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-H⁰),
   - 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-H⁰):

Ur-H⁰ (mass of 120.611 GeV/c²) can be transformed finally to the excited Higgs boson (H⁰) with corrected mass of 125.28 GeV/c², through multi-photon resonances of its component by irradiated γ-rays from neighboring (t̅t̅)’s onto it (ur-H⁰).

Bethe-Salpeter eq.

K.K: PoS(EPS-HEP 2013)002
The rate of excited Higgs boson would be equivalent to the rate of Atom itself. Then from the phase transition diagram,

$$R_{\text{Atom}}' = \frac{1}{N_e} \times (1 - \eta_{\gamma-Q}) = \frac{1}{N_e} \times \left(1 - \frac{2M_t - M_t/\sqrt{2}}{2M_t}\right) = 0.03728,$$

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

$$\Delta m = 125.28 - 120.611 = 4.669 \text{ GeV} / c^2, \quad E_\gamma = 492.35 \text{ MeV}.$$
The rate of ‘total matter’ is estimated as

\[ R_{(\text{total matter})}' = (1 - \eta_Q) = \frac{1}{2\sqrt{2}}. \]

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

\[ (1 - 1/3) \times R_{(\text{total matter})}' = \frac{1}{3\sqrt{2}} = 0.2357 \equiv R_{(\text{DM})}'. \]

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,

\[ R_{(\text{Atom})}' \equiv R_{(\text{Atom})}' \times (1/M_t) \left[ M_t + \left\{ M_b + M_c + M_s + n^* (\text{gluon}) \right\} \right] = 0.04609, \]

where we put \( n^* \equiv 1/\alpha \), \( \alpha \) : fine structure constant; and \( (\text{gluon}) \) : 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 $\sigma$ mesons
Gradual disruption of DE mesons by collisions of rather low-mass fullerene into smaller ones consist of several $\sigma$ mesons with some $\omega$ 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 $\omega$ 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 \( P = -\rho_i/3 \) by Robertson-Walker eq.

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

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

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

Where we assigned \( \frac{da}{dt} \bigg|_{a(t)=a_i(t)} = 0 \).

And, \( \frac{d^2 a}{dt^2} \bigg|_{a(t)=a_i(t)} = 0 \);

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

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

with \( a_0 = 1 \).

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 $\sigma$ mesons as a membrane, we shall firstly express the pressure produced by strong forces among $\sigma$ mesons (attractive) and also among $\omega$ mesons (repulsive) on local surface shown in figure below.
From Zoelly’s formula, classically, allowable buckling pressure is

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

\( E_Y \): Young modulus, \( \nu \): 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:

\[ \sum_{i} \frac{n_i}{N_i} = 1 \quad \text{is satisfied.} \]
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 $f_{\text{max}}$. In extreme case, the repulsive movement will be very small.
2) Completing moderate deformation with $f'_{\text{max}}$, then, DE leaves.
3) After the force reaches $f''_{\text{max}}$ with small deformation, DE leaves.

Apparently, $f''_{\text{max}, (i)} < f'_{\text{max}, (i)} < f_{\text{max}, (i)}$, 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.

$$ E_{\text{Total}}(i) = \int_0^{\delta(i)} F_{\text{disrupt}}(i) \cdot dr + \int_0^{l(i)} F_{\text{movement}}(i) \cdot dr $$
Moreover \( k(i) \) should be replaced by \( k(i+1) \) after \( i \)th disruption has occurred.

From Zoelly’s formula also, and referring the property of \( j \)th colliding angle \( K(ij) \) above,

\[
\Delta M : \text{DE mass} > 0, \quad u(l(i)) : \text{leaving velocity along } r \text{ at } l(i).
\]

Let \( K(ij) \equiv \cos \theta(ij), \quad 0 \leq \theta(ij) \leq \frac{\pi}{2} \); then \( K(ij) \) will express the effectiveness of \( j \)th collision in \( i \)th disruption. Where \( \theta(ij) \): colliding angle.

Moreover \( k(l) \) should be replaced by \( k(i+1) \) after \( i \)th disruption has occurred. From Zoelly’s formula also,

\[
k(i) \left( \propto 1/R^2(i) \right) \equiv c(i)/R^2(i).
\]

And referring the property of \( j \)th colliding angle \( K(ij) \) above,

\[
\sum_{j=1}^{N(i)} \left\{ K(ij) \left( \frac{k(ij) \Delta \delta(ij)}{2} \right) \right\} \equiv E_{<\text{net}>}^{\text{elastic}}(i) = \frac{c(i)}{2} \varepsilon(i)^2, \quad \text{where} \quad \varepsilon(i) \equiv \delta(i)/R(i).
\]
Since $c_{(i)j}=c_{(i)}$, then we have a formula for the saturated energy under local micro deformation:

$$\varepsilon_{(i)} = \sqrt{\sum_{j=1}^{N_{c(i)}} K_{(i)j}} \Delta \varepsilon_{(i)j}^2$$

or,

$$\delta_{(i)} = \sqrt{\sum_{j=1}^{N_{c(i)}} K_{(i)j} \left( k_{(i)j} / k_{(i)} \right) \Delta \delta_{(i)j}^2}$$

where $\Delta \varepsilon_{(i)j} \equiv \Delta \delta_{(i)j} / R_{(i)j}$.

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 ($\lambda$) is constant between $i_{th}$ and $(i+1)_{th}$ disruption with random velocity in direction of DE with Maxwell distribution,

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

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

$$= \frac{\sqrt{\Delta M}}{2 \rho_{DE(i)} \sigma_{DE(i)} \sqrt{E_{<Total>(i)}} - \left( k_{(i)} / 2 \right) \delta_{(i)}^2} \cdot \frac{N_{C(i)}}{\rho_{DE(i)} \sigma_{DE(i)} \sqrt{E_{<Total>(i)}}}.$$
Where, \( \Delta M = \lim_{\rho_N \to 0} \left\{ M - \frac{g^2}{m^2} \rho_N \left( 1 - \frac{3}{10} \frac{k_F^2}{M^2} \right) \right\} > 0; \) \( \) (H. Kurasawa: *Buturi*, 49(1994)628)

\[
\therefore \Delta M_{\text{min}} = \lim_{\rho_N \to 0} \left[ \sqrt{\frac{3}{5}} k_F^2 \frac{g^2}{m^2} \rho_N - \frac{g^2}{m^2} \rho_N \left\{ 1 - \frac{3}{10} k_F^2 \left( \frac{3}{5} k_F^2 \frac{g^2}{m^2} \rho_N \right)^{\frac{2}{3}} \right\} \right] > 0,
\]

\( k_F \): Fermi wave number, \( \rho_N \): density of nucleon.
Behavior of Expansion of the Universe – Number of DE

\[ n(t) = n_0 \exp \left[ \frac{1}{a_0^2} - \frac{1}{a^2(t)} \right] / 2, \]

where \( n_0, a_0 \) : at equilibrium of \( t = t_0 \gg 1 \).

The inflection point of \( a(t) \) is at \( n(t)/n_0 = 1/e \).

Here we put \( a_0 = 1 \).

(K.K: DPF2013)
Preliminary: Interval \( (i) \rightarrow (i+1) \) – \( i \) th disruption

Where \( N_{c(i)} \propto \exp(i-1) \).
Mean mass of proton and neutron is chosen for the value of $M$.

Putting $\Delta M_{(\text{min})} \rightarrow 0$ as an effective mass of DE at a limit, we obtain $M = 254.6$ MeV/c² at $\rho_N = 0.1331[1/\text{fm}^3]$. 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 $\Delta M \to 0$ with wave number ($k$),

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

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 $k_{(N+1)2} \equiv n_2 k^0$,

$$n_1 + n_2 = N + 1. \quad \text{And we assume } \left| n_1 - n_2 \right| \leq 1.$$

Then if $n_1 \neq n_2$, 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 $(\text{odd})^{th}$ collision.

In another case that disrupted two DEs have different (1:2) momentum, the disruption will occur after $(\text{even})^{th}$ 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:

\[ \Psi(r, \theta, \varphi, t) = \frac{A}{r} \cos (k \cdot r - \omega t + \varphi). \]

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

\[ \Psi_0 = \frac{A_0}{r} \cos (k_0 \cdot r - \omega_0 t + \varphi_0). \]

Also that of additional-DE is

\[ \Psi_{(i)} = \frac{A_{(i)}}{R_{(i)}} \cos (k_{(i)} \cdot R_{(i)} - \omega_{(i)} t_{(i)} + \varphi_{(i)}). \]

By superimposing all of them,

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

\[ = \frac{A_0}{r} \cos (k_0 \cdot r - \omega_0 t + \varphi_0) + \sum_i \frac{A_{(i)}}{R_{(i)}} \cos (k_{(i)} \cdot R_{(i)} - \omega_{(i)} t_{(i)} + \varphi_{(i)}). \]

\[ \therefore \] [Probability of presence] \( \propto (\Psi')^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)

\[
\begin{align*}
GB & \equiv f_0(500) \equiv \sigma \text{ meson; } \text{ur-Higgs} \equiv 80^* f_0(1500) \\
\text{DM}_{90f_0(1370)} & \equiv 90^* f_0(1370) \\
\text{DM}_{70f_0(1710)} & \equiv 70^* f_0(1710)
\end{align*}
\]

*: molecular state

\[
\begin{align*}
m_{f_0(1370)} & = \left[ GB + \left( \frac{3}{90} \right) \eta_0 + \left( \frac{70}{90} \right) K^0 + \left( \frac{2}{3} \times \frac{70}{90} \right) K^\pm + \left( \frac{75}{90} \right) \pi^\pm + \left( \frac{40}{90} \right) \pi^0 \right] m_i
\\
m_{f_0(1500)} & = \left[ 3GB \right] m_i \\
m_{f_0(1710)} & = \left[ GB + K^0 + \left( \frac{1}{3} \right) K^\pm + 4\pi^\pm \right] m_i
\end{align*}
\]

(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;

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

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 $q_{\bar{q}}$ (M-A) of same flavor in QGP state approaches. Here the process of $\pi^-$ shall be the conjugate one of $\pi^+$; 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: $\eta$, $\pi^0$. 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 ($\eta$, $\pi^0$) masses. Then

$$ (\eta/\pi^0\pi^0) \xrightarrow{+(q_i\bar{q}_i)^*/(gg=GB)\text{ resonant}} (\eta/\pi^0\pi^0)^* \xrightarrow{\text{inverse reaction in nucleous}} 2(p+e^-) \xrightarrow{\text{Recombination Atomization}} 2H, $$

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,

<table>
<thead>
<tr>
<th>mass rate of the DM undergoes reaction- in total DM mass rate ( $\Rightarrow$ now: 0.268)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\equiv$ mass rate of (M-A) in the early universe</td>
</tr>
<tr>
<td>$\Rightarrow$ (now: 0.049 as only Matter).</td>
</tr>
</tbody>
</table>

It is interesting that this observed value of Planck 2013 is very near the mean mass content of ($\eta$, $\pi^0$) in DM$_{90*\text{f0}(1370)}$ and DM$_{70*\text{f0}(1710)}$: 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 $\gamma f_0$ from ur-Higgs boson into $J/\Psi$, and that decay to $\eta_C (1S)$ from $\eta_C (2S)$ 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

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

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

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

Where the factors of $2/3$ and $1/3$ are splitting rates from ur-Higgs boson (GBs $240\sigma$-mesons) into DMs and resonant state: (tr-O)* of Higgs bosons (truncated-Octahedron) via fragmentation, respectively.
Overview of degenerate of ur-Higgs

- ur-Higgs
  - (fold) excite
  - decay (develop)

- (ur-Higgs)*
  - (fragmentation)
  - (fold)

- (tr-O)*
  - decay (γγ; ...)
  - excite

- Dark Matter
  - Dark Energy
  - Glueball level
  - Meson (mass) level

- GeV/c^2
  - 125.28
  - 120.611
  - (ΔM >0)