On a Singular Solution in Higgs Field (7)

- The stiffness of candidate for dark energy, and the matter-antimatter consumption by candidate for dark matter

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Contents

We have recently discussed the degenerates into the candidates for dark matter (DM) and for dark energy (DE) from ur-Higgs boson, and also a long time behavior of DE.

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

1. Short review

- The degenerates into DM and into DE from ur-Higgs boson ($ur\text{-}H^0$),
- A long time behavior of DE.

2. The stiffness of DE

- A critical collision number,
- A formula for the disruption interval, the disruption timing, etc.

3. A scenario of matter-antimatter (M-A) consumption by DM

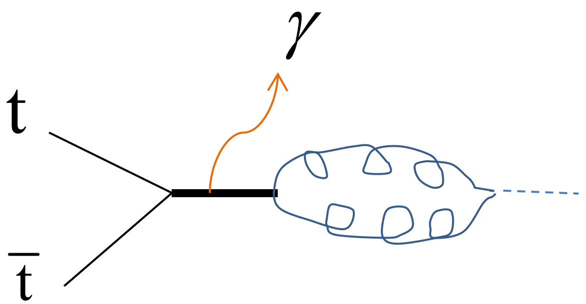
- Some constituent parts of DM neighboring M-A,
- Washing-out into only certain matter.

== Short review ==

- The degenerates into DM and into DE from ur-Higgs boson (ur-H^0):

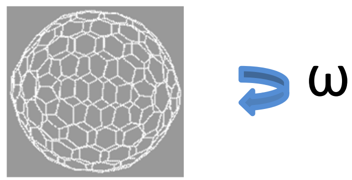
K.K: PoS(EPS-HEP 2013)002

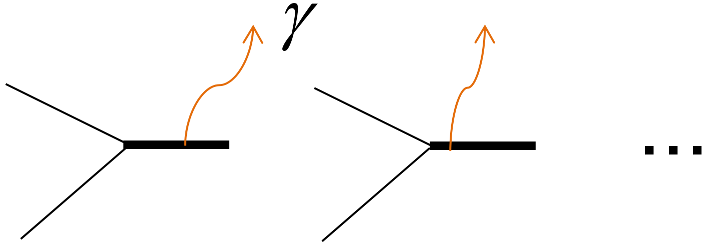
Ur-H^0 (mass of 120.611 GeV/c^2) can be transformed finally to the excited Higgs boson (H^0) with corrected mass of 125.28 GeV/c^2, through multi-photon resonances of its component by irradiated γ-rays from neighboring $(t\bar{t})^*$s onto it (ur-H^0).

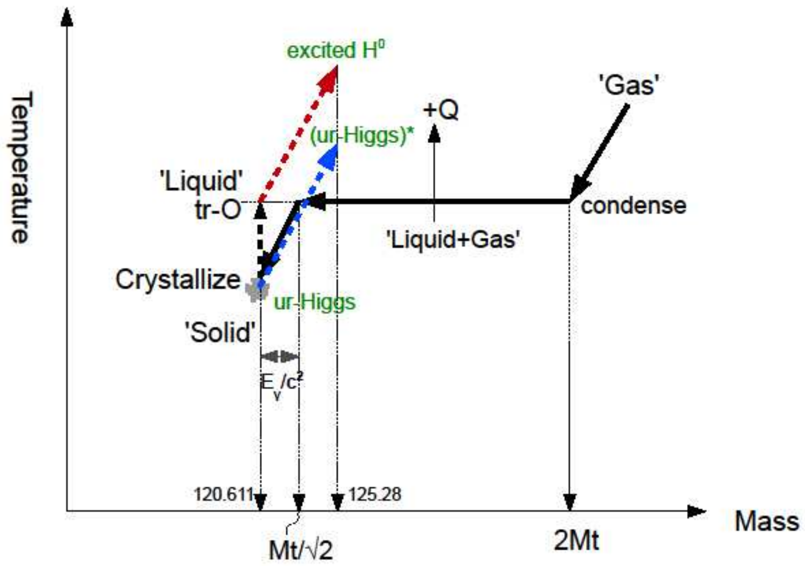


Bethe-Salpeter eq.

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







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

The rate of excited Higgs boson would be equivalent to the rate of Atom itself. Then from the phase transition diagram,

$$R_{(\mathrm{Atom})}{}' = \frac{1}{N_{\mathrm{e}}} \times \left(1-\eta_{+Q}\right) = \frac{1}{N_{\mathrm{e}}} \times \left(1-\frac{2M_{\mathrm{t}}-M_{\mathrm{t}}/\sqrt{2}}{2M_{\mathrm{t}}}\right) = 0.03728,$$

$$N_{\mathrm{e}} = \Delta\mathrm{m}\bullet\mathrm{c}^2/E_\gamma = 9.483,$$

$$\Delta\mathrm{m} = 125.28-120.611 = 4.669\ \mathrm{GeV/c^2},\quad E_\gamma = 492.35\ \mathrm{MeV}.$$

The rate of 'total matter' is estimated as

$$R_{(\text{total matter})}' = \left(1 - \eta_{+Q}\right) = \frac{1}{2\sqrt{2}}.$$

Since the rate of fullerene of pure Glueballs (GBs) has been computed as *one third* of the 'total matter' which was represented by the mixture of fullerenes of pure GBs and the hybrid molecules (one-GB and several certain light pseudo-scalar mesons) , the rate of remainder is

$$\left(1 - 1/3\right) \times R_{(\text{total matter})}' = \frac{1}{3\sqrt{2}} = 0.2357 \equiv R_{(\text{DM})}'$$

that is, the rate of degenerate into DM from ur-H^0.

And we re-calculate the rate of Atom by taking account of mass contribution from QGP such as totally equivalent to top quark,

$$R_{(\text{Atom})} \cong R_{(\text{Atom})}' \times \left(1/M_{\text{t}}\right)\left[M_{\text{t}} + \left\{M_b + M_c + M_s + n^*(gluon)\right\}\right] = 0.04609,$$

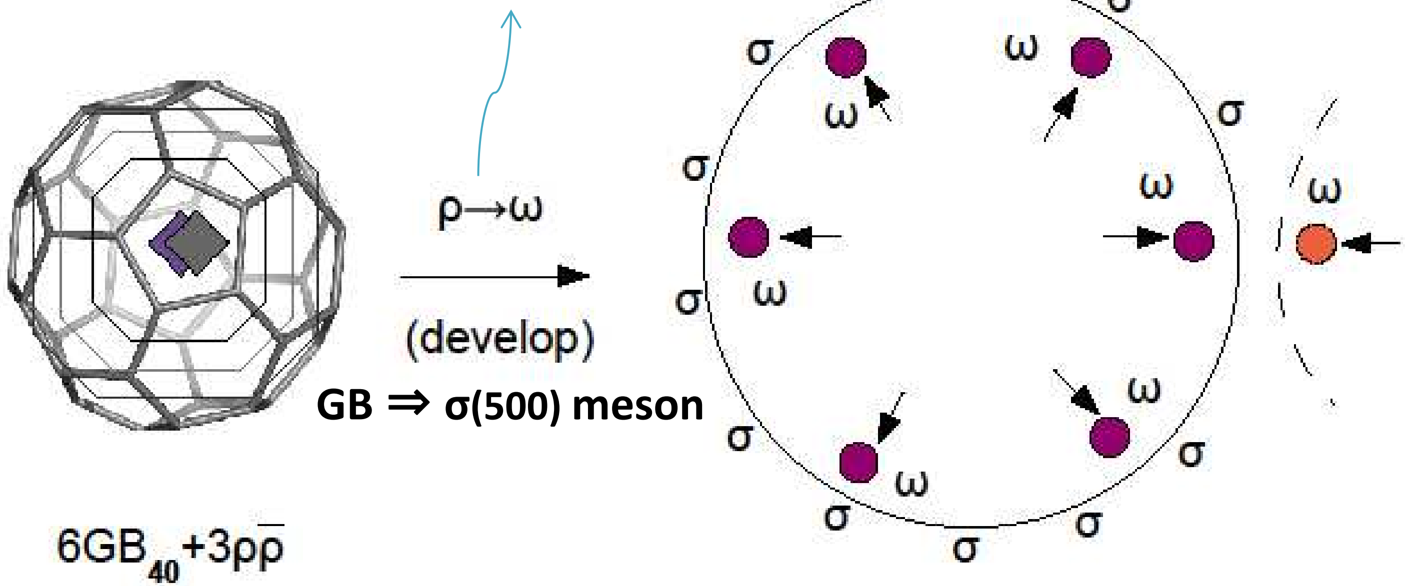
where we put $n^* \equiv 1/\alpha$, α : fine structure constant; and

$(gluon)$: mass of gluon $\equiv$ mass of GB$/2$.

excited ur-H^0 of multi-wall

developed fullerene: DE

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



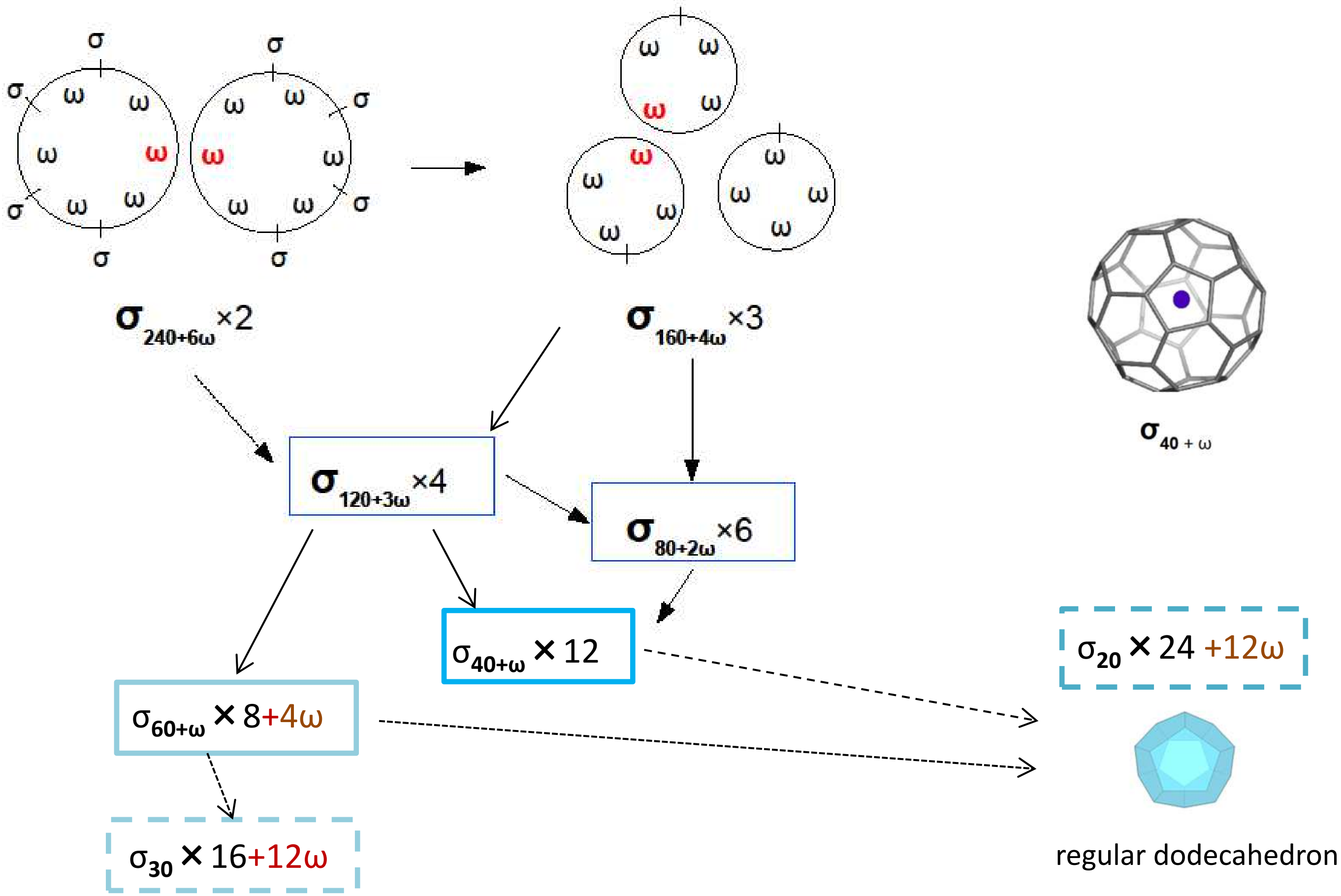
$6GB_{40}+3p\bar{p}$

$240\sigma + 6\omega$

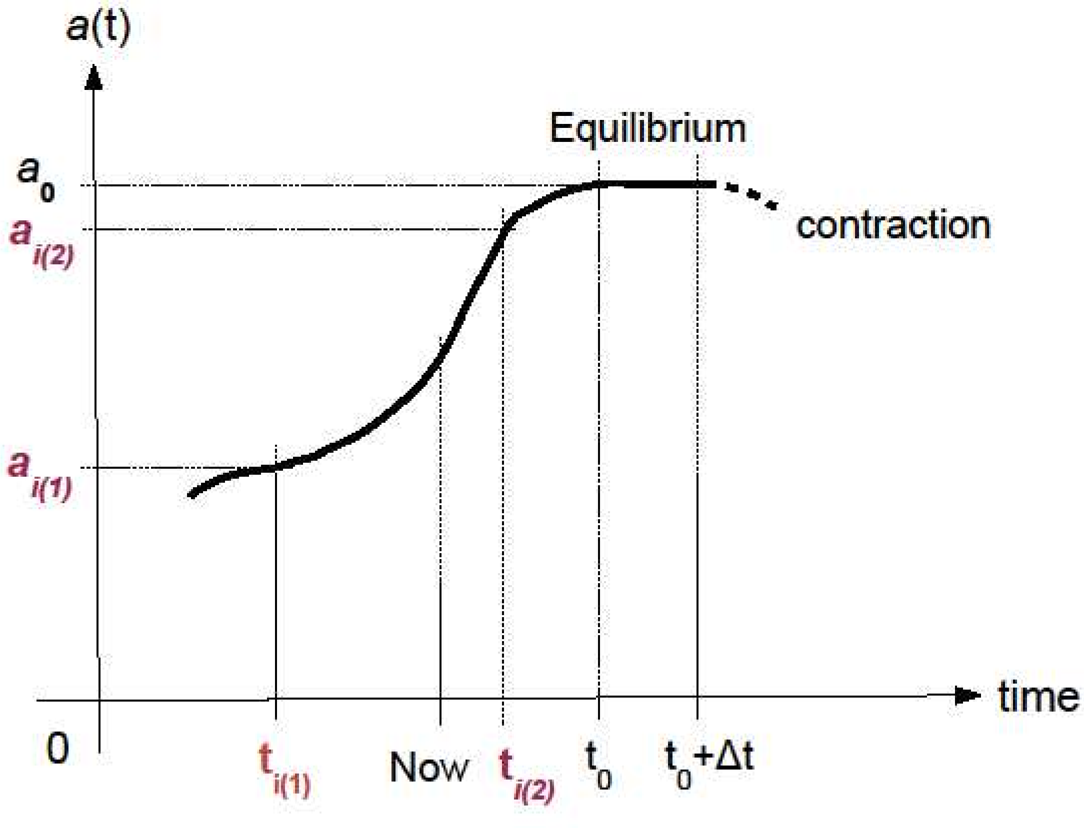
- A long time behavior of DE

K.K: DPF2013(Santa Cruz)_75

Gradual disruption of DE mesons by collisions of rather low-mass fullerene into smaller ones consist of several σ mesons with some ω mesons:



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.

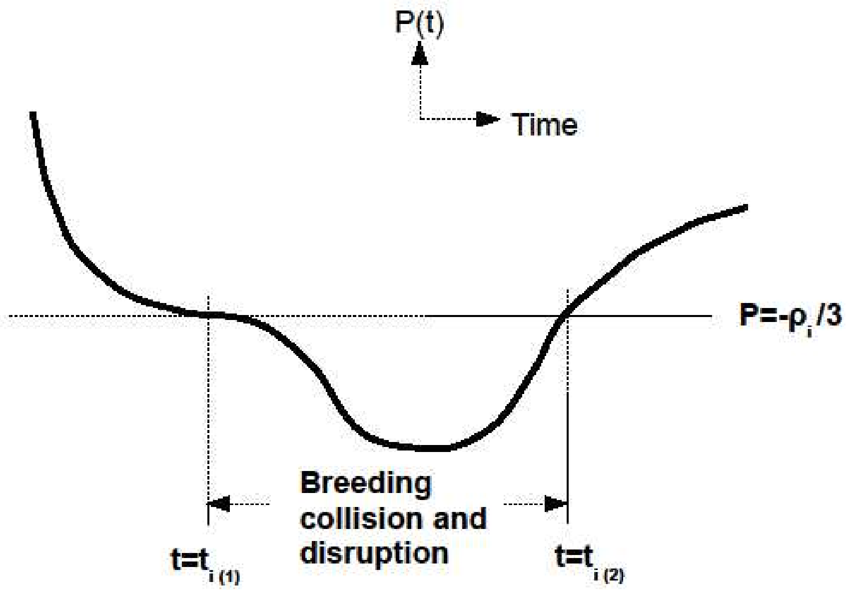


The P(t) behavior in the region around at P= -ρ_i /3 by Robertson-Walker eq.

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

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

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



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

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

with $a_0\equiv 1$.

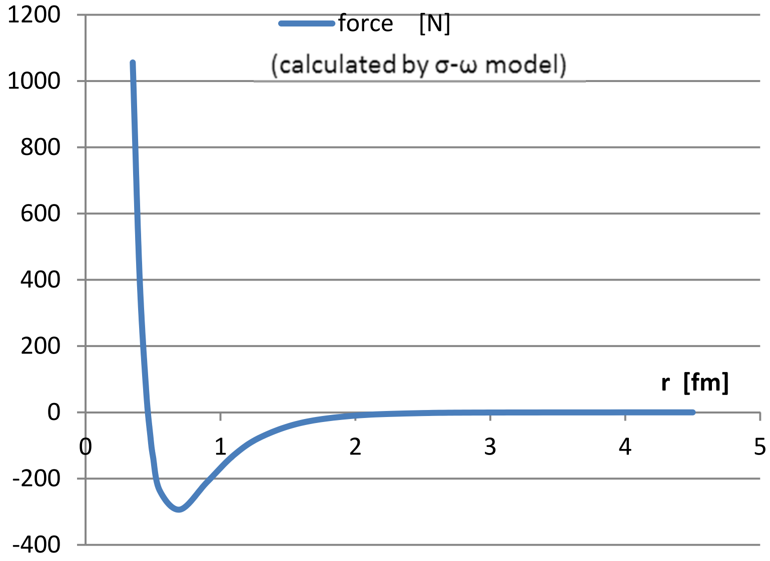
And, by numerical calculation,

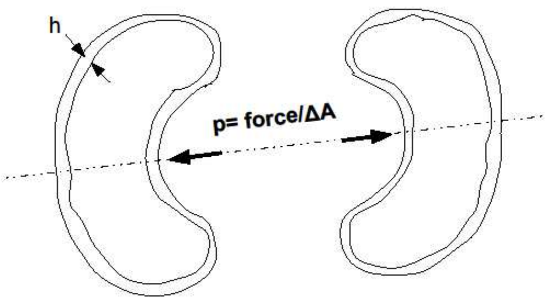
$a_{i(1)}\approx 0.62013$

== The stiffness of DE ==

- A critical collision number

We think that the disruption of DE would be caused by weariness from local micro deformation during several collisions. By considering the outer-wall of DE consists of σ mesons as a membrane, we shall firstly express the pressure produced by strong forces among σ mesons (attractive) and also among ω mesons (repulsive) on local surface shown in figure below.





From Zoelly's formula, classically, allowable buckling pressure is

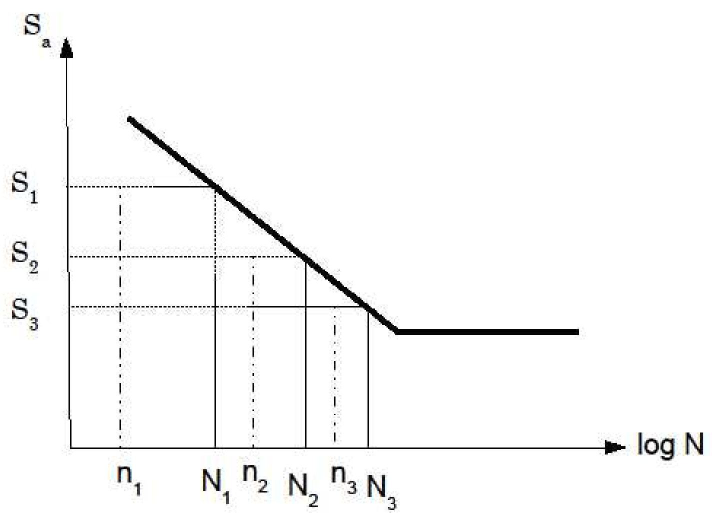
$$p_a = \frac{2E_Y h}{R(1-\nu^2)}\left(\sqrt{\frac{1-\nu^2}{3}}\frac{h}{R} - \frac{\nu h^2}{2R^2}\right) \approx \frac{2E_Y}{\sqrt{3(1-\nu^2)}}\left(\frac{h}{R}\right)^2, \quad \text{where } h \ll R,$$

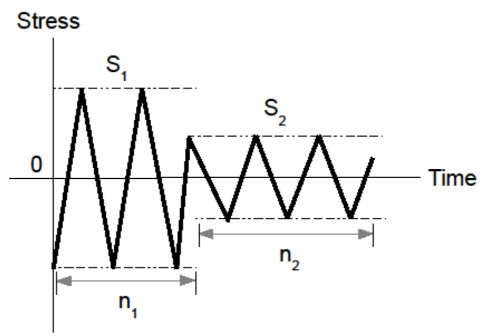
E_Y: Young modulus, ν: Poisson ratio, R: radius of DE.

Because we consider each damage at collision is independent, so that it is cumulative. Then 1st disruption of DE will occur as soon as Miner's law:

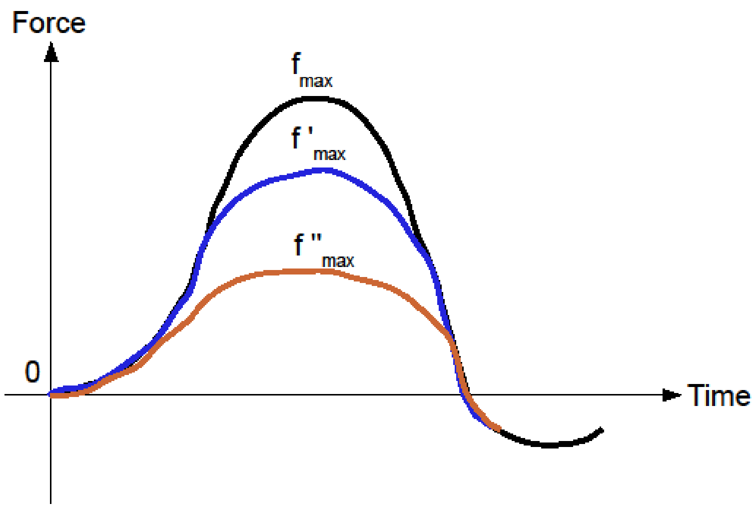
$$\sum_i \frac{n_i}{N_i} = 1$$

is satisfied.





To see the critical collision number (N_C) of DE, we need describe saturated energy for deformation. The patterns of deformation are to be classified by increasing N-value of S-N diagram (hence, the force decreases gradually):



1) Major part of energy is consumed for deformation with f_{max}. In extreme case, the repulsive movement will be very small.
2) Completing moderate deformation with f'_{max}, then, DE leaves.
3) After the force reaches f''_{max} with small deformation, DE leaves.

Apparently, $f''_{\max,\ (i)} < f'_{\max,\ (i)} < f_{\max,\ (i)}$, where i : number of disruption.

These (required) forces are thought to be larger as *i* is increasing because of the increasing stiffness.

Then we formulate the energy balance for deformation and repulsion of DE.

$$E_{<Total>(i)} = \int_0^{\delta_{(i)}} \mathbf{F}_{<disrupt>(i)} \cdot d\mathbf{r} + \int_0^{l_{(i)}} \mathbf{F}_{<movement>(i)} \cdot d\mathbf{r}$$

$$\approx \int_0^{\delta_{(i)}} k_{(i)} \mathbf{r} \cdot d\mathbf{r} + \frac{1}{l_{(i)}} \int_0^{l_{(i)}} \frac{1}{2} (\triangle \mathrm{M}) \left| \mathbf{u}(\mathbf{r}) \right|^2 \left| d\mathbf{r} \right| = \frac{k_{(i)}}{2} \delta_{(i)}{}^2 + \frac{1}{2} \triangle \mathrm{M}\, u^2 \left(l_{(i)} \right),$$

$\delta_{(i)}$: deformation along $\mathbf{r}$, $k_{(i)}$: spring constant ≡ stiffness of DE,

$\triangle\mathrm{M}$: DE mass > 0, $u(l_{(i)})$: leaving velocity along $\mathbf{r}$ at $l_{(i)}$.

Let $K_{(i)j} \equiv \cos\theta_{(i)j}, \quad 0 \le \theta_{(i)j} \le \frac{\pi}{2}$; then $K_{(i)j}$ will express the effectiveness of j_{th} collision in i_{th} disruption. Where $\theta_{(i)j}$: colliding angle.

Moreover $k_{(i)}$ should be replaced by $k_{(i+1)}$ after i_{th} disruption has occurred.
From Zoelly's formula also,

$$k_{(i)} \left(\propto 1 / R_{(i)}{}^2 \right) \equiv c_{(i)} / R_{(i)}{}^2 .$$

And referring the property of j_{th} colliding angle $K_{(i)j}$ *above*,

$$\sum_{j=1}^{N_{(i)}} \left\{ K_{(i)j} \left(\frac{k_{(i)j}\, \Delta\delta_{(i)j}{}^2}{2} \right) \right\} \equiv E^{elastic}_{<net>\,(i)} = \frac{c_{(i)}}{2} \varepsilon_{(i)}{}^2, \quad \text{where} \quad \varepsilon_{(i)} \equiv \delta_{(i)} / R_{(i)} .$$

Since $c_{(i)j}=c_{(i)}$, then we have a formula for the saturated energy under local micro deformation:

$$\varepsilon_{(i)} = \sqrt{\sum_{j=1}^{N_{C(i)}} K_{(i)j}\ \Delta\varepsilon_{(i)j}^{\ \ 2}},\ \ \text{or,}\ \ \delta_{(i)} = \sqrt{\sum_{j=1}^{N_{C(i)}} K_{(i)j} \left(k_{(i)j} \big/ k_{(i)}\right) \Delta\delta_{(i)j}^{\ \ 2}},\ \ \text{where}\ \ \Delta\varepsilon_{(i)j} \equiv \Delta\delta_{(i)j} \big/ R_{(i)j}.$$

Regarding each critical collision, $N_{C(i)}$ is determined to satisfy this equation.

- A formula for the disruption interval, the disruption timing, etc.

Assuming that the mean free path (λ) is constant between i_{th} and $(i+1)_{th}$ disruption with *random* velocity in direction of DE with Maxwell distribution,

$$\text{Interval}_{(\text{i}\rightarrow\text{i+1})} = \left(\frac{\lambda_{DE(i)}}{u(l_i)}\right) \times \left(\text{allowable collision number : } N_{C(i)}\right)$$

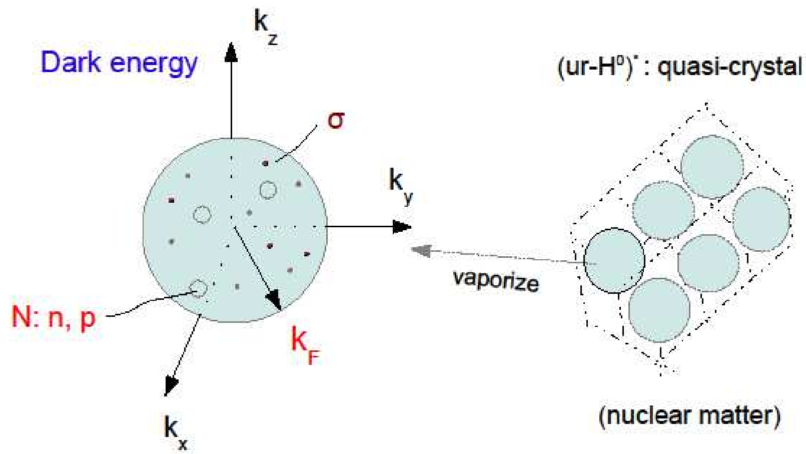
$$= N_{C(i)} \Big/ \left(\sqrt{2}\ \rho_{DE(i)} \sigma_{DE(i)}\ u(l_i)\right)$$

$$= \frac{\sqrt{\Delta \mathrm{M}}}{2} \frac{N_{C(i)}}{\rho_{DE(i)} \sigma_{DE(i)} \sqrt{E_{<Total>(i)} - \left(k_{(i)} / 2\right) \delta_{(i)}^{\ \ 2}}}.$$

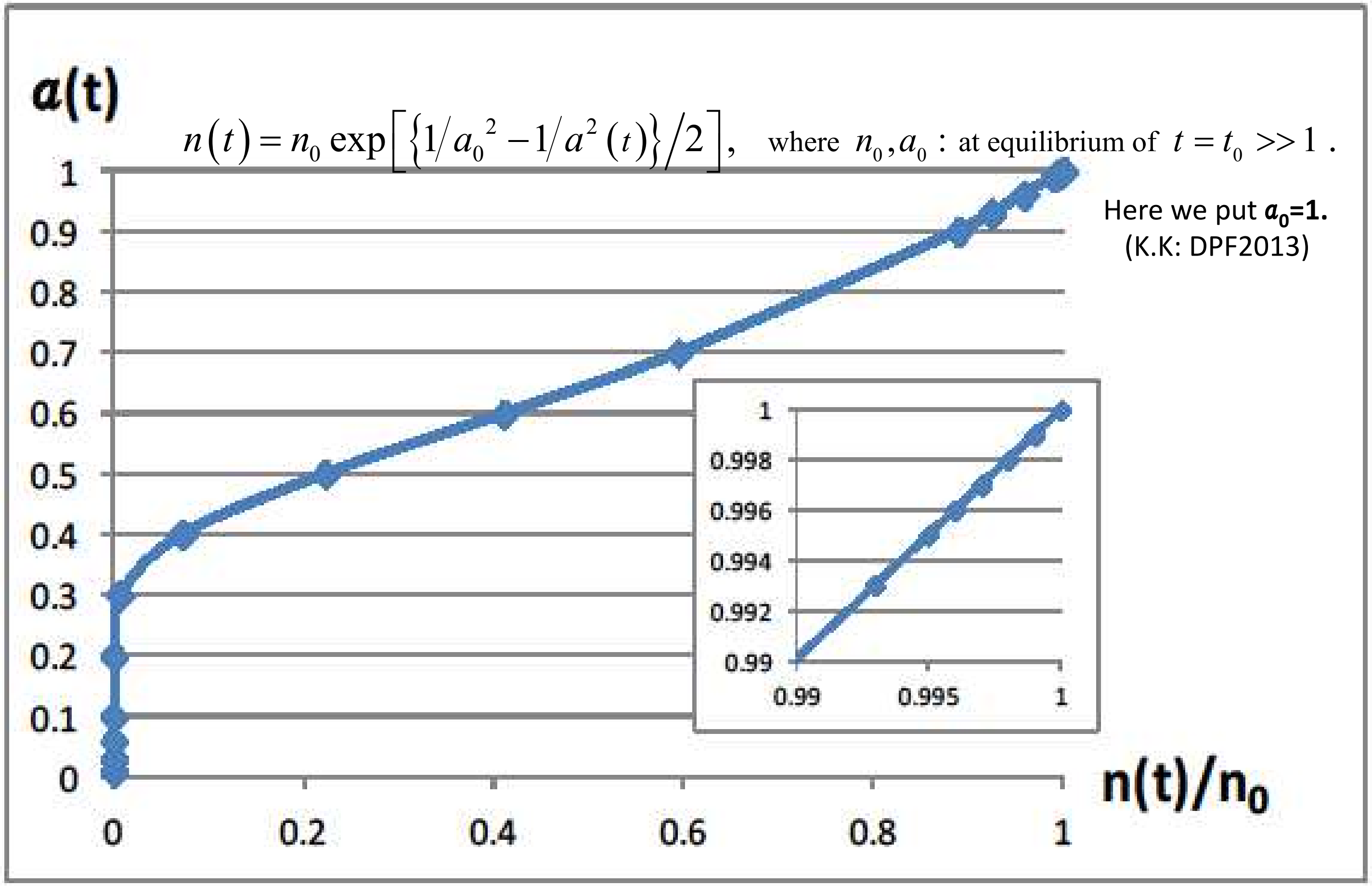
$$\text{Where,}\quad \triangle\mathrm{M} = \lim_{\rho_N \to 0}\left\{\mathrm{M} - \frac{g_\sigma{}^2}{m_\sigma{}^2}\rho_N\left(1 - \frac{3}{10}\frac{k_F{}^2}{\mathrm{M}^2}\right)\right\} > 0;$$ (H. Kurasawa: *Buturi*,49(1994)628)

$$\therefore\quad \triangle\mathrm{M}_{(\min)} = \lim_{\rho_N \to 0}\left[\sqrt[3]{\frac{3}{5}k_F{}^2\frac{g_\sigma{}^2}{m_\sigma{}^2}\rho_N} - \frac{g_\sigma{}^2}{m_\sigma{}^2}\rho_N\left\{1 - \frac{3}{10}k_F{}^2\left(\frac{3}{5}k_F{}^2\frac{g_\sigma{}^2}{m_\sigma{}^2}\rho_N\right)^{-\frac{2}{3}}\right\}\right] > 0,$$

k_F : Fermi wave number, ρ_N : density of nucleon.

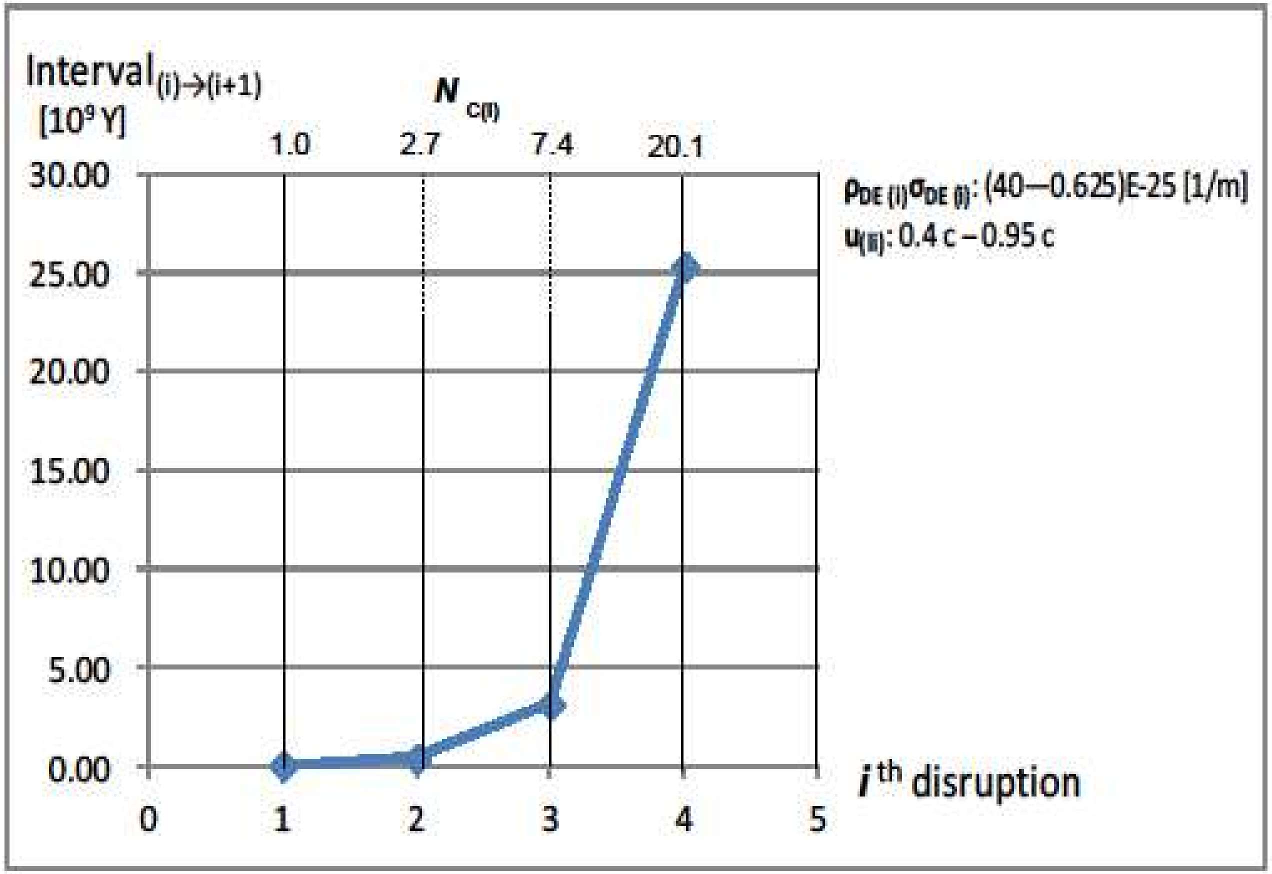


Behavior of Expansion of the Universe – Number of DE

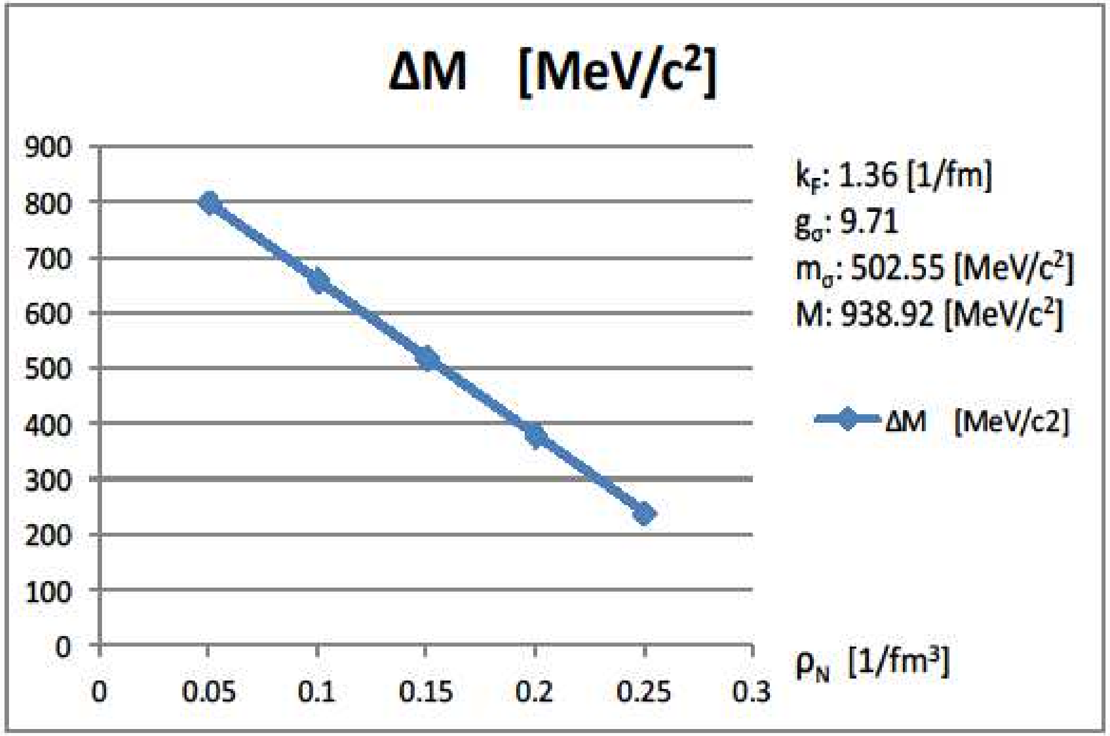


The inflection point of a(t) is *at n(t)/n$_0$ = 1/e*.

Preliminary: Interval$_{(i)\rightarrow(i+1)}$ – i th disruption



Where $\boldsymbol{N_{C(i)}} \propto \mathbf{exp}(\boldsymbol{i\text{-}1})$.



Mean mass of proton and neutron is chosen for the value of **M**.

Putting $\Delta M_{(min)} \rightarrow 0$ as an *effective* mass of DE at a limit, we obtain **M=254.6** MeV/c^2 at ρ_N=0.1331[1/fm^3]. It is noteworthy that this critical ***nucleon*** **mass** appears in reasonable agreement with '**(GB mass)/2+ (total bare mass of quarks which configure one proton and one neutron)/6**'.

Next we describe the momentum (*p*) of a DE at N^{th} and at $(N+1)^{th}$ collision in which a disruption occurs. For the limit of *ΔM→0* with wave number (*k*),

$$p_{N+1} - p_N \cong \hbar\left\{\left(k_{(N+1)1} + k_{(N+1)2}\right) - k_N\right\} \equiv \hbar N k^0 .$$

Here we assumed that the given energy or momentum is equal in each collision before the disruption. That is,

$$k^0 \equiv k_1 = k_2 = \cdots = k_{N.} \quad \therefore\ k_{(N+1)1} + k_{(N+1)2} = (N+1)k^0 .$$

Moreover if we put $k_{(N+1)1} \equiv n_1 k^0$ and $k_{(N+1)2} \equiv n_2 k^0$,

$n_1 + n_2 = N + 1$. And we assume $\left|n_1 - n_2\right| \le 1$.

Then if $n_1 \ne n_2$, always N is *even*; and if $n_1 = n_2$, always N is *odd*.

It will be usual that the disrupted two DEs have an equal momentum. So,

$$n_1 = n_2 .$$

Thus in this case the disruption will occur after ***(odd)***th collision.
In another case that disrupted two DEs have different (1:2) momentum, the disruption will occur after ***(even)***th collision.

And, to think about the confluent behavior of original-*DE* and additional-*DE (which would be decayed from some DM in long time)*, we shall approximate the front surface of *DE* as a three dimensional real spherical wave front (Ψ) in the universe:

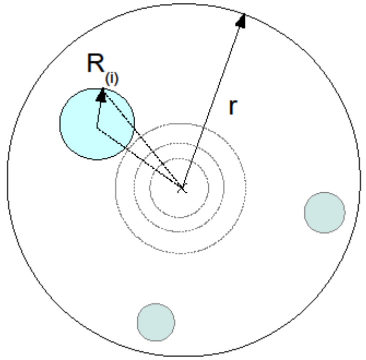
$$\Psi\left(r,\theta,\varphi,t\right)\equiv\frac{A}{r}\cos\left(\mathbf{k}\cdot\mathbf{r}-\omega t+\varphi\right).$$

Then the front surface of original-DE from the center of universe is

$$\Psi_0=\frac{A_0}{r}\cos\left(\mathbf{k}_0\cdot\mathbf{r}-\omega_0 t+\varphi_0\right).$$

Also that of additional-DE is

$$\Psi_{(i)}=\frac{A_{(i)}}{R_{(i)}}\cos\left(\mathbf{k}_{(i)}\cdot\mathbf{R}_{(i)}-\omega_{(i)}t_{(i)}+\varphi_{(i)}\right).$$



By superimposing all of them,

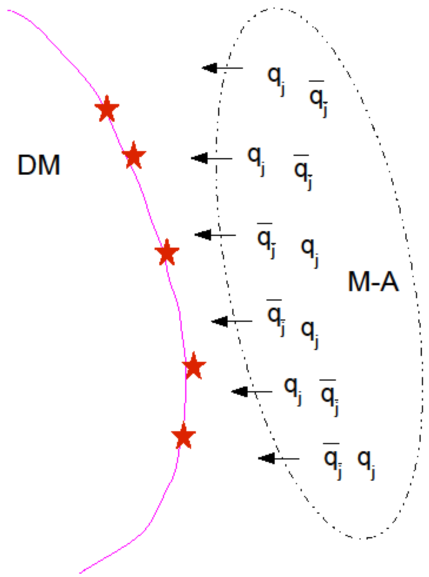
$$\Psi'\equiv\Psi_0+\sum_i\Psi_{(i)}$$

$$=\frac{A_0}{r}\cos\left(\mathbf{k}_0\cdot\mathbf{r}-\omega_0 t+\varphi_0\right)+\sum_i\left\{\frac{A_{(i)}}{R_{(i)}}\cos\left(\mathbf{k}_{(i)}\cdot\mathbf{R}_{(i)}-\omega_{(i)}t_{(i)}+\varphi_{(i)}\right)\right\}.$$

$$\therefore\ \left[\text{Probability of presence}\right]\propto\ \left(\Psi'\right)^2\leq\left(\frac{A_0}{r}+\sum_i\frac{A_{(i)}}{R_{(i)}}\right)^2.$$

== A scenario of matter-antimatter (M-A) consumption by DM ==

Hereafter we will propose a scenario of the matter-antimatter consumption by a candidate for dark matter (DM) of 120.611 GeV/c^2-mass, considering a situation of that the DM has firstly encountered with M-A in the early universe. Recently we showed that, (K.K: DPF 2013(Santa Cruz)_75)



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

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

*: molecular state

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

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

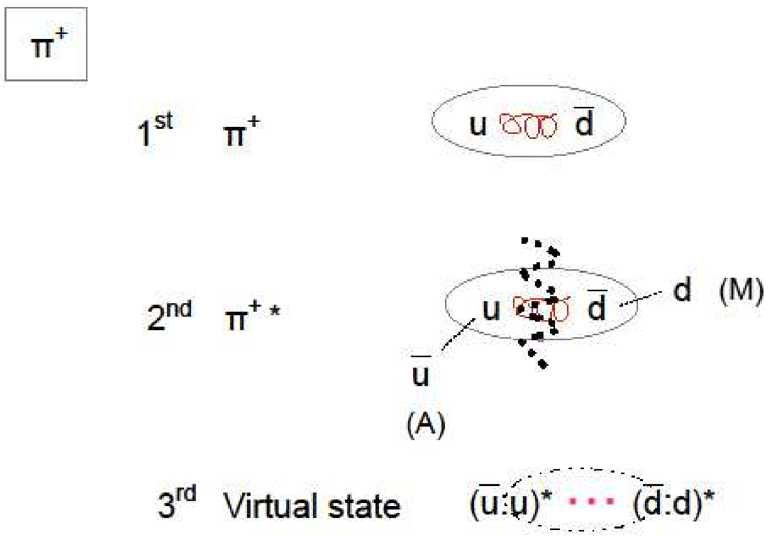
$$m_{f_0(1710)} = \left[\mathrm{GB} + K^0 + \left(\frac{1}{3}\right)K^{\pm} + 4\pi^{\pm}\right]_{m_i}.$$

(possibly be paired)

Then we shall focus on some parts of DM: $\pi^{\pm}$, $K^{\pm}$, K^0. Since respective meson consists of light quark pair of different flavor ;

$$\pi^{\pm} = \left(u\bar{d}, d\bar{u}\right),\ K^{\pm} = \left(u\bar{s}, s\bar{u}\right);\ K^0 = d\bar{s},\ \overline{K^0} = s\bar{d},$$

it is expected that constituent quarks of the meson are apt to have reunion with one from neighboring M-A, for each own flavor as in same momentum:



-Remind the Cornell potential *V* of quarkonium,

$$V(q\bar{q}) = -\frac{e}{r} + kr.$$

Therefore we consider that, in such meson, the bond of constituent quarks of different flavor tends to be weakened when *q* or *q*_bar (M-A) of same flavor in *QGP state* approaches. Here the process of π^- shall be the conjugate one of π^+; and for $K^{\pm}$, *d*-quarks are replaced by *s*-quarks.

Also for K^0, the constituent quarks would combine to that (M-A) of originally same flavor respectively as well as $K^{\pm}$.

Next we study on the behavior of remainder parts of DM : η, π^0. These mesons might have been resonant by the neighbor parts, i.e., fore-mentioned $\pi^{\pm}$ and K mesons of virtual state, which would forced an increase of (η, π^0) masses. Then

$$(\eta/\pi^0\pi^0) \xrightarrow[resonant]{+(q_i:\overline{q_i})^*/(gg=GB)} (\eta/\pi^0\pi^0)^* \xrightarrow[\substack{inverse\ reaction\\ in\ nucleous}]{} 2(p+e^-) \xrightarrow[Atomization]{\mathrm{Re}combination} 2\mathrm{H}\ ,$$

by which DM could have washed out both itself and M-A to only matter. Where the consumed mass of M-A would be equal to the mass of produced 'matter' from the washing-out, assuming a quasi-static process. In such a static condition,

$$\begin{aligned}&\text{mass rate of the } DM \text{ undergoes reaction- in total } DM \text{ mass rate } (\Rightarrow \text{now: } 0.268)\\ &\equiv mass\text{ rate of } (M\text{-}A) \text{ in the early universe}\\ &\Rightarrow (\text{now: } 0.049 \text{ as only Matter}).\end{aligned}$$

It is interesting that this observed value of Planck 2013 is very near the mean mass content of (η, π^0) in $DM_{90*f0(1370)}$ and $DM_{70*f0(1710)}$: 0.051, whose value should be necessarily constant as far as these DMs are surviving.

== NOTES ==

As seen we have calculated the content of Atom as 0.04609 based upon an inverse reaction of γ **f_0** from ur-Higgs boson into J/Ψ, and that decay to η_C (1S) from η_C (2S) is much suppressed in observation. (K.K: *2013 Bormio Conference*_71) Here if we admit such a rare decay, the content will be extended a little; so be put 0.049 after Planck 2013. Then the content of DM is also modified as

$$\Delta R_{(\mathrm{DM})} = R_{(\mathrm{DM})}{}'\left(=0.2357\right)\times\left(\frac{0.049-0.04609}{0.04609}\times\frac{2/3}{1/3}\right)\approx 0.030,$$

$$\therefore\ R_{(\mathrm{DM})}{}^{\mathrm{mod}} \equiv R_{(\mathrm{DM})}{}' + \Delta R_{(\mathrm{DM})} \approx 0.266,$$

$$R_{(\mathrm{DE})}{}^{\mathrm{mod}} \equiv 1 - R_{(Atom)}{}^{\mathrm{mod}} - R_{(\mathrm{DM})}{}^{\mathrm{mod}} \approx 1-0.049-0.266 = 0.685.$$

Where the factors of 2/3 and 1/3 are splitting rates from ur-Higgs boson (GBs $_{240\sigma\text{-mesons}}$) into DMs and resonant state: (tr-O)* of Higgs bosons (**tr**uncated-**O**ctahedron) via fragmentation, respectively.

Overview of degenerate of ur-Higgs