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Nucleon Halo Model of ^{8}Be*

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[Abstract]

A model of final state interaction for ^{8}Be* of 4D/TSC fusion is proposed. The ^{8}Be*(Ex=47.6MeV) may damp its excited energy by major BOLEP (burst of low energy photons) process from <n-h-h-n> nucleon-helion halo state to ^{8}Be-ground state. Intermediate decay states from the nucleon-halo states are scaled by number of effective binding PEF values for mean strong field interaction. A complex decay scheme is proposed. Minor two-alpha break-up channels emit characteristic discrete kinetic energy alpha-particles, which meets wonderful coincidence with observed data by Roussetski et al. X-ray burst data observed by Karabut et al may be photons by BOLEP.

Keywords: 4D/TSC, final state interaction, ^{8}Be* decay, nucleon-halo, BOLEP, alpha-particle

1. Introduction

Explanation for heat/^{4}He correlation, without neutron emission, by experimental CF claims (The first claim was done by M. Miles et al.: The Science of Cold Fusion, Italian Physical Society, 1991, pp. 363-372, and confirming claims by several other groups) is of great interest on possible novel nuclear reaction that is peculiar to condensed matter environments of deuterium-loaded metals. Our 4D/TSC theory predicts the consequence of 23.8 MeV/^{4}He with very low-level n/t secondary/minor production [1-3]. However, the final state interaction of ^{8}Be* at highly excited energy is very complex and yet to be studied in detail. This paper discusses on our new proposal of nucleon-halo model of ^{8}Be* and possible EM transitions (BOLEP) with 1 - 10 keV burst-photons-emission and with competing minor hadronic break-up channels, namely mostly going out to two alpha-particles with specific peaks of kinetic energy.

To make theoretical modeling on possible nuclear effects, we need to theorize the three steps of nuclear and electro-magnetic field interaction processes, as shown in Fig.1, rationally and quantitatively. In our past works of TSC theory [1-3], we have intensively studied on the initial state interactions and intermediate states. The final state interaction was very briefly speculated. The situation, including the consequence of this work, is shown by the simplified scheme of 4 steps in Fig.2.

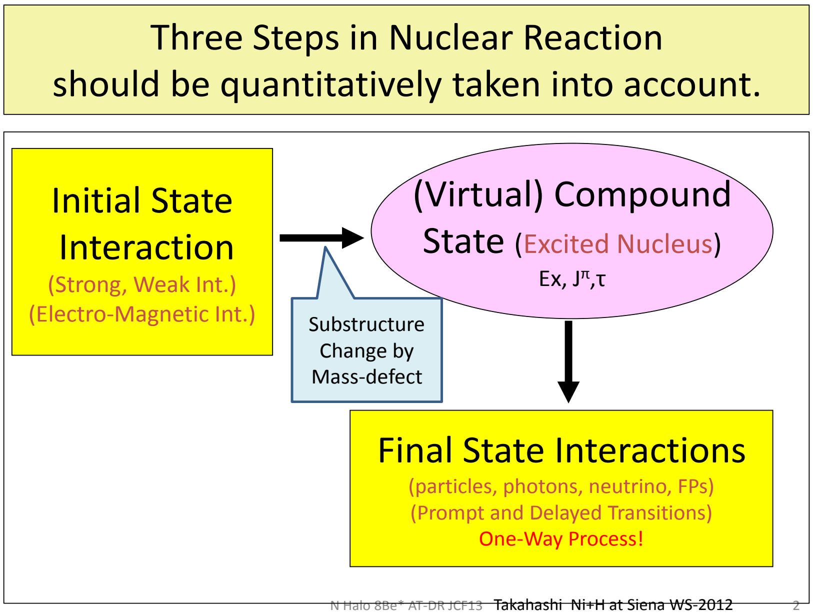

Fig.1: Three steps to be theoretically treated for condensed matter nuclear reactions

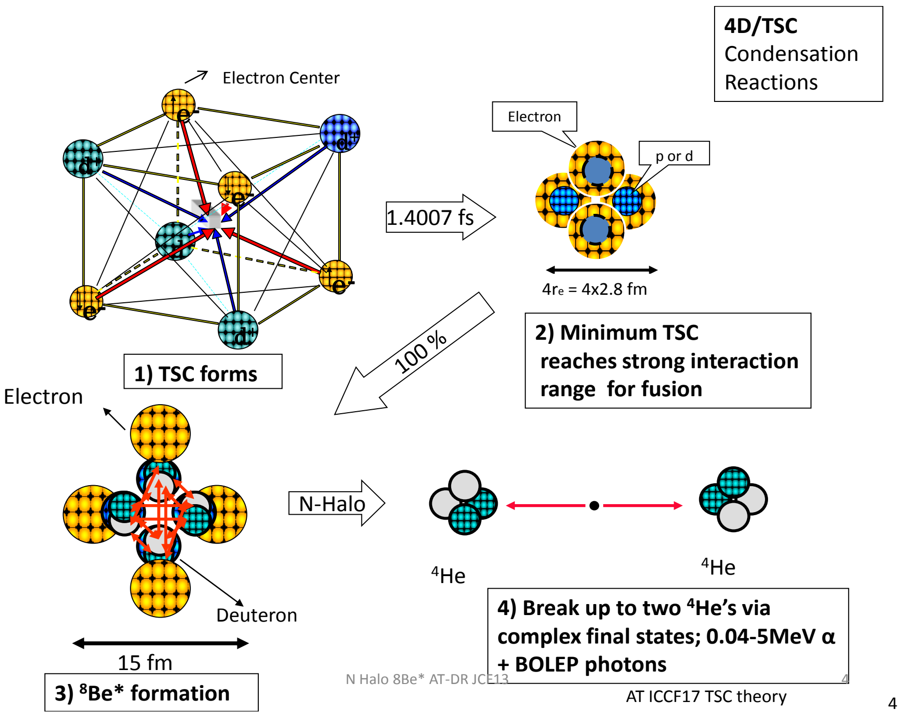

Fig.2: Process in four steps for 4D/TSC fusion model by the TSC theory [1-3]

2. Brief View on Recent Nucleon Halo Theories for Light Nuclei

L. Subshukin and H. Toki wrote a good text book [4] on recent progress of nuclear physics. They treated mean field-theory components as pionic exchanges and spin-orbital coupling tensor force based on a relativistic Dirac equation. An example of their book for nuclear binding energy calculation on light elements is picked up in Fig.3.

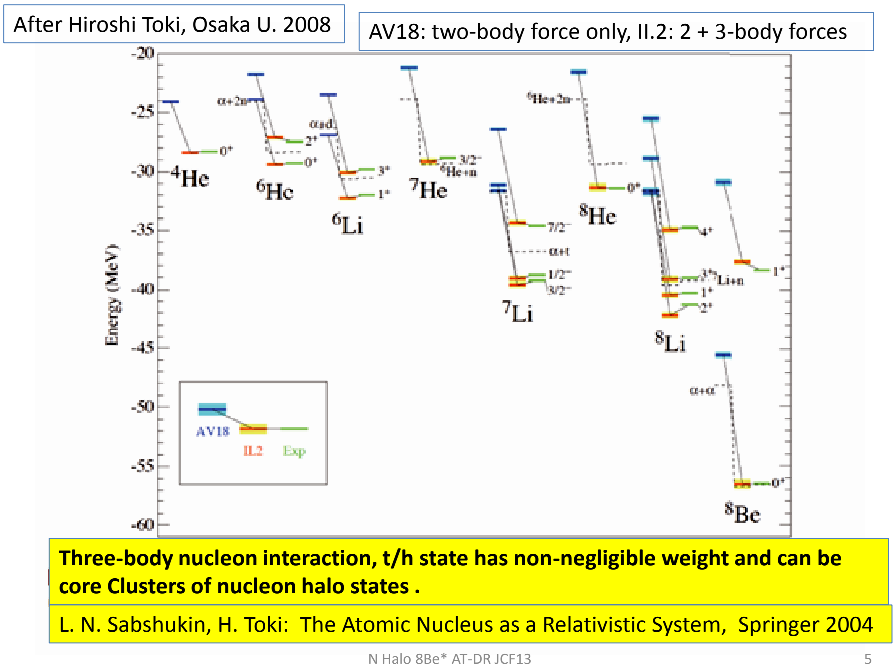

Fig.3: Nuclear binding energy calculated for light nuclei [4]

The component of two-body pionic interactions between nucleons (n-p, n-n and p-p) is the main force as expected by the mean field theory. However, three-body nucleon interaction, t/h state has non-negligible weight and can be core-clusters of nucleon halo state. Such hellion (h) or triton(t) cluster state is considered to appear at highly excited states of light nuclei or even at ground states of halo-nuclei as ^{8}He, ^{8}Li, ^{8}B, ^{10}Li, ^{12}Li, and so forth [5]. At highly excited states of ^{12}C, three-alpha cluster state appears first in the intermediate excited state range and the chaotic gaseous nucleon states bound each-others as shown in Fig.4 [5] appears finally at very highly excited state. In a simple image of understanding, very highly excited states of light nucleus must be sustained by vibration energies between ‘isolated’ α- or h/t-clusters and also by coupled rotation energies of ‘halo’ nucleons (neutron-halo state in many cases). When the excitation energy goes up to extremely high, the QM chaotic energy states must appear to sustain the very high excited energy. The ground state of ^{8}Be is exceptional among

A=8 nuclides: the recent precise 8-body calculation [6] showed a clear image of two-alpha-cluster state as shown in Fig.5. The n-halo states of Be isotopes are imaged in Fig.6 [5].

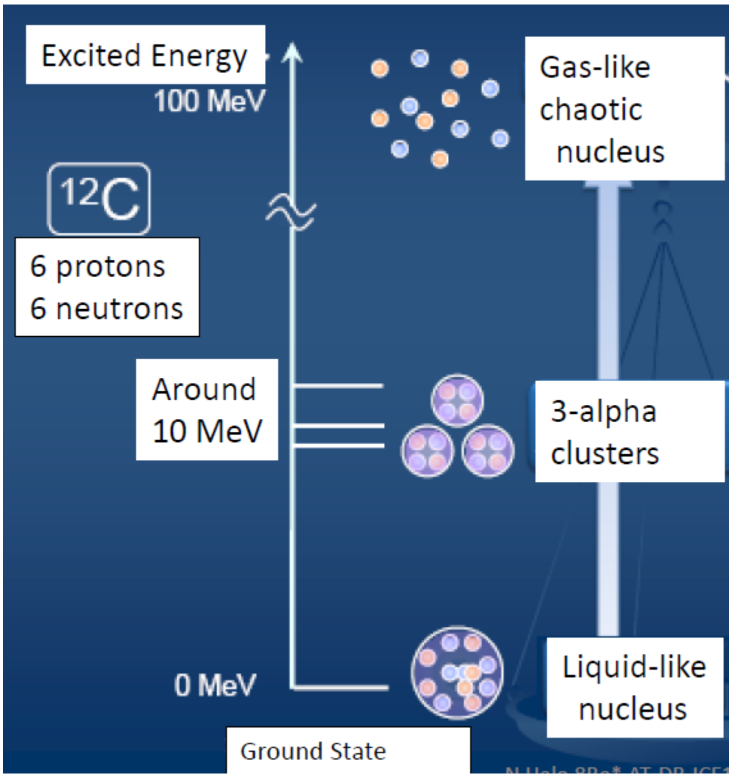

Fig.4: Cluster and chaotic gaseous states of nucleons at highly excited light nucleus ^{12}C [5]

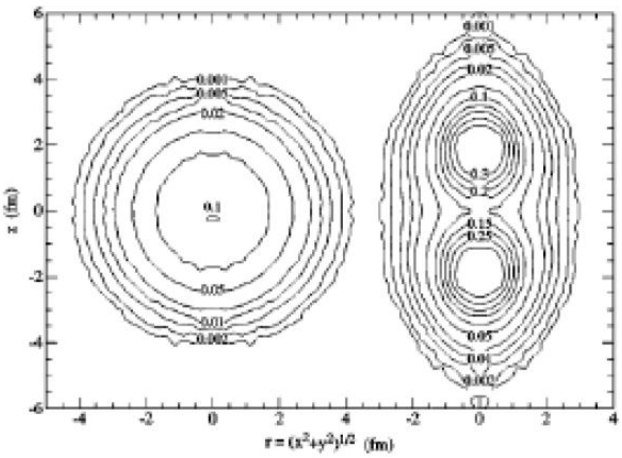

Fig.5: Precise 8 body calculation for ^{8}Be ground state [6] showing the tandem two-alpha clusters; view from top (left) and from side (right)

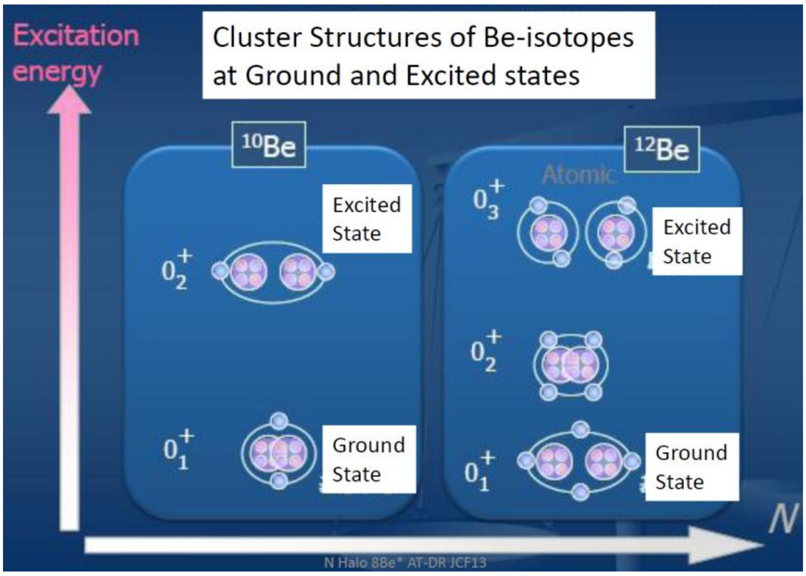

Fig.6: Nucleon halo modeling for highly excited states of Be isotopes [5]

3. Modeling for Nucleon-Halo States of ^{8}Be*

The tetrahedral/octahedral configuration of ^{8}Be* nucleons as intermediate compound state of 4d fusion needs further study. Pion (isospin) exchange between n and p states of nucleons may suggest 3-dimensional symmetric arrangement as n-p-n-p-n-p-n-p to form nuclear TSC state, which will have rotation energy level scheme as deformed from an ideal sphere. However, such non-cluster state should correspond to the QM chaotic 'gaseous' state of very high excited energy as shown in Fig.4. ^{8}Be (as well as most of light nuclei) can be described better as 2 clusters of alpha particles, each cluster being 2 protons and 2 neutrons in the 1s nuclear-shell. Excited states ^{8}Be* are described by excitations between these 2 clusters. However, at very highly excited state as ^{8}Be*(Ex=47.6 MeV) after 4D/TSC fusion, the deformed state configuration seems quite different, as we will discuss and model below.

Now, if we concentrate in a condition of a lot of energy together, maybe the force can fuse these 2 clusters in one core. The difference would be that this fusion would be endothermic and would create exotic excited states. For example:

1) Cluster A would lose 2 neutrons to cluster B, so, cluster B would have 2 extra neutrons, like ^{6}He. ^{6}He has a halo-sate of two satellite neutrons. Maybe this excited state will have a halo of h-cluster.
2) Cluster A would lose 1 neutron and 1 proton. So, cluster B would have a

configuration of ^{6}Li, cluster A would be like a deuteron. But, because of the symmetry, cluster A could be also a ^{6}Li and B is a deuteron. So, there could be 2 alpha-weird mode of excitation: 1 proton and 1 neutron would come and go from cluster A to B.

3) Cluster A and B could lose 1 neutron and 1 proton at the same time. So, cluster A and cluster B would both share a deuteron.

Now we are considering a PEF-number-to-effective-spring-potential model, for formulating a simplified effective Hamiltonian of ^{8}Be* for the final state interactions. Here PEF (pion exchange force) is a measure of mean charged pion exchange field based on Yukawa-Wigner force and isopin [1].

The h- and t-cluster are the same nuclear-equivalent state as nucleon is (<n> + <p>)/2 because of very rapid pion-exchange between neutron <n> and proton <p> state of nucleon inside nucleus.

In Fig.7, ^{4}He*(Ex=23.8MeV) state is imagined as a n-halo state with Ex > $(1/2)K_2R_{halo}^2$ (PEF spring potential). This may correspond to a rapid break-up to n + h + 3.25MeV channel. Binding PEF number is 2 there, which is not strong enough to sustain the 23.8 MeV excitation energy and causes a prompt break-up to n + h or p + t.

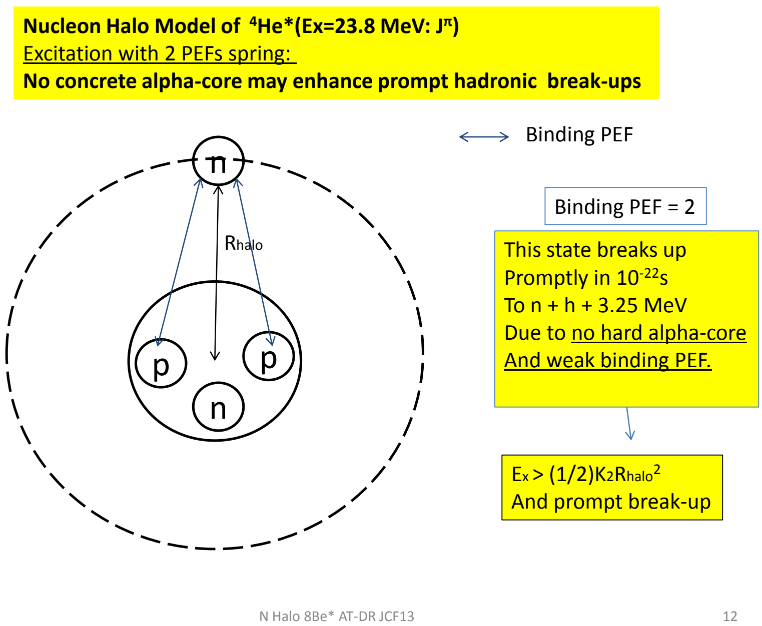

Fig.7: n-halo model for ^{4}He (Ex=23.8MeV) after d-d two-body fusion

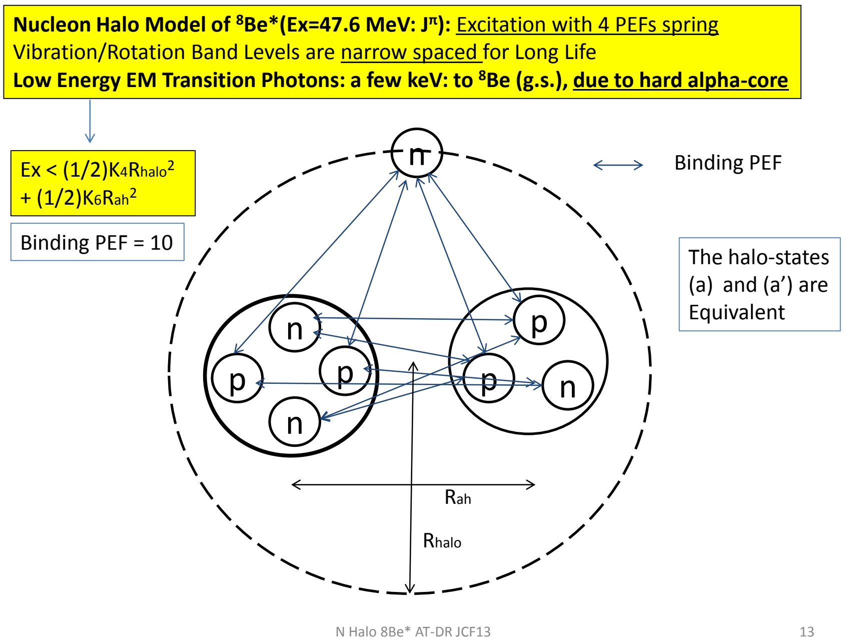

Fig.8: Nucleon-halo model for ^{8}Be* at highly excited state (Ex= 42 MeV)

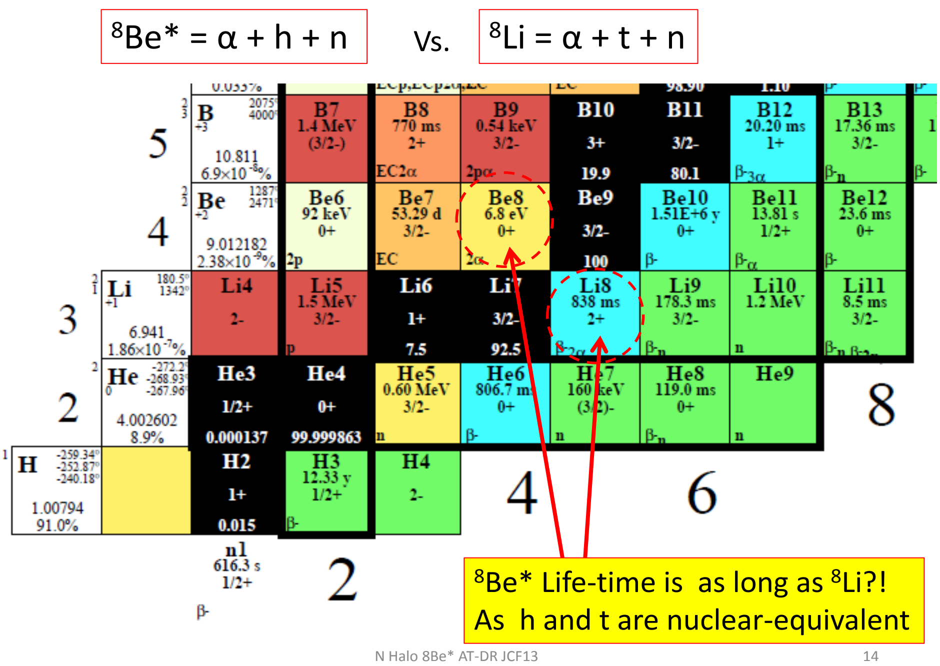

Fig.9: Nuclide chart for light elements and A=8 nuclides for comparison

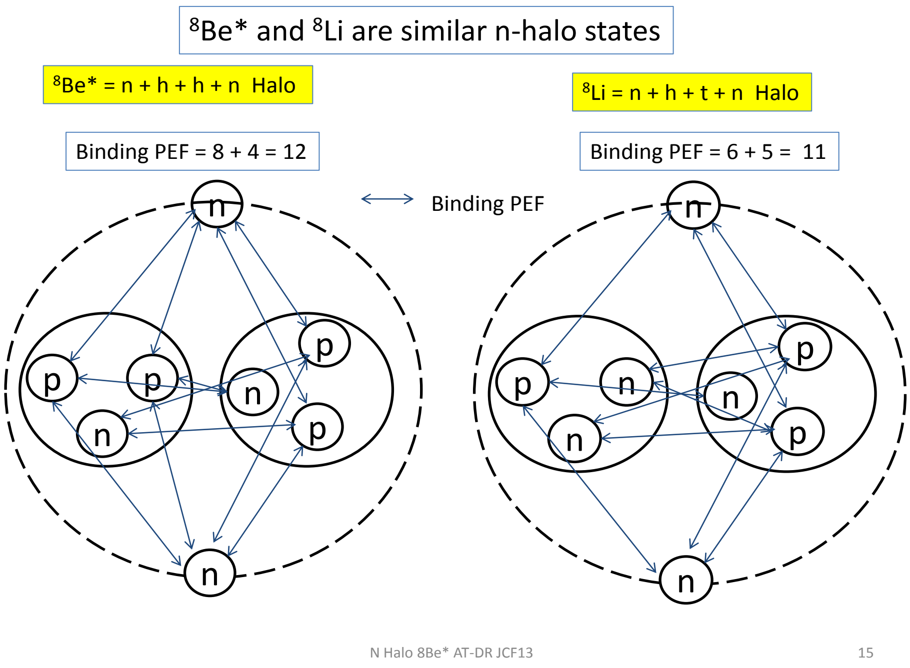

Fig.10: The proposed <n-h-h-n> halo-state of ^{8}Be*(Ex=47.6MeV) compared with ^{8}Li halo-state

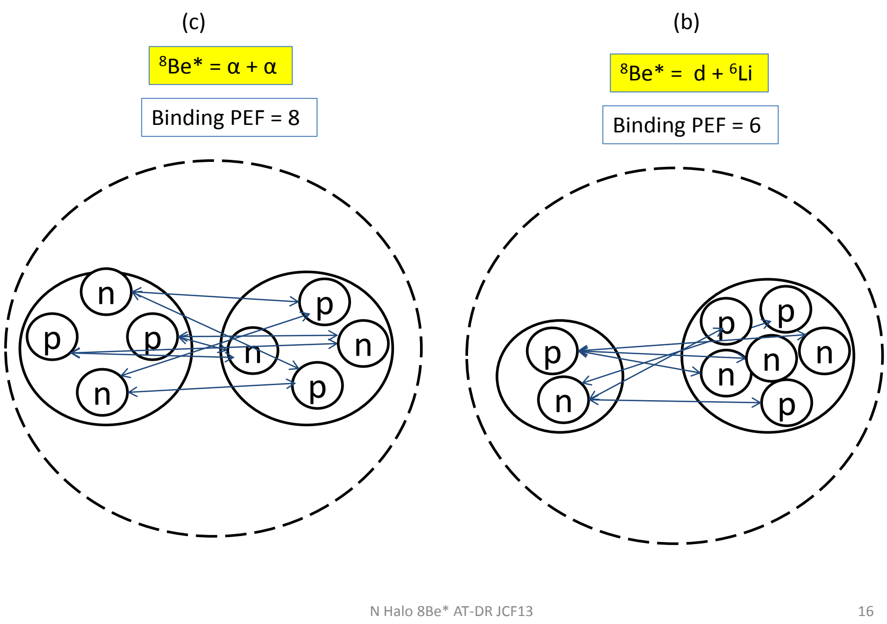

Fig.11: PEF model for cluster states of ^{8}Be* at lower excited states Ex $\leqq$ 34 MeV

Similarly, when we consider the inter-nuclear configuration of 'virtual' ^{4}H nucleus, we may model it as a n-halo with a t-cluster, which has only 1 binding PEF and therefore weak enough to break up to n + t channels very promptly in 10^{-23} s.

In Fig. 8, ^{8}Be*(Ex=47.6MeV) state is speculated as a n-halo state with Ex < (spring potential of n-halo) + (alpha-h vibration potential). Excess inertia by the rotation of n-halo will make the ^{8}Be* state more meta-stable to generate narrow-spaced rotation-vibration energy-eigen-values. It also seems that ^{8}B is also a halo nucleus, but with protons. Similarly ^{8}Li has a halo state with halo neutrons. So, it seems that A=8 is a magical number for halos. We will also try to test the idea with ^{4}He, considering it that t and ^{3}He (h: helion) are nuclear-symmetrical, as discussed above already. To this respect it is interesting to see Fig.9, which compares life-times and decay-schemes of A=8 nuclei. Most A=8 nuclei have long life times as several hundred ms at their ground states, except for ^{8}Be that decays to two-alphas with 0.067 fs life time. As seen by Figs.8, 10 and 11, ^{8}Be* (excited state) may have very similar nucleon-halo states to that of ^{8}Li, with similar binding PEF numbers. Such analogous states suggest us that the life time of ^{8}Be*(Ex=47.6 MeV) may be 'rather' long as a few ms or more.

The ^{4}He-cluster has a very powerful binding (PEF=4 in inside binding) for keeping its rest mass because of the symmetry between h- and t-cluster inside it. We can think of a pair of t and h sharing a deuteron there. Also, we may consider the coincident completion of the shell model.

The ^{6}Li-cluster can be split to a pair of h and t clusters. These clusters are weakly bound (binding PEF = 5, as seen in Fig.10, compared with binding PEF = 6 for h-h coupling) which explains the experimentally verified very low average nuclear binding. This configuration should be more stable than the shell model, which may let a deuteron alone around the alpha core. Next, we consider that ^{8}Be* can be 2-alpha clusters. It should be h and t clusters with 2 halo neutrons, also, at higher excitation energy than the threshold of two-alpha cluster state (see Table-1). Note that the evidence of a cluster of h and t can be seen considering the reactions: ^{6}Li + n → ^{4}He + ^{3}T and ^{7}Li + p → ^{8}Be → 2^{4}He, as evaluated in TUNL Library [7].

Possible maximum excitation energy (Ex) states of ^{8}Be* can be scaled by the measure of binding pion-exchange-force number (Binding PEF) as shown in Table-1. This evaluation was deduced by comparing the TUNL level scheme [7] of ^{8}Be and nucleon-halo status shown in Figs.8, 10 and 11, as we know the threshold-energies of two-body reactions as p + ^{7}Li (Binding PEF = 4 and maximum excitation energy 17 MeV) and d + ^{6}Li and their binding PEF numbers (see Table-1). From this speculative extrapolation assuming the proportionality of maximum excitation energy versus binding PEF number, we can define the maximum excited energy of two-alpha cluster state (binding PEF =8) of ^{8}Be* is ca. 34 MeV, over which ^{8}Be* should be ‘dissociated’ to the <α-t-n> halo state (binding PEF =10) or the <n-h-h-n> halo state (binding PEF =12) for sustaining definite life-time of such highly excited states.

Table-1: Speculated maximum excitation energies for various cluster/halo states of ^{8}Be*

Possible Maximum Excitation Energy (Ex) States of ^{8}Be* can be scaled by Binding Pion-Exchange-Force Number.

Cluster/Halo State	Binding PEF	Maximum Ex	Dominance
(e) p + ^{7}Li (n + ^{7}Be)	4	17 MeV	Minor
(c) ^{6}Li + d	6	25 MeV	Minor
(b) α + α	8	34 MeV	Minor
(a) h + α + n (a’) t + α + p	10	42 MeV	**2nd**
(d) n +h + h + n (p+t+t+p)	12	50 MeV	**Main for 4D/TSC**
(f) 4p + 4n chaotic admixture	16	ca. 66 MeV	None

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Consequently, the ^{8}Be*(Ex=47.6MeV) state is defined as the <n-h-h-n> halo state to sustain the very high excitation energy of 47.6 MeV and might have a few ms life time. From such an evaluation, we can draw the decay scheme of ^{8}Be* as shown in Fig.12.

See also Fig.13, for understanding relations between A=8 nuclei. The ground state of ^{8}Be is peculiar in comparison with ^{8}He, ^{8}Li and ^{8}B ground states which have very long life-times to allow beta- and positron decay. The ground state ^{8}Be has a definite life-time but as short as 0.067fs and decays to two alpha-particles. However, the highly excited states ^{8}Be* may behave somewhat similarly to ^{8}Li due to possible nucleon-halo states and may have prolonged life time (maybe on the order of a few ms or more).

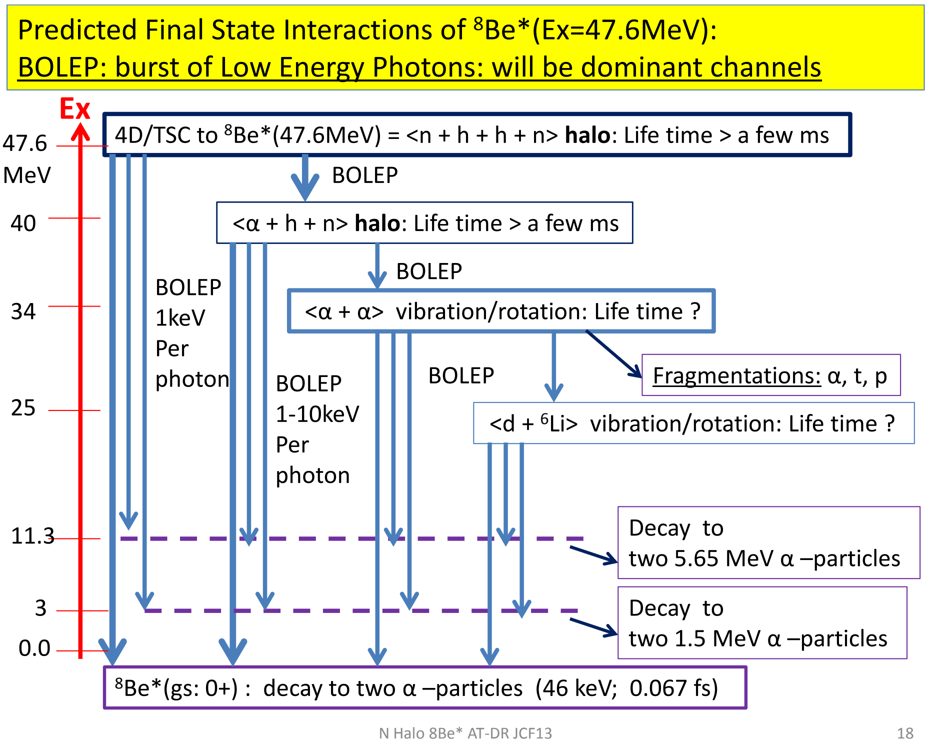

Fig.12: Proposed final state decay scheme of ^{8}Be*(Ex=47.6MeV) by 4D/TSC fusion; There are several even spin-parity states (see Table-2) between 34 and 11.3 MeV, which are not drawn here to avoid complexity of scheme-figure.

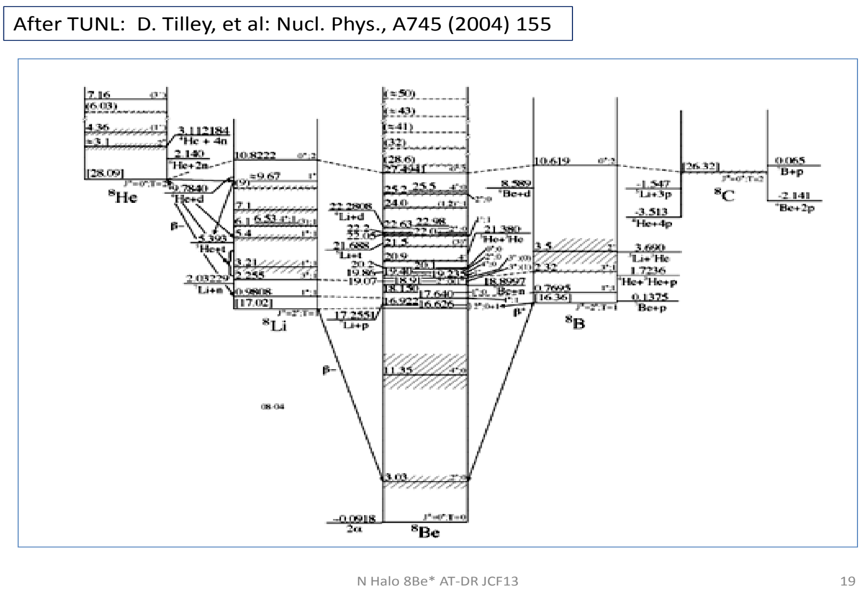

Fig.13: Level scheme of A=8 nuclides from TUNL library [7]

After: RIKEN Nishina Center talk0707 2007

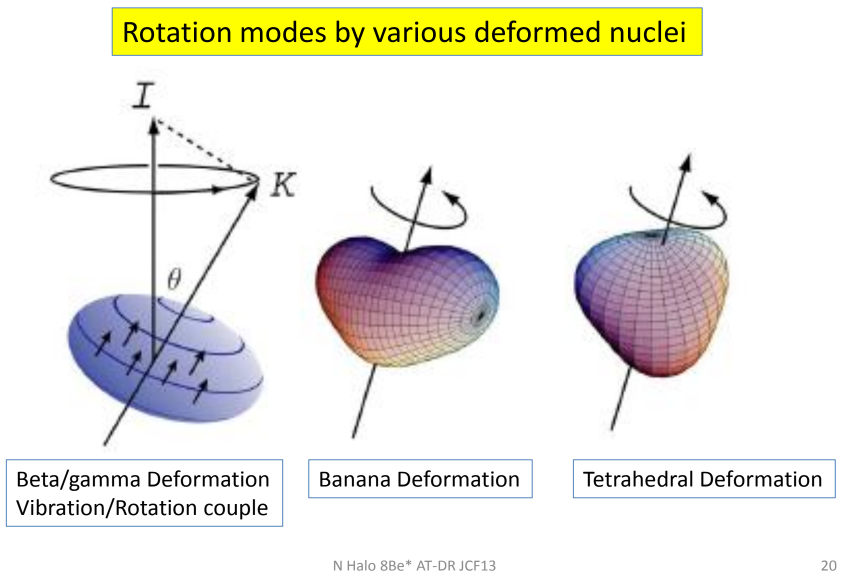

Fig.14: Rotation mode of typical deformed nuclei [8]

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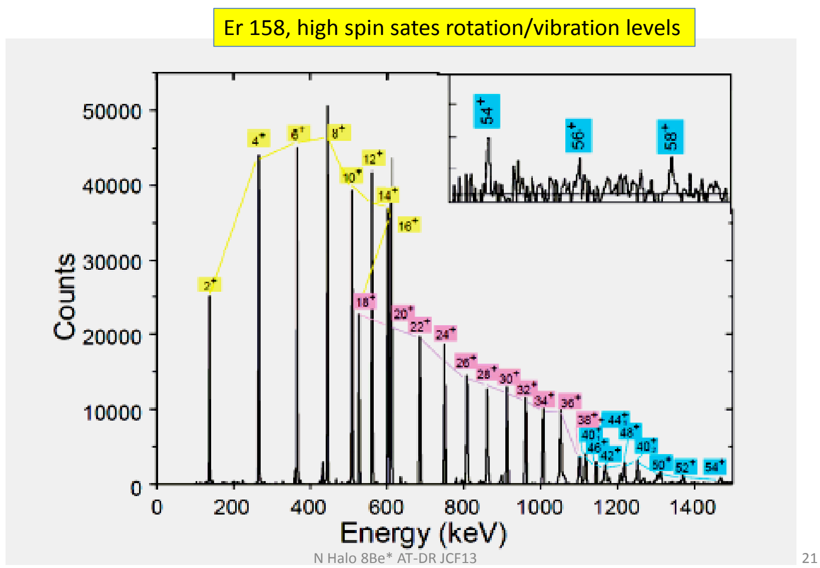

Fig.15: Very high spin state rotation-vibration coupled modes for Er-158 excitation [8]

4. Discussions on the Burst of Low Energy Photons (BOLEP) and Minor Alpha-Emitting Channels

It is possible for ^{8}Be* to exist a large multi-pole momentum for the <n-h-h-n> halo state. We consider, as a rough example: 2^((2(incoming tetrahedral)+2(recoil tetrahedral))*2(at least 1 extra transverse node between each incoming and outgoing components)=2^{16} (=65,536) pole momentum. Considering that it is possible to describe ~15,000 or more independent waves, and each of those carry a quantum of high deformation. The high deformation state could share 47.6 MeV of ^{8}Be* nuclear excitation energy between many 1.5 KeV wave-packets (Low Energy photons), and burst of low energy photons (<u>BOLEP)</u> will happen like as thermal black-body radiation. See Fig.16 for imagined deformed state for ^{8}Be*(Ex=47.6MeV) as very high spherical harmonics mode [9].

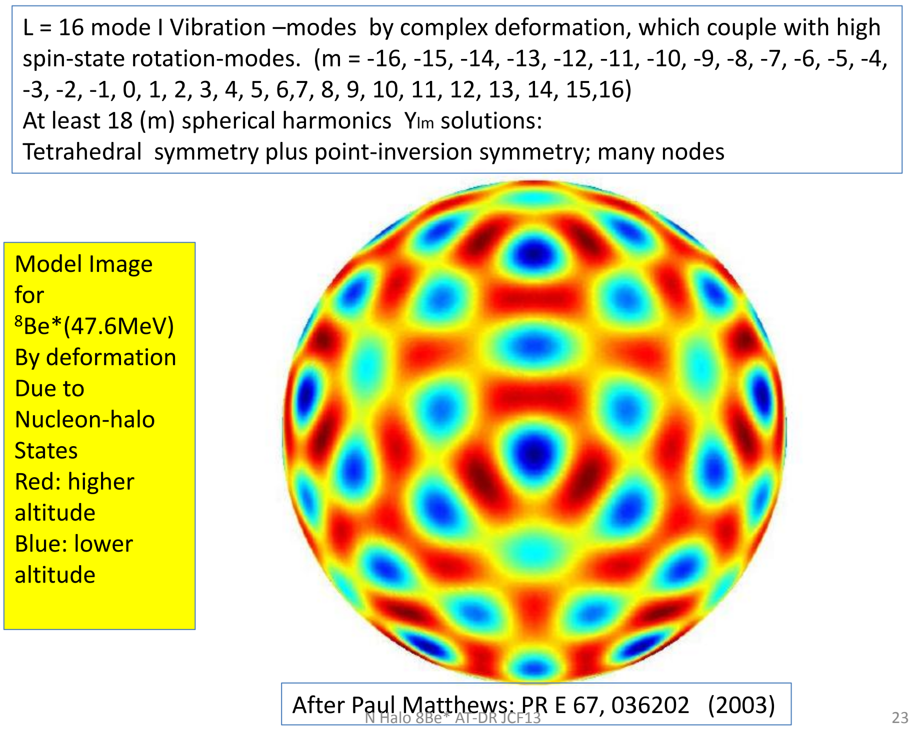

Fig.16: Highly deformed spherical harmonics state (l=16) imagined for ^{8}Be*(Ex=47.6MeV) [9]

A rotation-vibration coupled high spin state of nucleon-halo ^{8}Be* will make such a highly deformed state in 3-dim image. Concerning the deformed nuclei, we did mention about very high deformation modes, which we think is an important point as an example. If 4 nuclei coalesce like liquid drops, the deformation will be higher than a tetrahedral deformation (see Fig. 17), since the collision shock waves can have radial inward and outward (recoil) components and also transverse modes since each incoming proton collides with 3 other protons. We thought that it is possible to enhance existence of a large multi-pole momentum. Also, note that the number of node deformation in the picture is small, but we think there is need to see the superposition with longer wavelength nodes that are not present in the picture. We probably have to think more.

In the basis of alpha-cluster model we shall do modeling. The n-, p-, d-halo state of highly (Ex=47.6 MeV) excited state of ^{8}Be*, as very deformed nuclei has been considered above. A nucleon-halo admixture will have rotation-vibration combined level states with small level-gap band structure (See a case of collision experiment for high mass nucleus Er*, in Fig.16). As ^{8}Li n-halo state has 'very' long life (ca. 0.8 s), ^{8}Be* halo-state may have long life time, due to h/t cluster's nuclear equivalence, which allow cascade-EM-transitions dominant (see Fig.12, accordingly).

To extend quantitative analysis, we need to define effective Hamiltonians for various types in Figs. 8,10, 11 and 16. Core oscillator (α-h or α-t) plus n-(or p-) halo rotator makes band structure of energy-eigen-values: so called rotation/vibration coupled band (see standard nuclear physics text book). Coupled Schroedinger equations for rotation and vibration, for so many modes should be solved. Competition with CP (charged particle) fragmentation channels should be studied. These are difficult task for future.

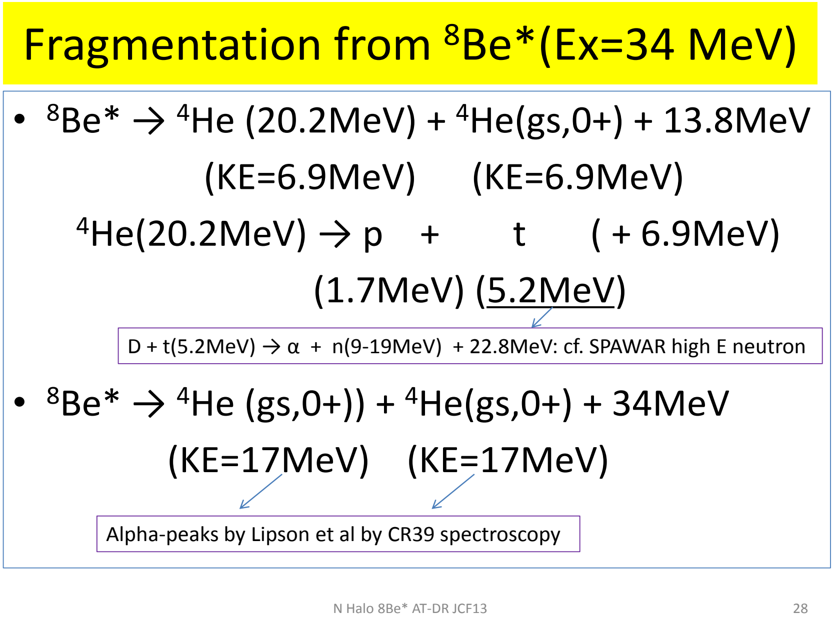

Fig.17: fragmentations from the highest excited state of two-alpha cluster of ^{8}Be*

Possible hadronic break-ups of ^{8}Be* via symmetric fragmentation or asymmetric fragmentation should be considered. Cascade break-ups via lower excited states of ^{8}Be* to two α-particles after the BOLEP transition should be considered. These states are in competition with main EM transitions (BOLEP: black-body radiation-like mechanism) of nucleon-halo rotation/vibration states, damping nuclear excited energy by burst photons to transit to the ground state ^{8}Be(gs:0+) which decays to two 46 keV alpha-particles.

Emitted alpha-particle energies are predicted as follows (see Table-2 also):

Major channel: **46 keV** from ^{8}Be(gs:0+) break-up after BOLEP transitions

(Secondary neutron yield by 46 keV alpha may be negligible, cf. Hagelstein limit, by heterogeneous matter for 4D/TSC generation without other local Ds.)

Minor channels: 1.55MeV, 5.65 MeV, 6.9 MeV, 8.3 MeV, 10 MeV, 11 MeV, 11.5 MeV, 13.8 MeV, **17** MeV (cf. Lipson and Roussetski exp.)

Minor triton emission: 5.2 MeV (cf. SPAWAR exp.)

A lot of works are needed for knowing branching ratios, by experiments and theories.

Fig.18 is added for Roussetski's alpha-spectrum data (beautiful) [10], which is compared with the prediction of this work (Table-2). We find wonderful coincidence for discrete energies (KE) of alpha-particles between Roussetski experiment and the present prediction. This coincidence of alpha-spectrum between our theoretical prediction and other group experiment is a convincing result for the present nucleon halo ^{8}Be* model.

Table-2: Predicted alpha emission channels and their kinetic energies

4D → ^{8}Be*(47.6MeV) → BOLEP + ^{8}Be*(34MeV)
and possible intermediate states which decay to 2α
(Note: only 11.4 and 3.04 MeV states are drawn in Fig.12)

Ex (MeV)	Spin-Parity	Isospin (T)	KE of α-particle (MeV)
34	(0+)	(0)	17
27.5	0+	2	13.8
22.98	(0+)	(0)	11.5
22.0	2+	0	11
20.1	2+	0	10
16.6	2+	0	8.3
11.4	(2+)	(0)	5.7
3.04	2+	0	1.55
-0.092(gs)	0+	0	0.046

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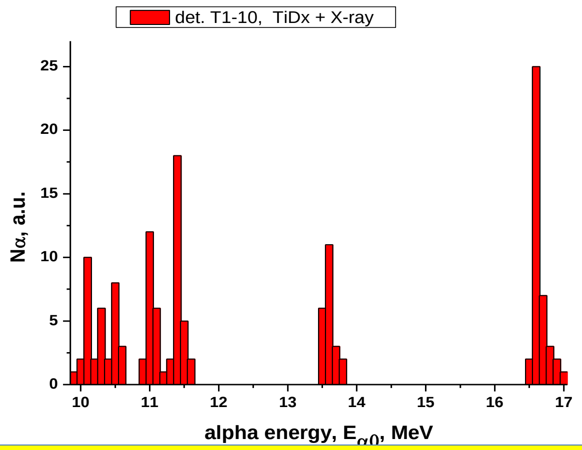
Alpha particle energy spectra (fine structure)
demonstrates few bands in the range 10 – 17 MeV

After A. Roussetski et al, Siena WS 2012: for TiDx system under e-X beam stimulation
JETP Vol.112 (2011) 952



Prediction by N-Halo Model: 17, 13.8, 11.5, 11, 10, 8.3, 5.7, 1.55
and 0.046 (in MeV): Good Agreement with Roussetski Exp.

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Fig.18: Discrete alpha-particle energies observed by Roussetski et al are all agreed with the prediction of minor channels by the 4D/TSC to n-halo ^{8}Be* model

X-ray (0.6-6keV: peak around 1.5 keV)bursts observed by Karabut et al for D-Glow Discharge Experiment with various metals, JCMNS Vol.6, 2012

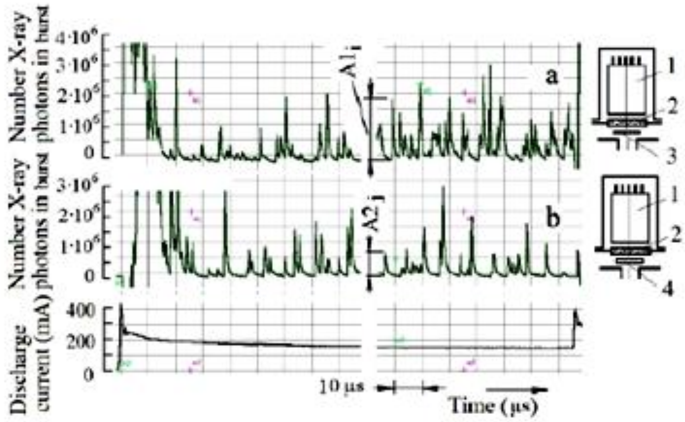

Figure 6. Typical oscillograms of X-ray emission from the PMMA/PM scintillator detector covered with Be foils with different thicknesses: (a) covered with a 15 μm Be foil; (b) covered with a 30 μm Be foil. In this case the cathode was Pd, the gas was D_2, and the discharge current was 150 mA.

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Fig.19: Low energy X-ray burst observed by Karabut et al.[14]; BOLEP may explain it.

Now the story of TSC theory [1-3] looks more rational and more fitting to main experimental observations: Miles et al [10] for the original heat-^{4}He correlation which have been followed by McKubre et al and others[15,16], Lipson [11] for ca.15MeV alpha-particle peak (probably a bunched peak of 17 and 13.8 MeV) from PdDx system, Boss[12] for ^{12}C(n,n')3α reaction by En>14MeV neutrons – see also Fig.4.

We know what Hagelstein spoke and wrote at ICCF17. One of authors questioned him at the Meeting that he did not treat yet nuclear (strong interaction/intermediate/final state) process properly. His 'going-forth and -back oscillation model' is wrong in the nuclear physics view, as pointed out by Fig.1, of one-way stochastic process flow from the initial state to the final state interactions. However, it seems that the Karabut-Karabut- Hagelstein work [14] might see the very BOLEP in their observed hot spots, although they interpreted as those were being from the radiation from electrons of each kind of metal in Hagelstein's theory of collective atoms, as referred in [14], or downloadable at:

http://www.iscmns.org/CMNS/JCMNS-Vol6.pdf :

"Experimental results on Excess Heat Power, Impurity Nuclides and X-ray Production in Experiments with a High-Voltage Electric Discharge System", A.B. Karabut, E.A. Karabut. See page 223(214 in journal), figure 15. Where we see black-body radiation type spectrum that peaks at 1.5KeV. The high nucleon momentum should have an emission that would look like a black body since its distribution is similar to the gas of photons in a box. Compare: downloadable at:

http://en.wikipedia.org/wiki/Bose-Einstein_statistics#A_derivation_of_the_Bose.E2.80.93Einstein_distribution

with http://en.wikipedia.org/wiki/Spherical_harmonics#Spherical_harmonics_expansion

:"Spectral and Temporal Characteristics of X-ray Emission from Metal Electrodes in a High-current Glow Discharge" A.B. Karabut, E.A. Karabut, P.L. Hagelstein. See page See page 231(264 in journal), figure 6, the time between bursts, BOLEP, is around 0.1 to 1ms. Compatible to what we would expect from halo orbits.

We saw the beautiful alpha-particle data by Roussetski et al at the last Siena Workshop, with great impression. We are now studying a nucleon-halo model of ^{8}Be* by 4D/TSC fusion. We have compared our consequence of alpha-particle energies (discrete) and his Siena data:

http://www.iscmns.org/work10/program.htm

Although the predicted alpha discrete energies are from minor channels of the final state interaction of ^{8}Be*(47.6MeV), no other models than that could find such beautiful coincidence with several alpha-peak-energies (see Fig.18).

Why do we not include the blackbody radiation from the Karabut-Karabut-Hagelstein work in conclusion? They tried to explain it with the Hagelstein's collective theory, but the theory is too high for that. They say they still cannot explain it properly. The 1.5KeV peak is however within the range of the BOLEP. We think it would be good to include it due to BOLEP in our conclusion.

Mean photon energy by BOLEP was speculated on the order of 1-2 keV, albeit not precise QM calculations done. We shall reserve 'coincident agreement issue' for future quantitative QM analysis. We think it is possible to do a reasonable approximation to relate BOLEP and the thermal black body radiation, using similarities between the photon gas in a box and the photons from the rotation/vibration of spherical harmonics modes/nodes. We will think about it more. The mere division by the number of states to get 1.5KeV assumes the equivalent-partition theorem as valid. While this might be reasonable because of the relatively large number of states, it is about the peak energy of the black body radiation, as seen in the Karabut-Karabut-Hagelstein spectrum. So, that treating this problem as a classical problem is not enough.

The n-halo state of ^{8}Be*(47.6MeV) may be close to quantum-chaos (4n + 4p chaotic admixture to sustain that very high excitation energy) but still keeping order of helion (h) clusters. So we need QM study for the complexity. Comparing it with Fig.13 for A=8 nuclides and Table-1, we may imagine 'rather long life time' of ^{8}Be*(Ex=47.6MeV) as imagined as more than a few ms. The equilibrium time should be much shorter than the wavelength of the emission time, that is, the wavelength of the outgoing radiation. Since we are thinking about radiation with energies below 10KeV, which is 2 orders of magnitude less than typical nuclear reactions, this is a likely explanation. "Broadening due to local conditions is due to effects which hold in a small region around the emitting element, usually small enough to assure local thermodynamic equilibrium".

We may imagine a burst of low energy photons from a highly excited nucleus with high spin rotation/vibration mixture of isolated/clustered nucleons, since that has no paths to direct fragmentations like ^{8}Be*(47.6MeV) to two 23.8MeV alphas but the multi-photon EM transition (BOLEP) down to lower excited states where alpha-alpha cluster states of excitation (with Ex less than 34 MeV, see Table-1) are of possible sub-structure of excited nucleus.

The ground state of ^{8}Li decays by beta emission, weak interaction, to ^{8}Be*(3MeV:2+), more than 90 % branch, (then breaks up to two alphas), since ^{8}Li is at ground state and cannot have any EM paths to change nuclear substructure. Decays by weak interactions for ^{8}Be*(47.6MeV) are however defeated by the BOLEP EM transition, in contrast, because of its excited state having freedom going to lower states.

However, the BOLEP transition is not a photon emission process with such continuous wave length distribution as the thermal black-body radiation, since it has discrete wave length structure of distribution reflecting QM states of near 'chaotic' rotation/vibration sates of the <n-h-h-n> halo nucleus.

We may have intuition that the BOLEP state can be 'approximately' treated as classical black-body radiation. To prove it we need however some precise QM studies on discrete energy levels structure, maybe strongly coupled mutually as bosonic states (nuclear phonons) of discrete energies, of the <n-h-h-n> halo nucleus under 47.6MeV excited energy. The strong bosonic coupling between 'excitons' will lead to catastrophic/spontaneous burst-photons (BOLEP) dominantly damping directly to the ground state ^{8}Be(gs:0+).

We may however consider that we are talking about trillions of photons detected by the Karabut-Karabut-Hagelstein work [14]. Also, the interval they detected was small, from

~0.5KeV to 10KeV. That means less than 1eV for every level. We may consider variations due to large recoil, since H/D is light, and the non linear variation of the levels. So, trillions of detections would form a continuous spectrum. Yes it may be so, but we have to take it into account that first BOLEP photons with 1.5keV mean discrete energies may be emitted from the ^{8}Be*(Ex=47.6MeV) state and they ionized surrounding metals outer electron-orbits. The recombination of ionized metal atoms emits a few eV photons as is usual process. We observe EM radiations by all possible primary and secondary reactions. So far distinction or direct observation of BOLEP from deformed (excited) nuclei is not easy. It is not easy. So, we may be proposing that the Karabut-Karabut-Hagelstein spectra was due to BOLEPs, as a conjecture of direct observation. Secondary radiation could be related to hot spots.

5. Summary and Conclusion

A model of final state interaction for ^{8}Be* of 4D/TSC fusion is proposed. The ^{8}Be*(Ex=47.6MeV) may damp its excited energy by major BOLEP (burst of low energy photons) process from <n-h-h-n> nucleon-helion halo state to the ^{8}Be-ground state. Intermediate decay states from the nucleon-halo states are scaled by number of effective binding PEF values for mean strong field interaction. Analogous states to A=8 ground state nuclei as ^{8}He, ^{8}Li and ^{8}B which are typical neutron-halo states with rather long life times as 838 ms for ^{8}Li are discussed, to speculate that the life time of <n-h-h-n> halo sate of ^{8}Be*(Ex=47.6 MeV) may be as long as a few ms or more and the dominant BOLEP electro-magnetic transition will be sustained. More quantitative QM analysis is to be done to know the detail of discrete energy states for the very deformed halo state.

A complex decay scheme is proposed. Major decay channel is modeled as an electro-magnetic transition of BOLEP to the ^{8}Be-ground state which breaks up to two 46 keV alpha-particles with 0.067fs life time. BOLEP is modeled as emission of rather slow (in a few ms) and stochastic burst events of ca. 1.5 keV averaged energy photons due to strongly coupled bosonic (nuclear phonon) states of many high spin quanta by the rotation-vibration coupled motion of very deformed <n-h-h-n> halo state of ^{8}Be*(Ex=47.6 MeV). Minor channels are modeled as BOLEP transitions to lower even spin-parity excited states (Ex = 34, 27.5, 22.98, 22.0, 20.1, 16.6, 11.4 and 3.04 MeV), from where two-alpha break-up channels open. Minor two-alpha break-up channels emit characteristic discrete kinetic energy alpha-particles at 17, 13.8, 11.5, 11, 10, 8.3, 6.9, 5.7 and 1.55 MeV, which meets wonderful coincidence with observed data by Roussetski et al. The asymmetric break-up from the Ex = 34 MeV state has a branch to emit 5.2 MeV triton, which will induce secondary D-t reaction in deuterium contained metal to emit 9-19 MeV (En) neutrons that would have 3-alpha tracks of CR39 detector by $^{12}C(n,n')3\alpha$ reaction as observed by Boss et al. X-ray burst data observed by Karabut et al may be photons by BOLEP. Further confirmation data by experiments for checking such consequences of the present work is expected.

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