite nucleus of the limit of N(p, n)→0, namely, m(p, n)→0.

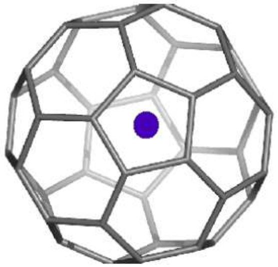
Because the masses of degenerate fullerenes are thus to be some ultimately small effective mass which has been reduced by σ-potential, the removing speed by the repulsive force between their ω mesons would not be so small, overcoming the attractive force by σ mesons, after approaching very near each other.

- Gradual disruption of dark energy of almost non-mass fullerene into smaller ones consist of several σ mesons with some ω mesons by collisions

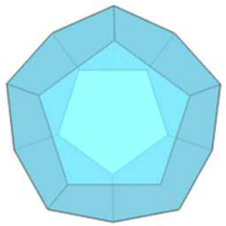


$\sigma_{40+\omega} \times 12$

$\sigma_{20} \times 24 + 12\omega$

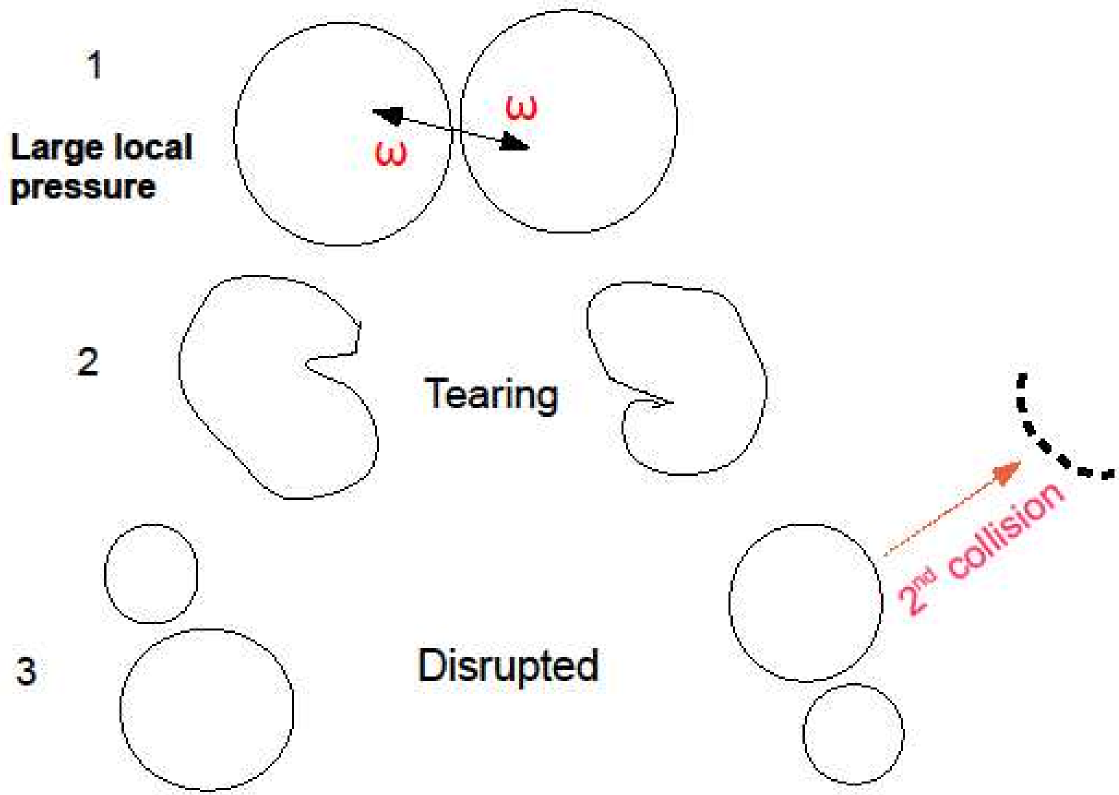


$\sigma_{40+\omega}$



regular dodecahedron

A disruption figure like ‘soap bubble’ of the candidate for dark energy



The rate of the candidate of dark energy

The rate of dark energy per unit volume of the universe is to be expressed as

$$R = \Sigma \cdot \Phi,$$

where $\Sigma \equiv N\sigma$: the macroscopic cross section,

Φ : the flux of the dark energy,

N : the density of the target dark energy,

σ : the microscopic cross section.

So it is needed **at least to keep the expansion of universe** that ***NΦ>0***.
Moreover for **accelerating expansion**, ***dR/dt=d(NσΦ)/dt >0*** is needed.

The respective acceleration expression by force balance

$$M^{*}\alpha = \left(f_{\omega} + f_{\sigma}\right) + f_{G},$$

where $\left(f_{\omega} + f_{\sigma}\right) = -\partial V_{\omega,\sigma}\left(r\right) / \partial r$

$$= -\frac{\partial}{\partial r}\left\{\frac{\pi}{4}\left({g_{\omega}}^{2}\frac{e^{-m_{\omega}r}}{r} - {g_{\sigma}}^{2}\frac{e^{-m_{\sigma}r}}{r}\right)\right\}$$

$$= \frac{\pi}{4r} \left\{ \frac{1}{r} \left(g_{\omega}{}^{2} e^{-m_{\omega} r} - g_{\sigma}{}^{2} e^{-m_{\sigma} r} \right) + \left(m_{\omega} g_{\omega}{}^{2} e^{-m_{\omega} r} - m_{\sigma} g_{\sigma}{}^{2} e^{-m_{\sigma} r} \right) \right\},$$

M^{*} : effective mass for respective dark energies,

$m_{\omega,\sigma}$: mass of ω-, σ-meson,

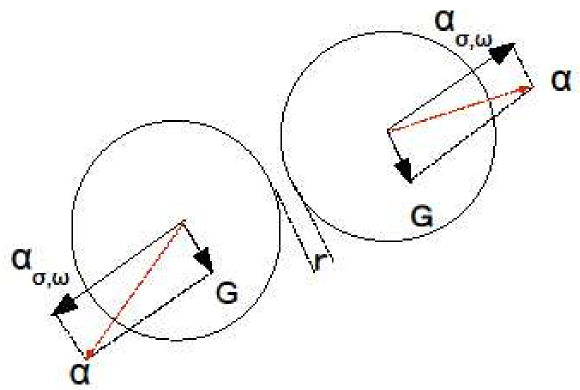
α : acceleration of respective dark energies,

$f_{\omega}, f_{\sigma}, f_{G}$: forces from ω mesons, σ meson and central gravity,

$V_{\omega,\sigma}$: potentials from ω-, σ-meson,

$g_{\omega,\sigma}{}^{2} / 4\pi$: ω-, σ-meson coupling constant of fundamental interaction,

r : distance between respective mesons.



Although at the early time the outgoing acceleration would have been apt to cancel between dark energies, the expansion might have gradually begun at the point far from the center of the universe.

Where the effective mass of a candidate for dark energy of fullerene could be approximately estimated by taking a limit for the nucleon density in a known formula of nuclear matter:

$$M^* \equiv M + U_s = M - 4\frac{g_\sigma{}^2}{m_\sigma{}^2}\int_0^{k_F}\frac{d^3k}{(2\pi)^3}\frac{M^*}{\sqrt{M^{*2}+\mathbf{k}^2}}$$

$$\cong \lim_{\rho_N \to 0}\left\{M - \frac{g_\sigma{}^2}{m_\sigma{}^2}\rho_N\left(1 - \frac{3}{10}\frac{k_F{}^2}{M^2}\right)\right\}$$

$$= \Delta M > 0.$$

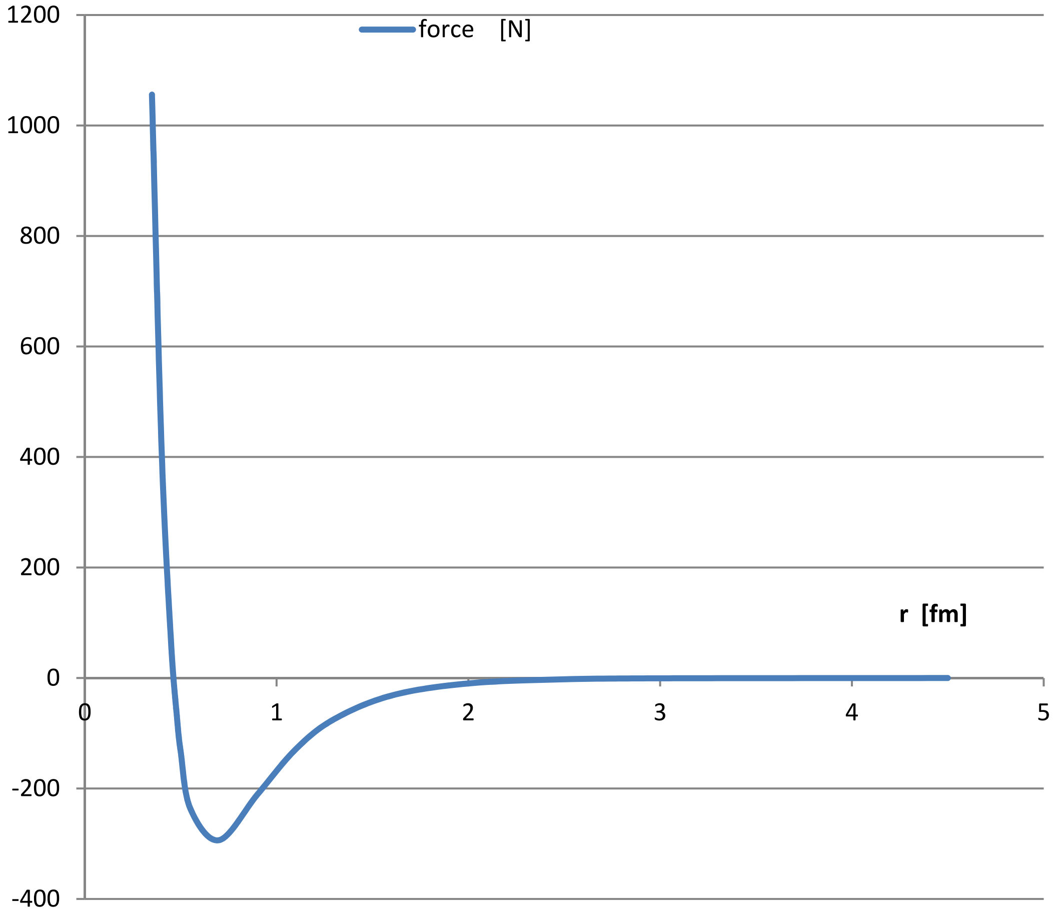
M : mass of nucleon

U_s : potential energy of σ meson

k_F : Fermi wave number

ρ_N : density of nucleon

The force between the *young* dark energies at short distance (computed by σ-ω model)



- The working force to expand the volume of universe is thought to be the result of these fullerenes' mutual repulsive strong force between respective ω mesons.

  The ω mesons are mutually repulsive not only in their fullerenes but also with intercalated ω mesons of another fullerenes.

- The observed accelerating expansion of the universe would be explained with the scale factor (*a*) in Robertson-Walker metric by describing a long time disruption-behavior:

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\left(\rho + 3P\right),$$

  So when (ρ+3P) < 0, i.e., P < -ρ/3, the universe is in the accelerating expansion, whose minus pressure is produced by a lot of *newly* outgoing fullerenes under repulsive force.

  And,

- The accelerating expansion will continue until number of ω meson in the disrupted fullerene becomes around one or zero; then the expansion slows down and at last the contraction of universe begins after equilibrium by central gravity which may feel effective mass (M^*) from σ potential, with some quasi-static clustering of the disrupted fullerenes under attractive force between their σ mesons.

Let *dn(t)* as the infinitesimal number of *active* (outgoing or repulsive) dark energies against *da(t)* of the universe, then

$$dn(t) \propto \left\{ n(t) / a^3(t) \right\} da(t) \quad \therefore\ n(t) = n_0 \exp\left[\left\{ 1/a_0{}^2 - 1/a^2(t) \right\} / 2 \right],$$

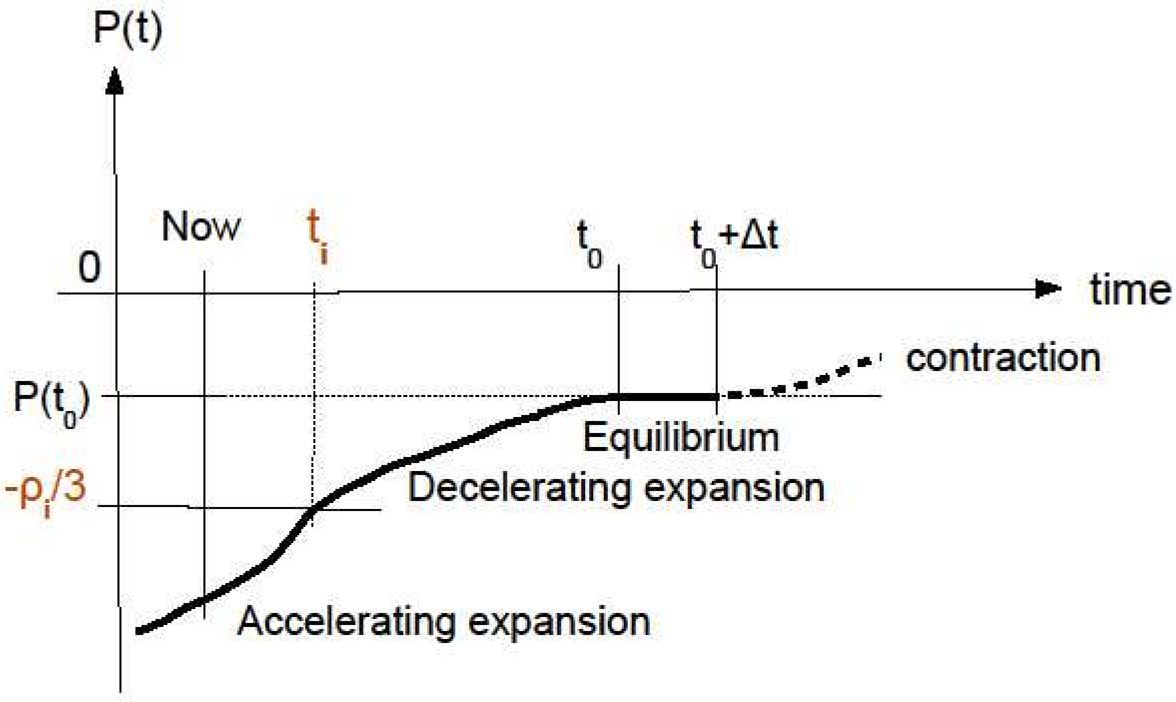
where n_0, a_0 : at equilibrium of $t = t_0 >> 1$

On the other hand, $\left| \mathrm{P}(t) \right| \propto n(t) / a^2(t)$;

$$\therefore\ \left| \mathrm{P}(t) \right| \propto n_0 \exp\left[\left\{ 1/a_0{}^2 - 1/a^2(t) \right\} / 2 \right] / a^2(t).$$

We can then compute the formula of P(t) with an inflection point of $a(t_i)$ as

$$\mathrm{P}(t) = -\frac{a_i^{\,2}}{3a^2(t)}\rho_i \exp\left[(1/2)\left\{1/a_i^{\,2} - 1/a^2(t)\right\}\right].$$



Since the acceleration of *a(t)* is then expressed as

$$\ddot{a} = -\frac{4\pi G}{3} a(t)\left[\rho(t) - \frac{a_i^{\,2}}{a^2(t)}\rho_i \exp\left\{(1/2)\left(1/a_i^{\,2} - 1/a^2(t)\right)\right\}\right],$$

the inflection point should satisfy

$$\rho(t) - \frac{a_i^{\,2}}{a^2(t)}\rho_i \exp\left\{(1/2)\left(1/a_i^{\,2} - 1/a^2(t)\right)\right\} = 0.$$

Actually it is noted that $a(t_i) = a_i$ and $\rho(t_i) = \rho_i$ surely satisfy above condition. Then we may write:

$$\text{i) } t < t_{\mathrm{i}_{(1)}} \quad (\text{decelerating expansion})$$

$$a(t) < a_{i_{(1)}},$$

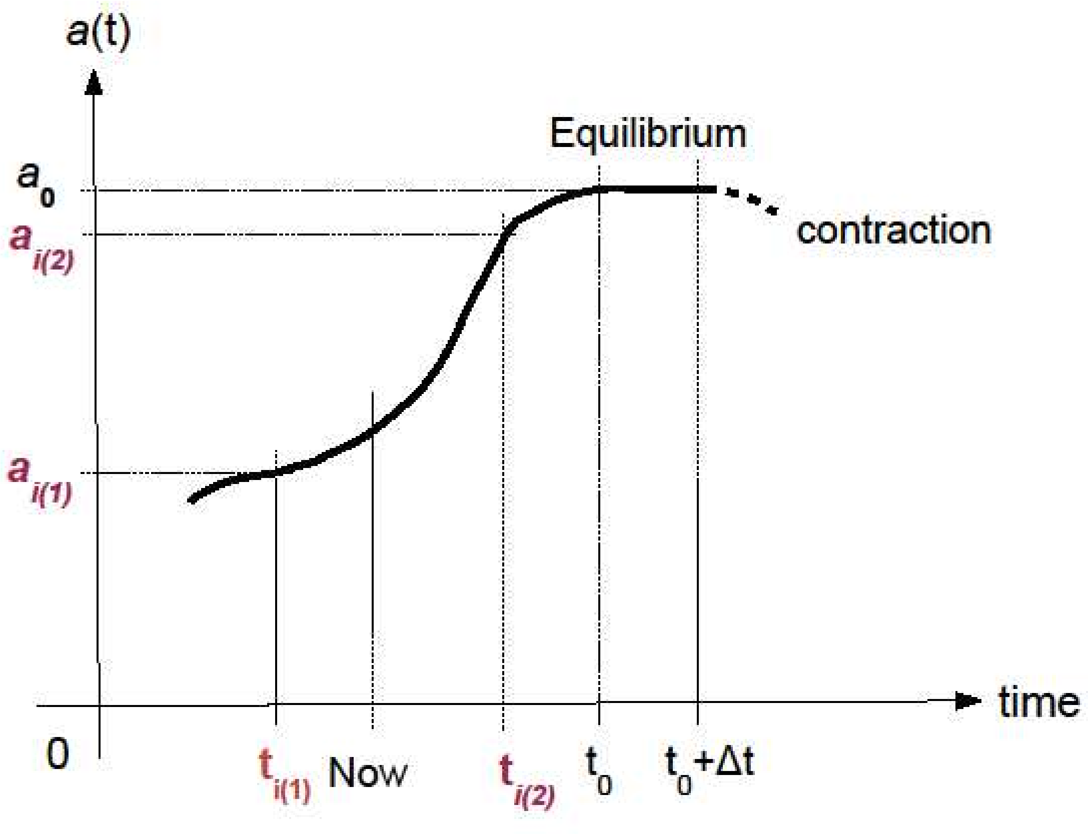
$$\text{ii) } t_{\mathrm{i}_{(1)}} \le t < t_{\mathrm{i}_{(2)}} \quad (\text{accelerating expansion})$$

$$a_{i_{(1)}} < a(t) < a_{\mathrm{i}_{(2)}},$$

$$\text{iii) } t_{\mathrm{i}_{(2)}} \le t \le t_0 \quad (\text{decelerating expansion}^{*})$$

$$a_{\mathrm{i}_{(2)}} \le a(t) \le a_0.$$

*: The number of ***active*** fullerene is insufficient to produce **the breeding-collision or disruption when $t_{i(2)} < t < t_0$**. At $t = t_{i(2)}$, each fullerene would no longer have only one or zero ω meson inside. Each interval is to be determined by **the stiffness** against the disruption of the fullerene.

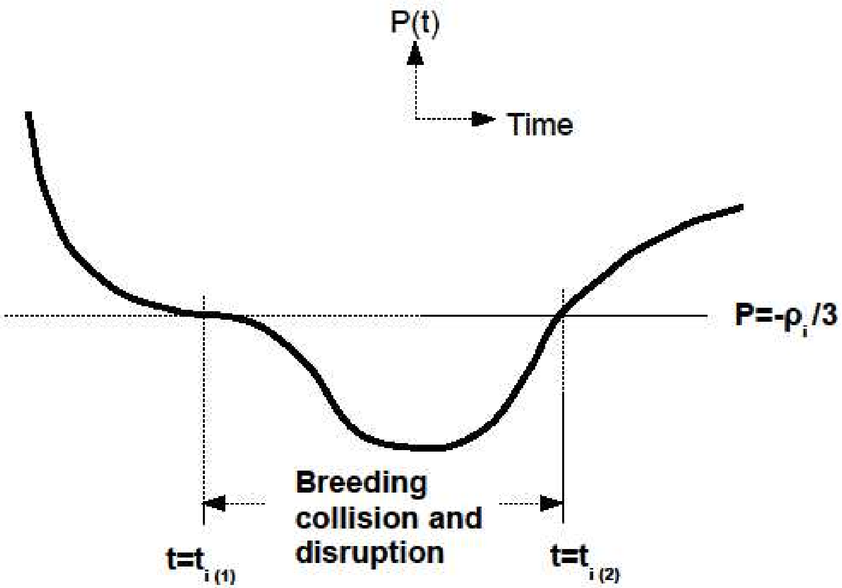


The P(t) behavior in the region around at P= $-\rho_i/3$

$$\frac{dP}{dt}=\frac{2}{3}\frac{a_i^2}{a^3(t)}\rho_i\left(1-\frac{1}{2a^2(t)}\right)\cdot exp\left(\frac{1}{2}\left(\frac{1}{a_i^2}-\frac{1}{a^2(t)}\right)\right)\cdot\frac{da}{dt}\equiv 0.$$

$$\frac{d^2P}{dt^2}=\frac{2}{3}\frac{a_i^2}{a^3(t)}\rho_i\cdot exp\left(\frac{1}{2}\left(\frac{1}{a_i^2}-\frac{1}{a^2(t)}\right)\right)\cdot\left\{\left(-\frac{3}{a(t)}+\frac{2}{a^3(t)}\right)\left(\frac{da}{dt}\right)^2+\left(1-\frac{1}{2a^2(t)}\right)\frac{d^2a}{dt^2}\right\}\equiv 0,$$

$$\therefore\ \frac{d^2a}{dt^2}=\frac{2\left(3a^2(t)-2\right)}{a(t)\left(2a^2(t)-1\right)}\left(\frac{da}{dt}\right)^2.$$



Where we assigned $\left.\frac{da}{dt}\right|_{a(t)=a_{i(1)}}=0.$

And, $\left.\frac{d^2a}{dt^2}\right|_{a(t)=a_{i(1)}}=0$;

then $a(t)_{P_{(\mathrm{MINIMUM})}}=1/\sqrt{2}$,

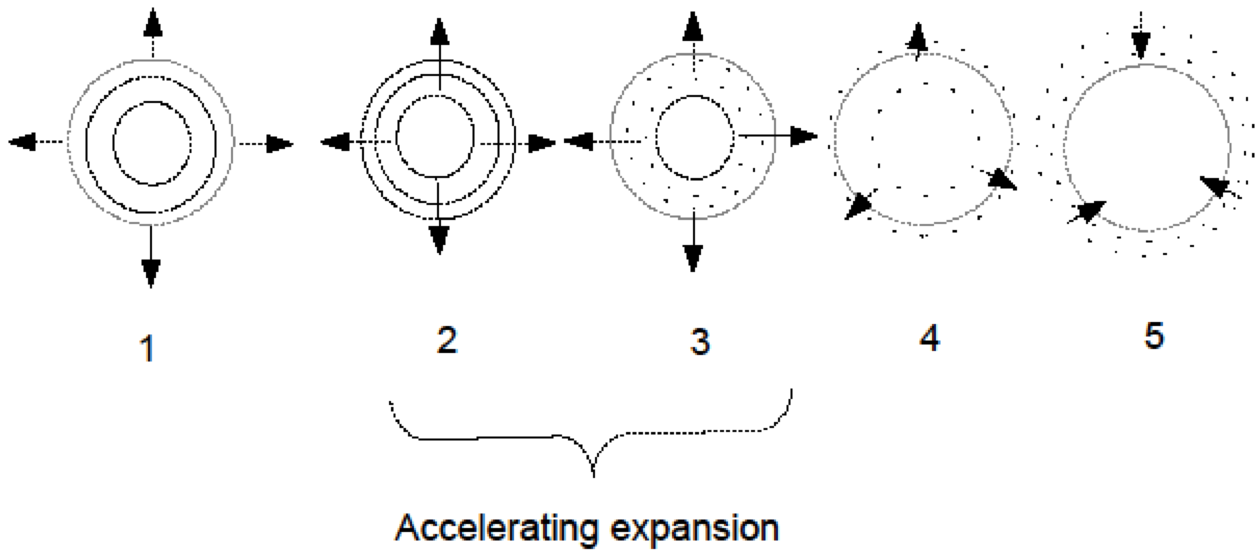
$a_{i(2)}=\sqrt{2/3}$

with $a_0\equiv 1$.

And, by numerical calculation,

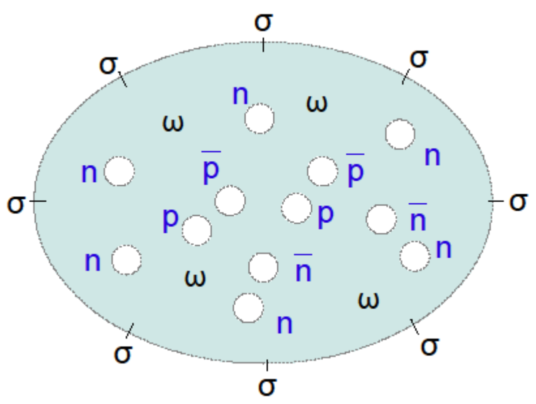
$a_{i(1)}\approx 0.62013$

After all, we can describe that the breeding collision and disruption of the outgoing developed fullerene would be a factor of the accelerating expansion of the universe, i.e. the candidate of dark energy. And the repulsive potential energies between ω mesons of the fullerenes are thus to be consumed at respective disruptions to expand the universe.



- A certain decay route into **dark energy** from dark matter

As seen, the candidate for dark matter to which major part of ur-Higgs boson may degenerate, is expected to decay into the candidate for dark energy. We propose a structural model of nucleus of the candidate for dark matter from the stand point of a former state of ***the dark energy****.*



We'll *reconstruct* a model so as the nucleus consists of many neutrons, protons and their antiparticles with several σ mesons and some ω mesons (i.e., σ-ω model), which could also be regarded as *a descendant* of the degenerate from ur-Higgs boson.

Because we *have considered* that

$$\mathrm{GB} \equiv \mathrm{f}_0(500) \equiv \sigma \text{ meson}; \quad \boxed{\text{ur-Higgs} \equiv 80{*}\mathrm{f}_0(1500)}$$

$$\boxed{\begin{aligned} \mathrm{DM}_{90\mathrm{f}_0(1370)} &\equiv 90 * \mathrm{f}_0(1370) \\ \mathrm{DM}_{70\mathrm{f}_0(1710)} &\equiv 70 * \mathrm{f}_0(1710) \end{aligned}}$$

*: molecular state

These f_0 mesons' masses were able to be represented by masses of π-octet (pseudo-scalar mesons) and mass of GB which was computed at 502.55 MeV/c^2:

$$m_{f_0(1370)} = \left[\begin{aligned} & \mathrm{GB} + \left(\frac{3}{90}\right)\eta_0 + \left(\frac{70}{90}\right)K^0 + \\ & \left(\frac{2}{3} \times \frac{70}{90}\right)K^{\pm} + \left(\frac{75}{90}\right)\pi^{\pm} + \left(\frac{40}{90}\right)\pi^0 \end{aligned} \right]_{m_i},$$

$$m_{f_0(1500)} = \left[3\mathrm{GB}\right]_{m_i},$$

$$m_{f_0(1710)} = \left[\mathrm{GB} + K^0 + \left(\frac{1}{3}\right)K^{\pm} + 4\pi^{\pm}\right]_{m_i}.$$

(possibly be paired)

By interpreting as an effective mass as well for mass of these f_0 mesons because the light quarks in $3\pi^+\pi^-$ of them are equivalent to that of (nn_bar +pp_bar); and so on, we approximately write:

$$\mathrm{DM}_{90 f_0(1370)}: \quad N_1 \times M_{n,p} - \alpha_1 \cdot 90 M_\sigma = 120.611\ \mathrm{GeV/c^2},$$

$$\mathrm{DM}_{70 f_0(1710)}: \quad N_2 \times M_{n,p} - \alpha_2 \cdot 70 M_\sigma = 120.611\ \mathrm{GeV/c^2},$$

$$N_1 - N_2 = 4i, \quad N_1, N_2 = 4j, 4j',$$

$$\alpha_1 \approx \alpha_2,$$

where $N_1,\ N_2$: total number of included neutrons, protons and their antiparticles

α_1, α_2 : mass effective factor of σ meson,

$M_{n,p}$: mean mass of neutron and proton,

M_σ : mass of σ meson (502.55MeV/c^2),

$i; j, j'$: integer.

And by the condition that $\alpha_1, \alpha_2 < 1$, we have

$$N_1 = 164,\ N_2 = 156,$$

$$\alpha_1 \approx 0.7377,\ \alpha_2 \approx 0.7351.$$

A scheme of nucleon-decay cycle ***in the nucleus*** might be

$n \to p + e^- + \bar{\upsilon}_e$, (*merely* happens in an *almost*-stable nucleus)

$\therefore\ \bar{n} \to \boxed{\bar{p}} + \lfloor e^+ + \upsilon_e$ (thus *merely* happens in an *almost*-stable nucleus)

while the $\boxed{\bar{p}} \to \lfloor e^- + \gamma$ (lifetime: $300{,}000\,years$);

then these $\lfloor e^-, e^+$ captures by *current* $p, \bar{p}$ will be happened *in long time*:

$p + \lfloor e^- \to n + \upsilon_e\ , \quad \bar{p} + \lfloor e^+ \to \bar{n} + \bar{\upsilon}_e.$

As a result, one $n, \bar{n}$ pair would be dripped out for the sake of keeping stability of nucleus, with $(2\upsilon_e + \bar{\upsilon}_e) + \gamma$.

The number of neutron is supposed to be maximum at the early time. And this number, i.e. the effective mass of dark matter, ***very*** gradually decreases with dripping out the neutron pair and so on above in long time. Hence, ***finally such a dark matter will reach the dark energy which could have only few neutron***.