Nuclear Products of Cold Fusion by TSC Theory

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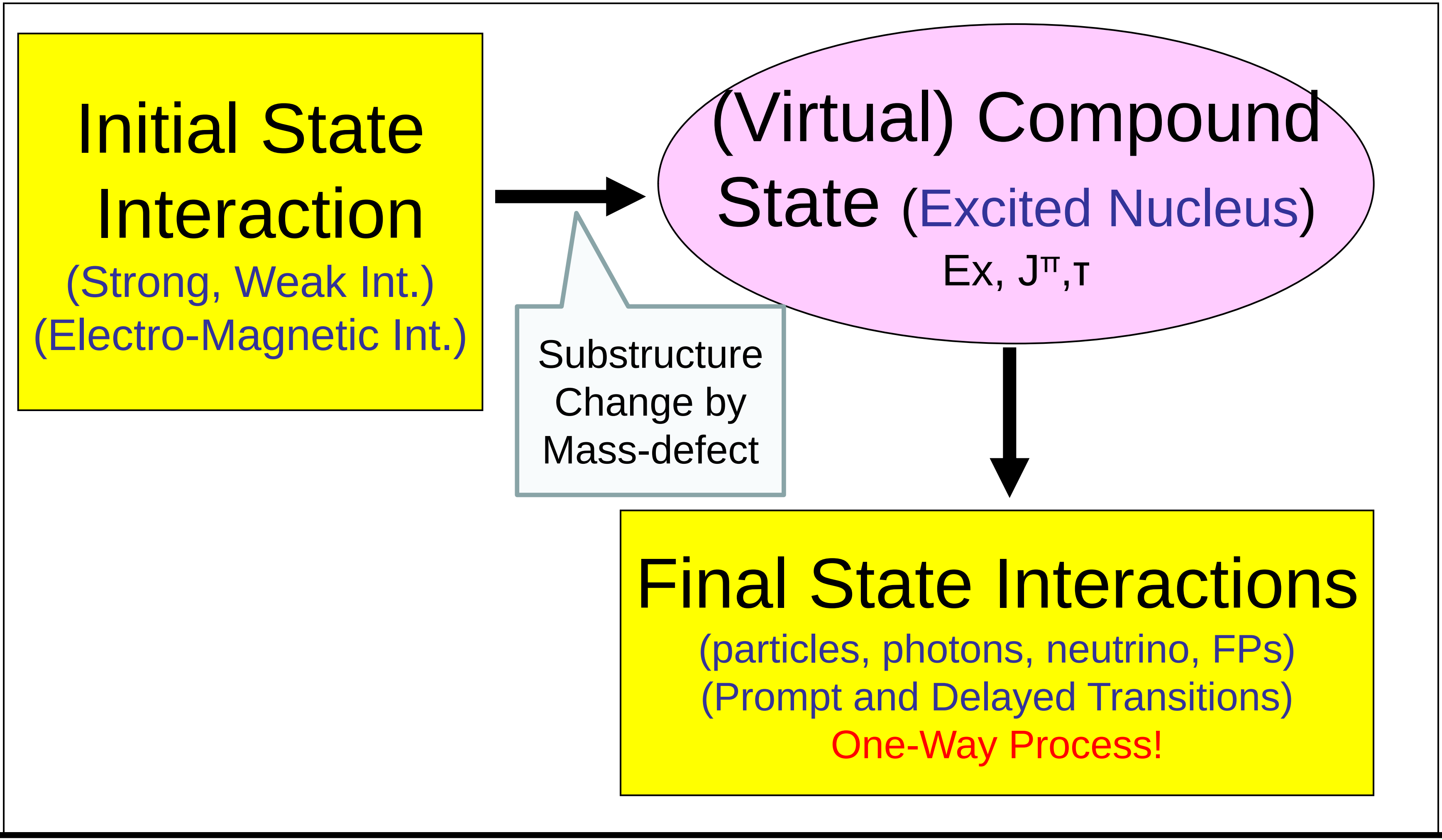
Why so radiation-less results?

	Claims by Experiments	**Predictions by TSC Models**
MDE (Metal Deuterium Energy)	Heat: 24±1MeV/^{4}He (Miles, McKubre, et al) Weak alpha-peaks (Lipson, Roussetskii, etc) Weak neutrons (Takahashi, Boss, etc.) *X-rays burst* (Karabut, et al.)	23.8MeV/^{4}He by 4D/TSC fusion with low-E alphas (46keV) Minor alpha-peaks by nucleon-halo BOLEP minor decay channels High-E neutron by minor triton emission *BOLEP* in ca.1.5keV
MHE (Metal Hydrogen Energy)	Heat w/o n and gamma unknown ash (Piantelli, Takahashi-Kitamura, Celani, etc.)	4H/TSC WS fusion 7-2MeV/^{3}He and d Very weak secondary Gamma and n Ca. 10^{-11} of ^{3}He and d

Three Steps in Nuclear Reaction should be quantitatively taken into account.



Initial State Interaction
(Strong, Weak Int.)
(Electro-Magnetic Int.)

Substructure Change by Mass-defect

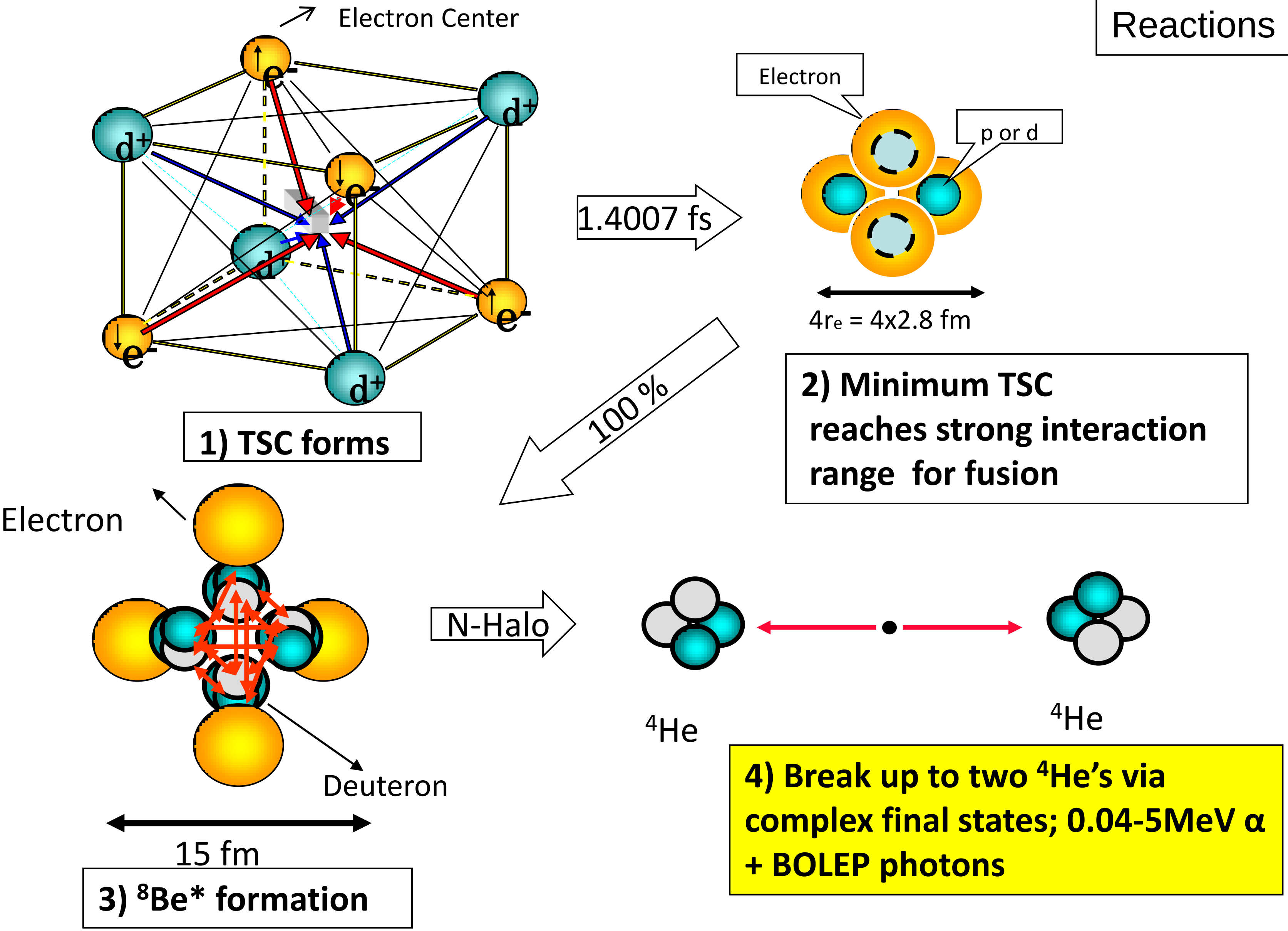
(Virtual) Compound State (Excited Nucleus)
Ex, J^{π},τ

Final State Interactions
(particles, photons, neutrino, FPs)
(Prompt and Delayed Transitions)
One-Way Process!

Part-I: MDE

- TSC condensation and 4D/TSC fusion (ACS-LENRSB Vol.1,2 and ICCF17, etc.)
- Final state interaction modeled by the nucleon-halo model (Takahashi-Rocha: JCF13)

4D/TSC Condensation Reactions



1) TSC forms

2) Minimum TSC reaches strong interaction range for fusion

3) ^{8}Be* formation

4) Break up to two ^{4}He's via complex final states; 0.04-5MeV α + BOLEP photons

Outline of Nucleon Halo Model of ^{8}Be*

- Explanation for heat/^{4}He correlation, without neutron emission, by CF claims (M. Miles et al.: The Science of Cold Fusion, Italian Physical Society, 1991, pp. 363-372) is of interest.
- 4D/TSC theory predicts 23.8 MeV/^{4}He with very low-level n/t secondary/minor production.
- However, the final state interaction of ^{8}Be* at high excited energy is very complex.
- This paper discusses on <u>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</u>.

After Hiroshi Toki, Osaka U. 2008

AV18: two-body force only, II.2: 2 + 3-body forces

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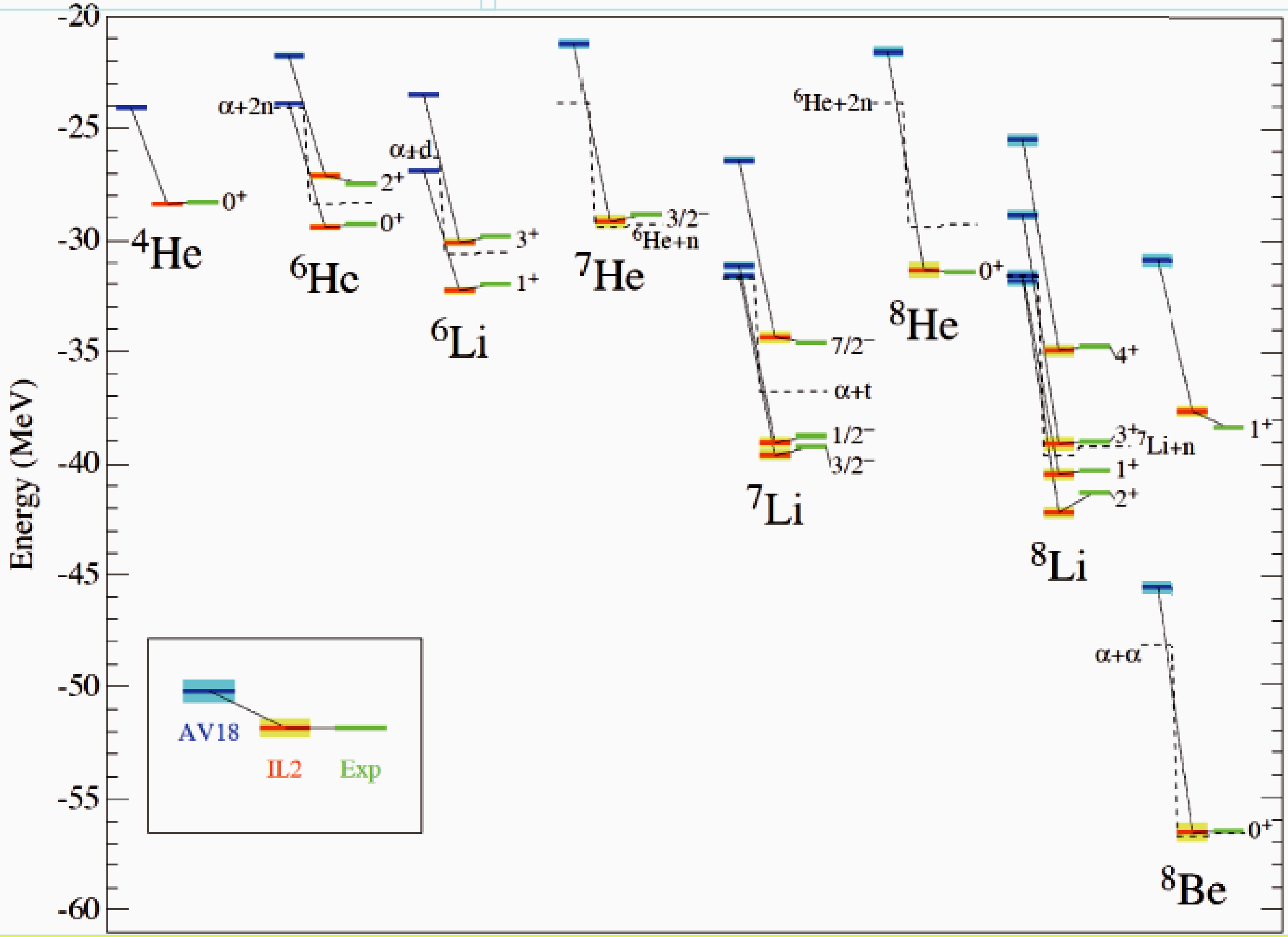

Three-body nucleon interaction, t/h state has non-negligible weight and can be core Clusters of nucleon halo states .

L. N. Sabshukin, H. Toki: The Atomic Nucleus as a Relativistic System, Springer 2004

After Yoshiko Enyo, Kyoto U., 2012

Y. Kanada-Enyo, H. Horiuchi, A. Dote: Nucl. Phys. 687 (2001) 146

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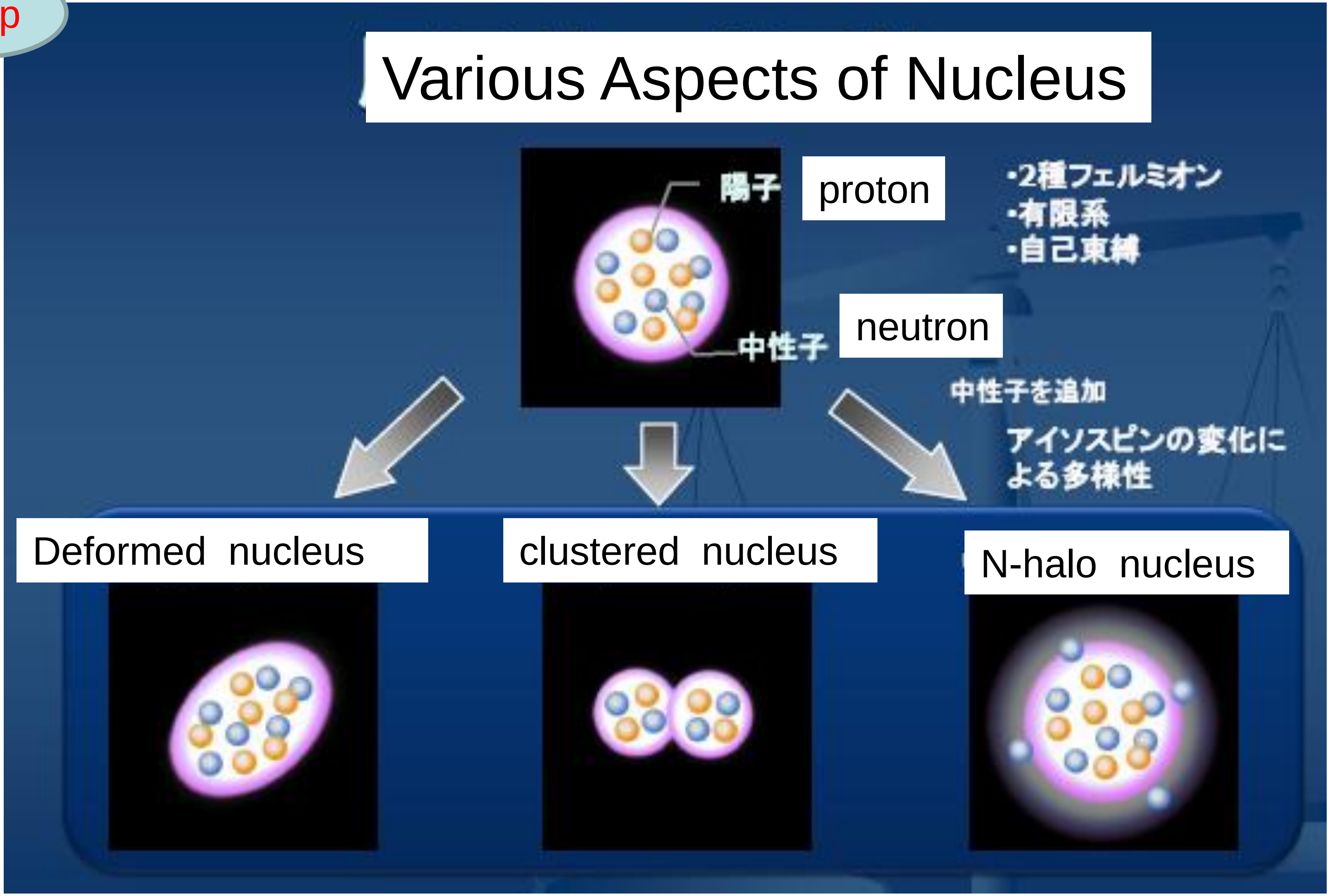
Various Aspects of Nucleus



proton

neutron

Deformed nucleus

clustered nucleus

N-halo nucleus

After Yoshiko Enyo, Kyoto U., 2012

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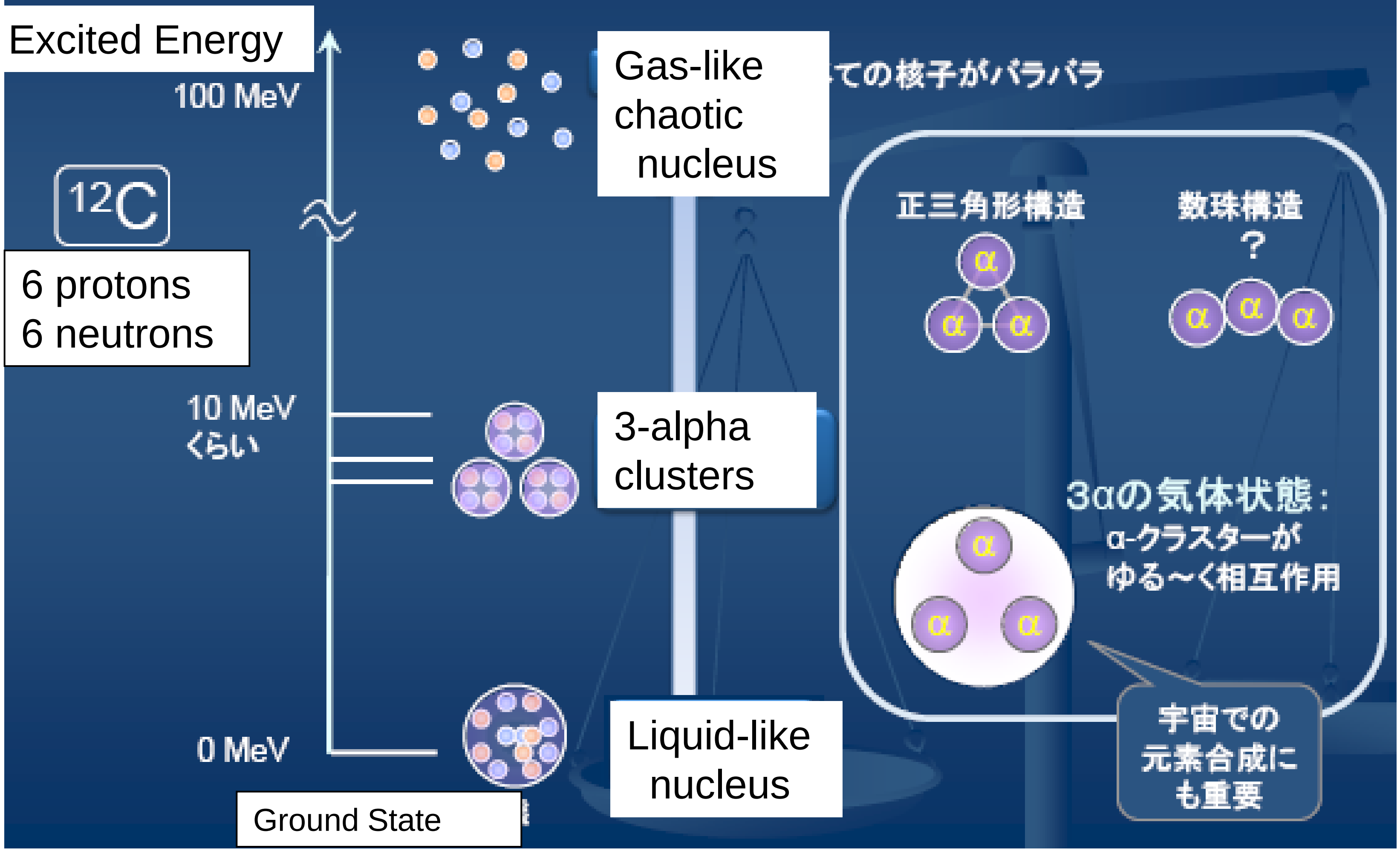
Excitation Energy Dependency of Clusters



Excited Energy

Gas-like chaotic nucleus

6 protons
6 neutrons

3-alpha clusters

Liquid-like nucleus

Ground State

After Yoshiko Enyo, Kyoto U., 2012

2-alpha Clusters of ^{8}Be (gs:O+)
By precise 8-body calculation

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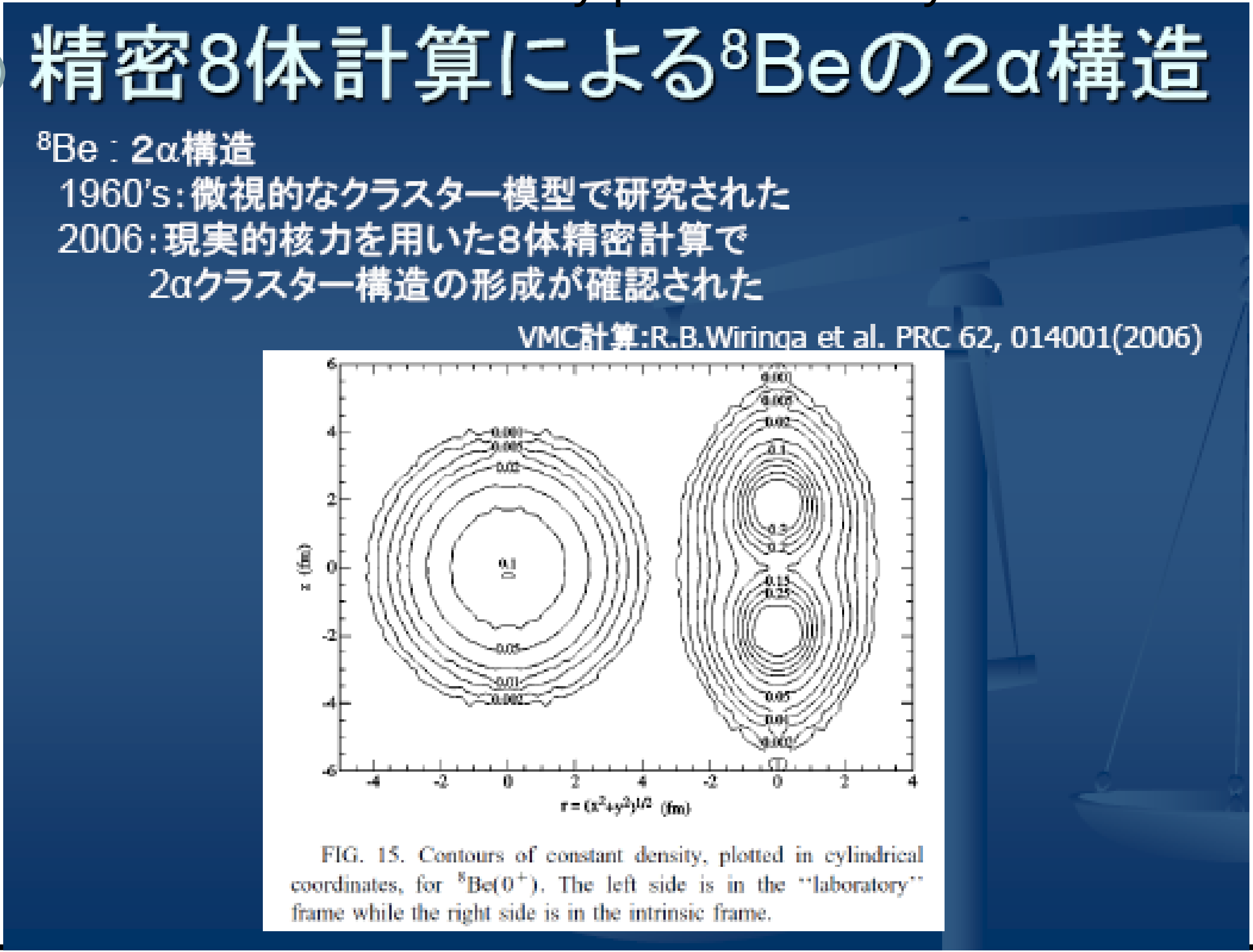

精密8体計算による^{8}Beの2α構造

^{8}Be：2α構造

1960's：微視的なクラスター模型で研究された

2006：現実的核力を用いた8体精密計算で
2αクラスター構造の形成が確認された

VMC計算:R.B.Wiringa et al. PRC 62, 014001(2006)

FIG. 15. Contours of constant density, plotted in cylindrical coordinates, for ^{8}Be(0$^+$). The left side is in the "laboratory" frame while the right side is in the intrinsic frame.

After Yoshiko Enyo, Kyoto U., 2012

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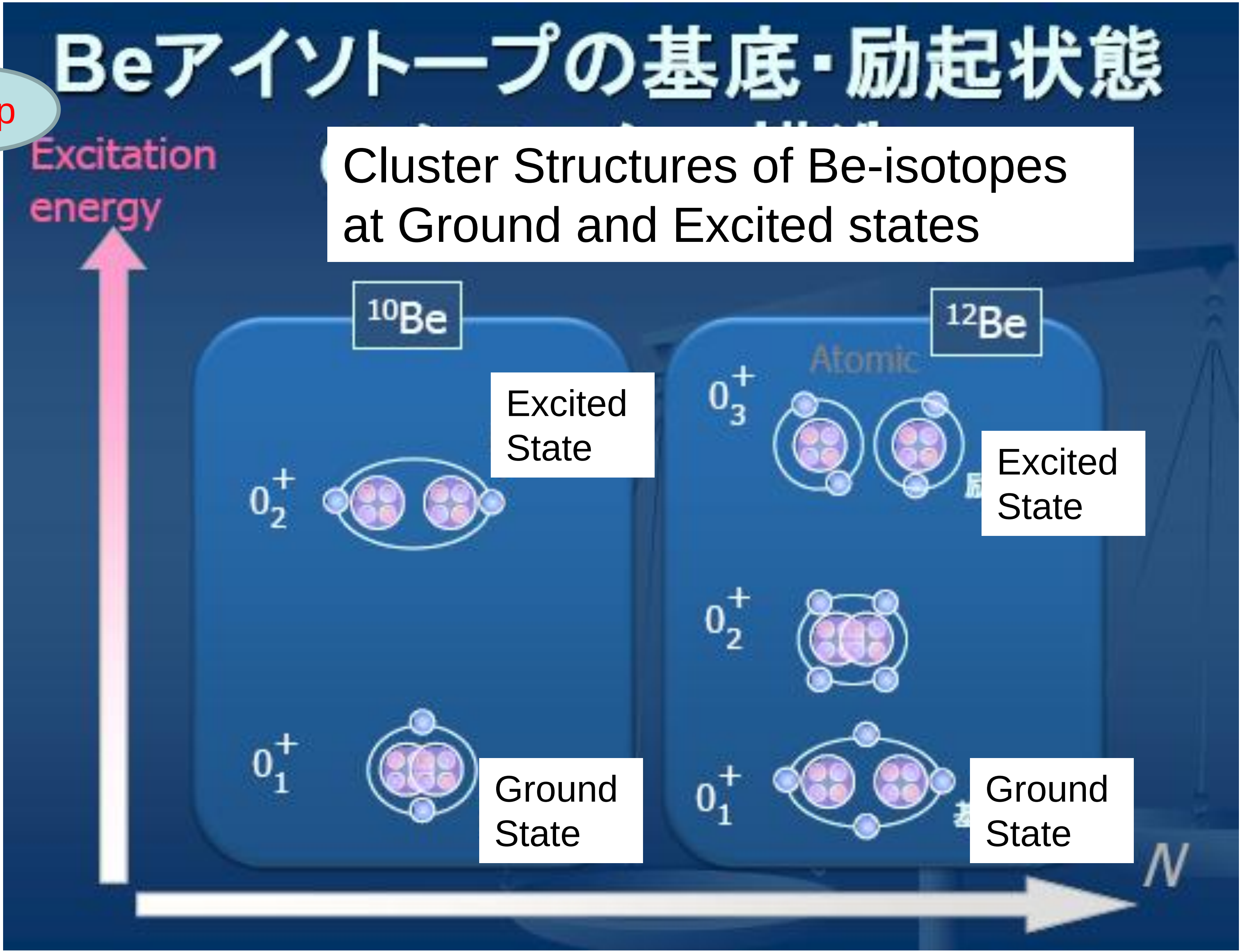
Cluster Structures of Be-isotopes at Ground and Excited states



Beアイソトープの基底・励起状態

Excited State

Ground State

Excited State

Ground State

Asymmetric Molecular Dynamics

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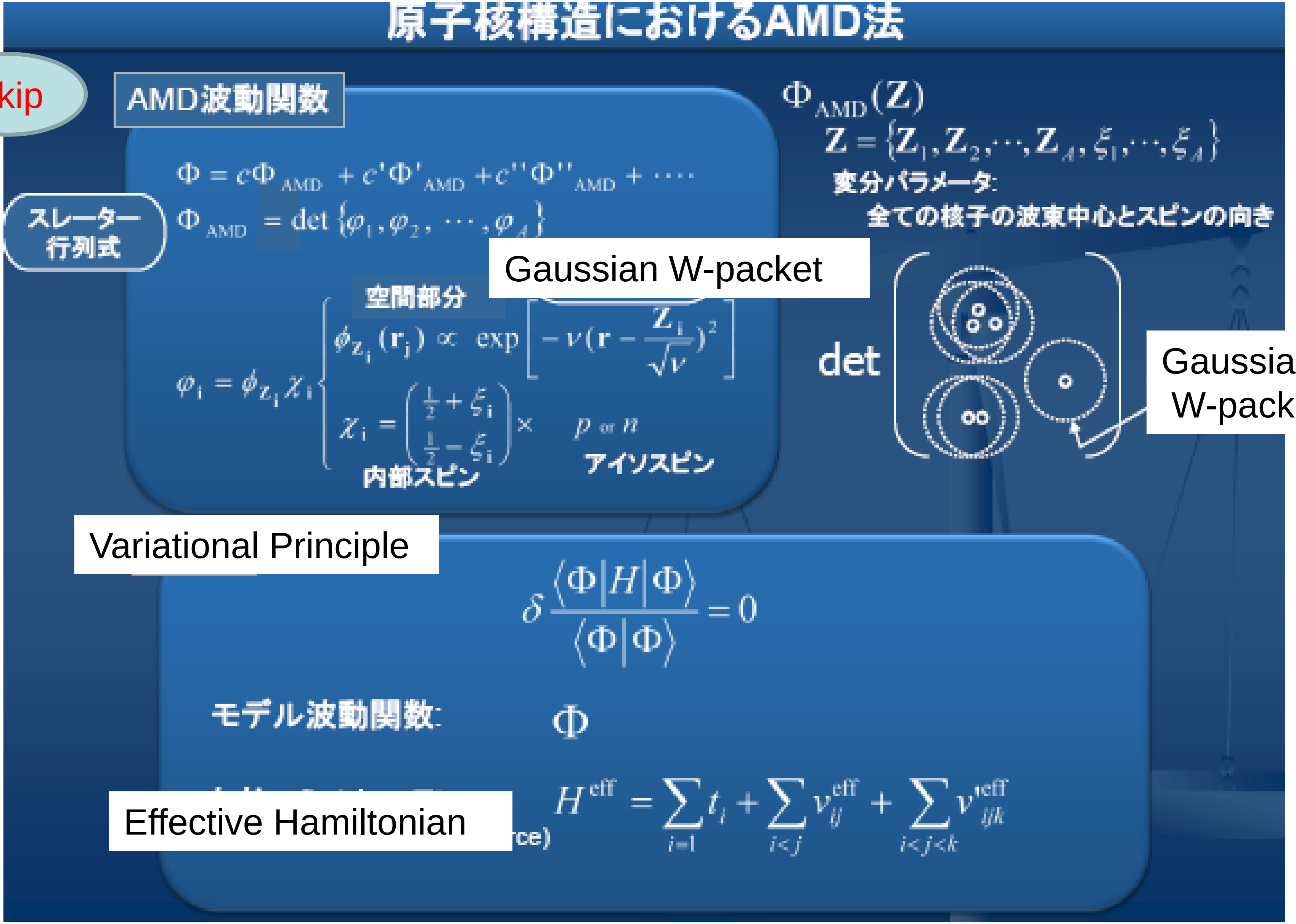

原子核構造におけるAMD法

AMD波動関数

$$\Phi = c\Phi_{\rm AMD} + c'\Phi'_{\rm AMD} + c''\Phi''_{\rm AMD} + \cdots$$

スレーター行列式

$$\Phi_{\rm AMD} = \det\{\varphi_1, \varphi_2, \cdots, \varphi_A\}$$

Gaussian W-packet

空間部分

$$\varphi_i = \phi_{\mathbf{Z}_i}\chi_i \begin{cases} \phi_{\mathbf{Z}_i}(\mathbf{r}_j) \propto \exp\left[-\nu\left(\mathbf{r}-\frac{\mathbf{Z}_i}{\sqrt{\nu}}\right)^2\right] \\ \chi_i = \begin{pmatrix} \frac{1}{2}+\xi_i \\ \frac{1}{2}-\xi_i \end{pmatrix} \times \quad p \text{ or } n \end{cases}$$

内部スピン　アイソスピン

$$\Phi_{\rm AMD}(\mathbf{Z})$$

$$\mathbf{Z} = \{\mathbf{Z}_1, \mathbf{Z}_2, \cdots, \mathbf{Z}_A, \xi_1, \cdots, \xi_A\}$$

変分パラメータ:
全ての核子の波束中心とスピンの向き

det

Gaussian W-packet

Variational Principle

$$\delta\frac{\langle\Phi|H|\Phi\rangle}{\langle\Phi|\Phi\rangle} = 0$$

モデル波動関数:　Φ

Effective Hamiltonian

ce)

$$H^{\rm eff} = \sum_{i=1} t_i + \sum_{i<j} v_{ij}^{\rm eff} + \sum_{i<j<k} v_{ijk}^{\rm eff}$$

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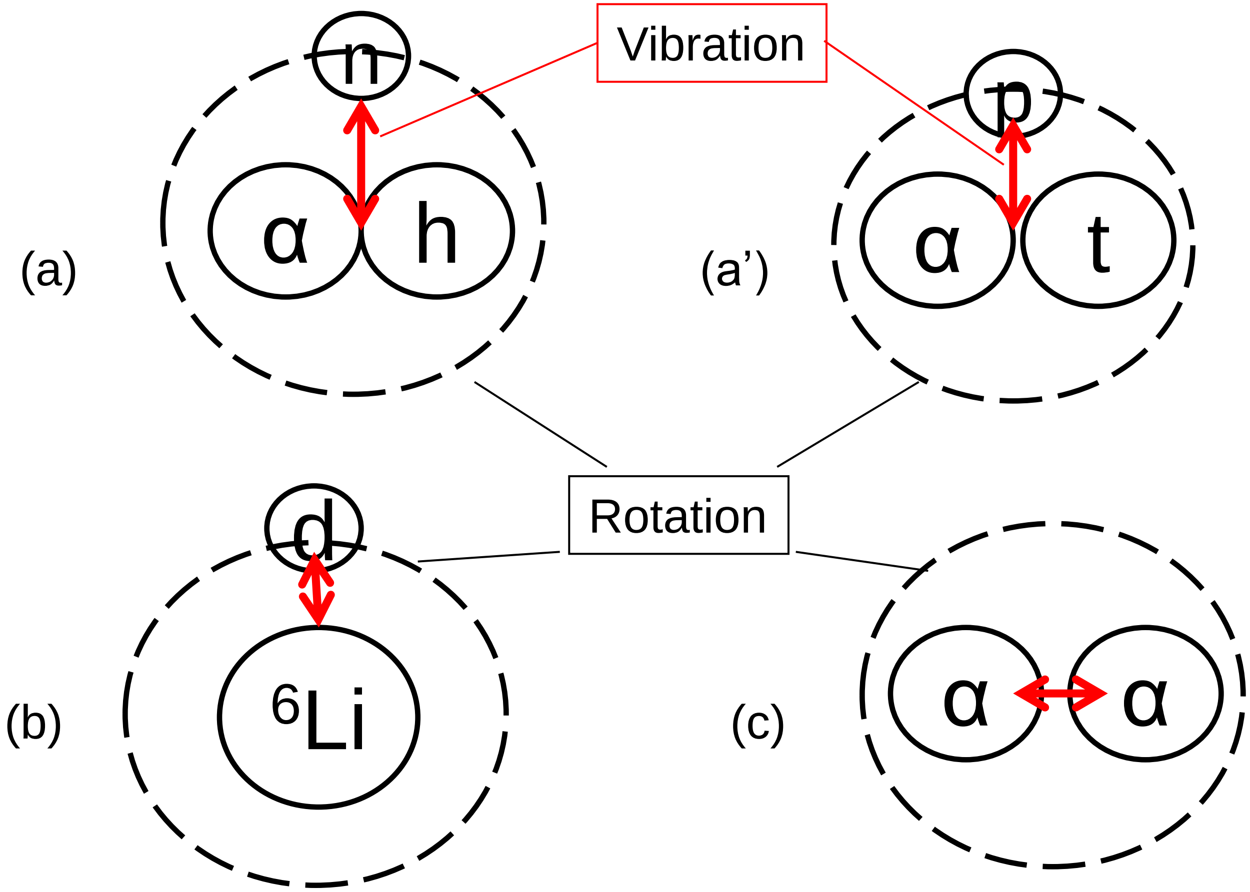
Nucleon Halo Model of ^{8}Be*(Ex=47.6 MeV: J$^{\pi}$) by alpha- and helion (triton)-cluster

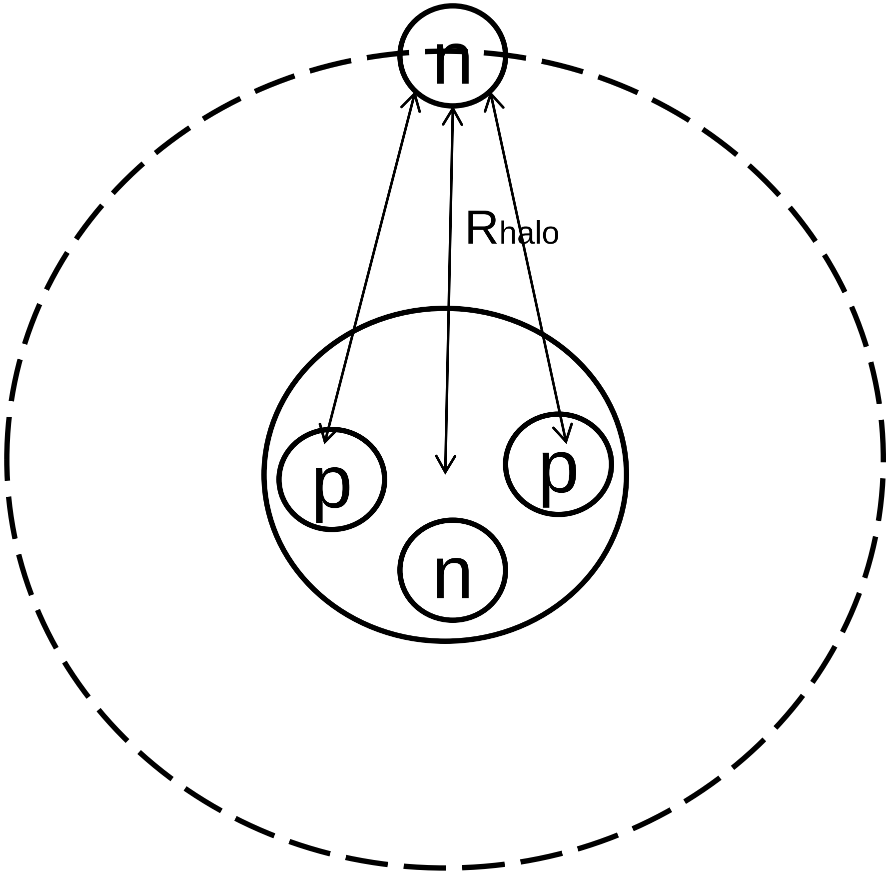
Vibration/Rotation Band Levels are <u>narrow spaced</u> for Long Life

Low Energy EM Transition Photons: a few keV: to ^{8}Be (g.s.)


Vibration

Rotation

Nucleon Halo Model of ^{4}He*(Ex=23.8 MeV: J^{π}): <n> is equivalent to <p>.
Excitation with 2 PEFs spring**: <p-n-p> is equivalent to <n-p-n> cluster.**
No concrete alpha-core may enhance prompt hadronic break-ups.



↔ Binding PEF

Binding PEF = 2

This state breaks up
Promptly in 10^{-22}s
To n + h + 3.25 MeV
or p + t + 4.02 MeV
Due to no hard alpha-core
And weak binding PEF.

$E_x > (1/2)K_2R_{halo}^2$
And prompt break-up

Nucleon Halo Model of ^{8}Be*(Ex=47.6 MeV: J^π): Excitation with 4 PEFs spring
Vibration/Rotation Band Levels are narrow spaced for Long Life
Low Energy EM Transition Photons: a few keV: to ^{8}Be (g.s.), due to hard alpha-core

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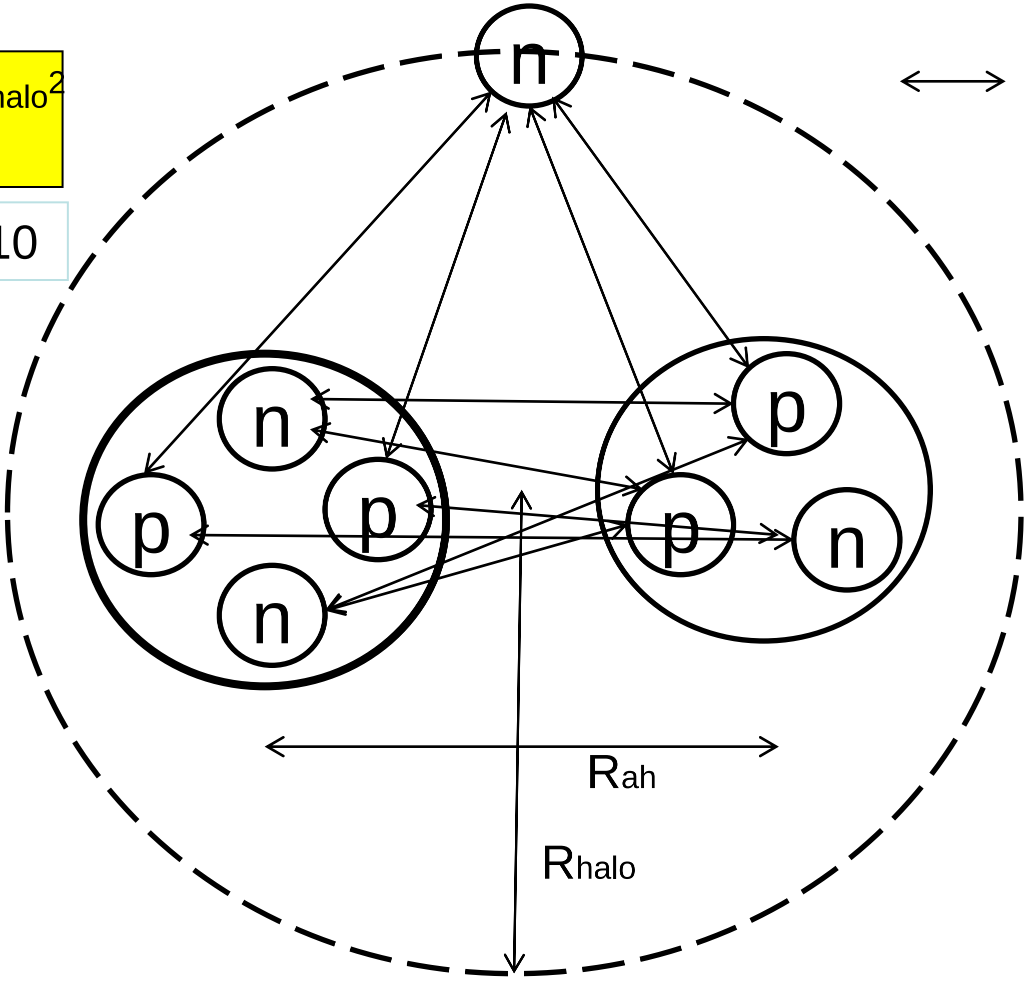
$Ex < (1/2)K_4 R_{halo}^2 + (1/2)K_6 R_{ah}^2$

Binding PEF = 10



$\leftrightarrow$ Binding PEF

The halo-states (a) and (a’) are Equivalent

$^{8}Be^{*} = \alpha + h + n$ Vs. $^{8}Li = \alpha + t + n$

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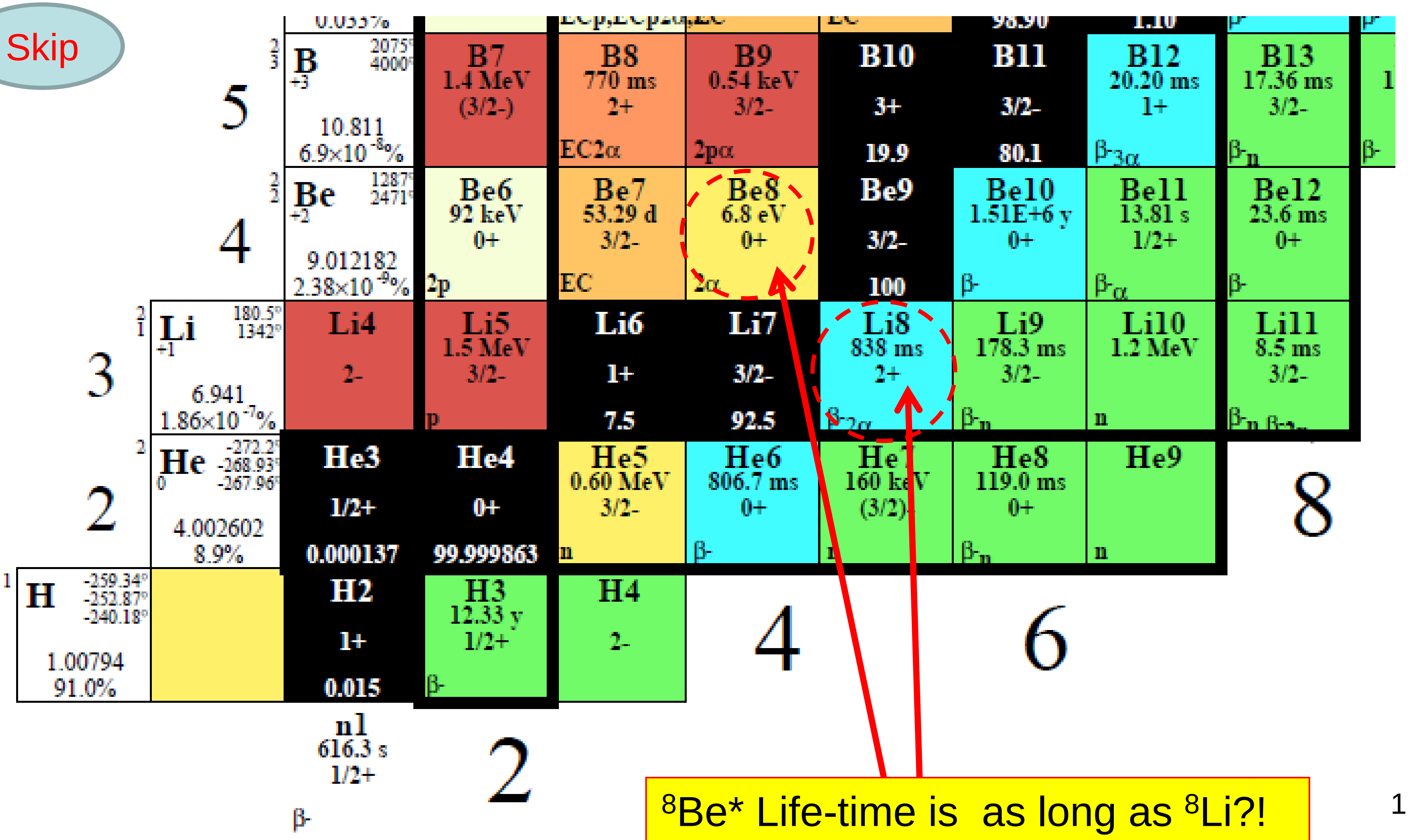


		0.033%		ECp,ECp2α,EC		EC	98.90	1.10	β-	β-
	5	2 3 **B** +3 2075° 4000° 10.811 6.9×10^{-8}%	**B7** 1.4 MeV (3/2-)	**B8** 770 ms 2+ EC2α	**B9** 0.54 keV 3/2- 2pα	**B10** 3+ 19.9	**B11** 3/2- 80.1	**B12** 20.20 ms 1+ β-3α	**B13** 17.36 ms 3/2- β-n	1 β-
	4	2 2 **Be** +2 1287° 2471° 9.012182 2.38×10^{-9}%	**Be6** 92 keV 0+ 2p	**Be7** 53.29 d 3/2- EC	**Be8** 6.8 eV 0+ 2α	**Be9** 3/2- 100	**Be10** 1.51E+6 y 0+ β-	**Be11** 13.81 s 1/2+ β-α	**Be12** 23.6 ms 0+ β-	
3	2 1 **Li** +1 180.5° 1342° 6.941 1.86×10^{-7}%	**Li4** 2-	**Li5** 1.5 MeV 3/2- p	**Li6** 1+ 7.5	**Li7** 3/2- 92.5	**Li8** 838 ms 2+ β-2α	**Li9** 178.3 ms 3/2- β-n	**Li10** 1.2 MeV n	**Li11** 8.5 ms 3/2- β-n β-2n	
2	2 **He** 0 -272.2° -268.93° -267.96° 4.002602 8.9%	**He3** 1/2+ 0.000137	**He4** 0+ 99.999863	**He5** 0.60 MeV 3/2- n	**He6** 806.7 ms 0+ β-	**He7** 160 keV (3/2)- n	**He8** 119.0 ms 0+ β-n	**He9** n	8	
1 **H** -259.34° -252.87° -240.18° 1.00794 91.0%		**H2** 1+ 0.015	**H3** 12.33 y 1/2+ β-	**H4** 2-	4		6			
		n1 616.3 s 1/2+ β-	2							

$^{8}Be^{*}$ Life-time is as long as ^{8}Li?!
As h and t are nuclear-equivalent

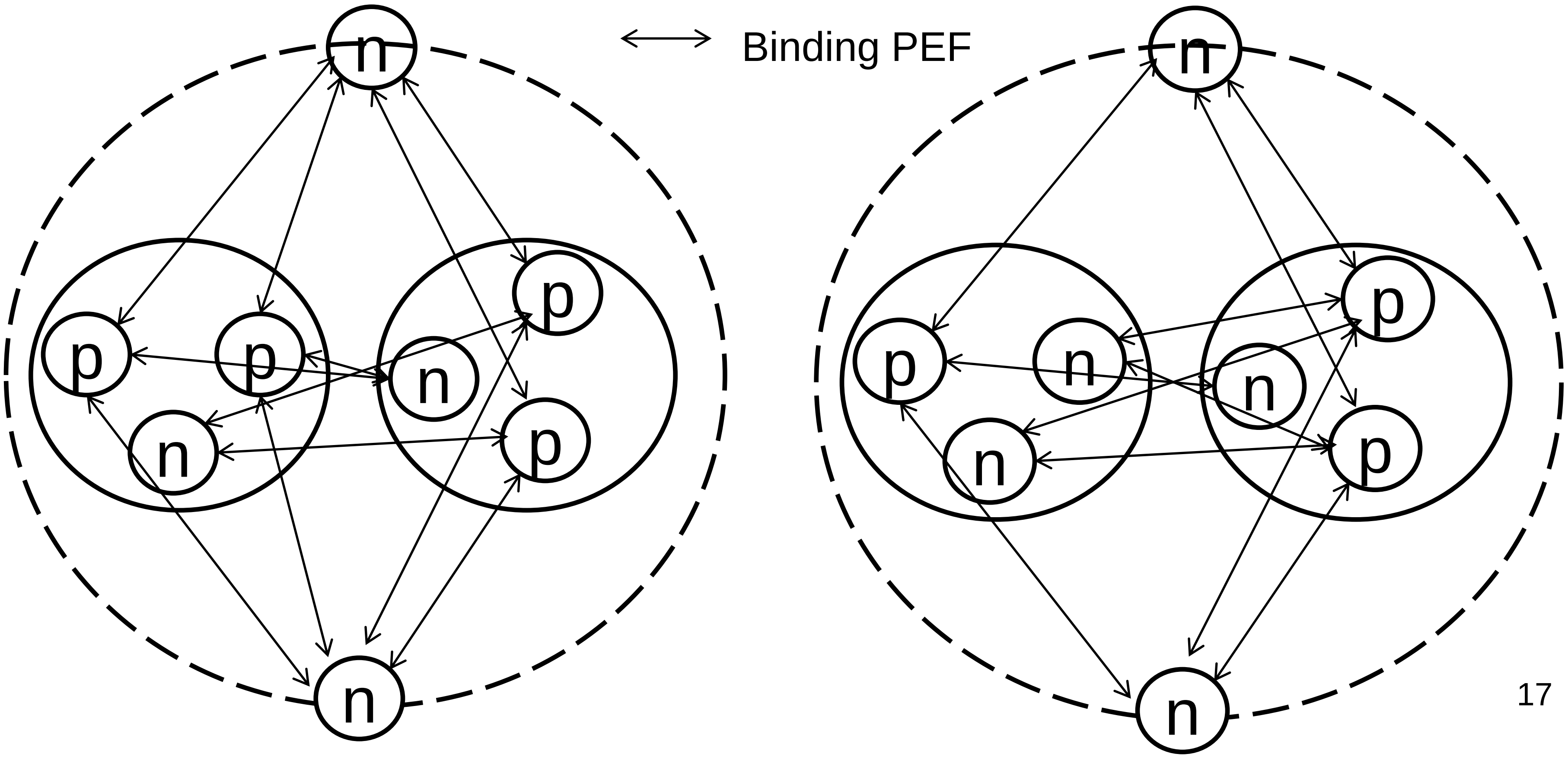
^{8}Be* and ^{8}Li are similar n-halo states

^{8}Be* = n + h + h + n Halo

Binding PEF = 8 + 4 = 12

^{8}Li = n + h + t + n Halo

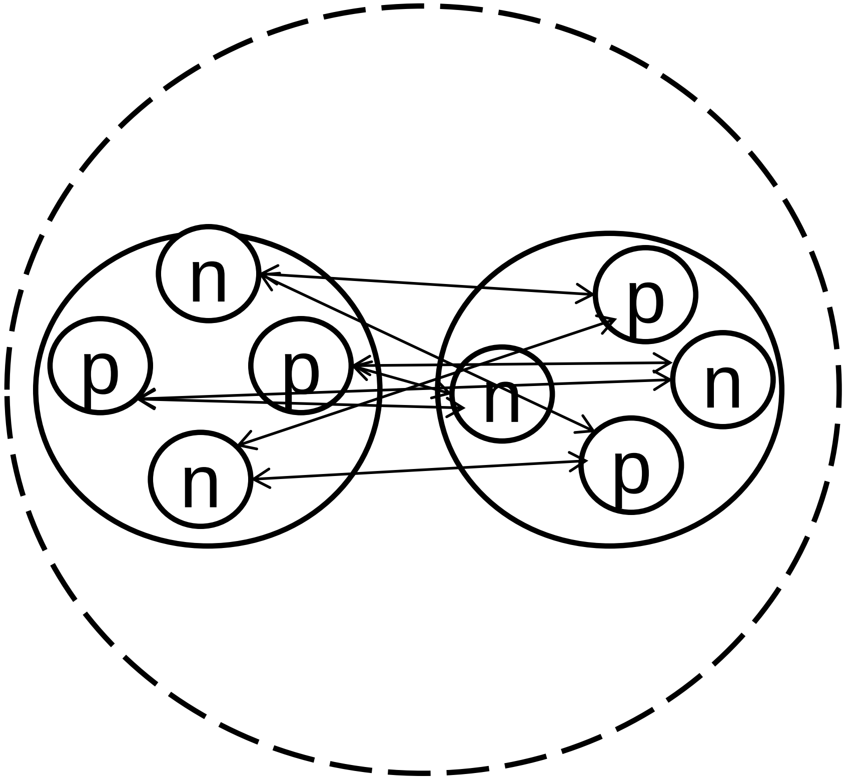
Binding PEF = 6 + 5 = 11



(c)

^{8}Be* = α + α

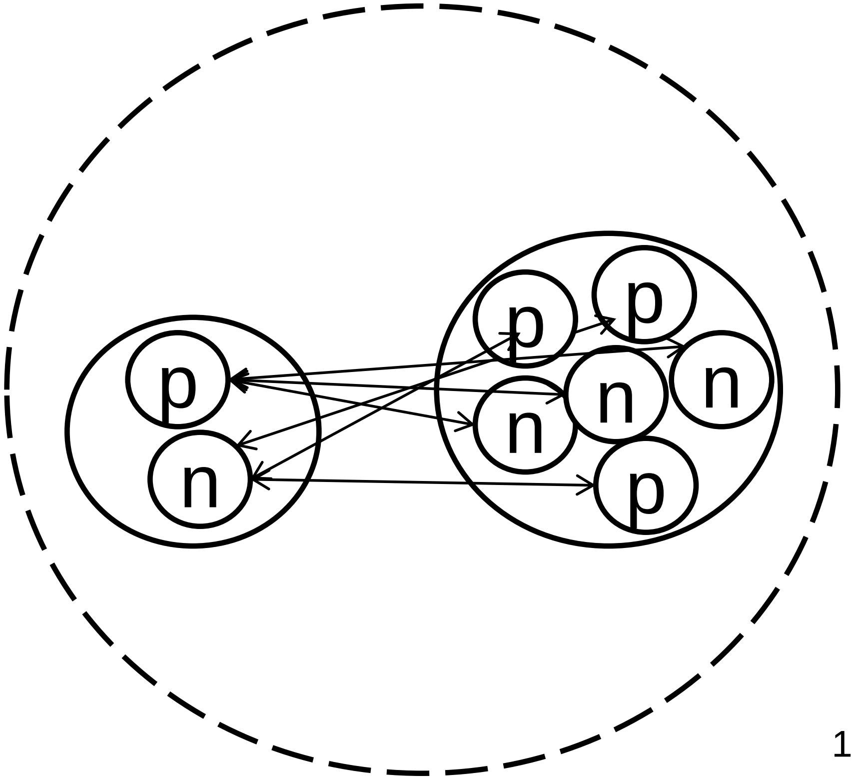
Binding PEF = 8



(b)

^{8}Be* = d + ^{6}Li

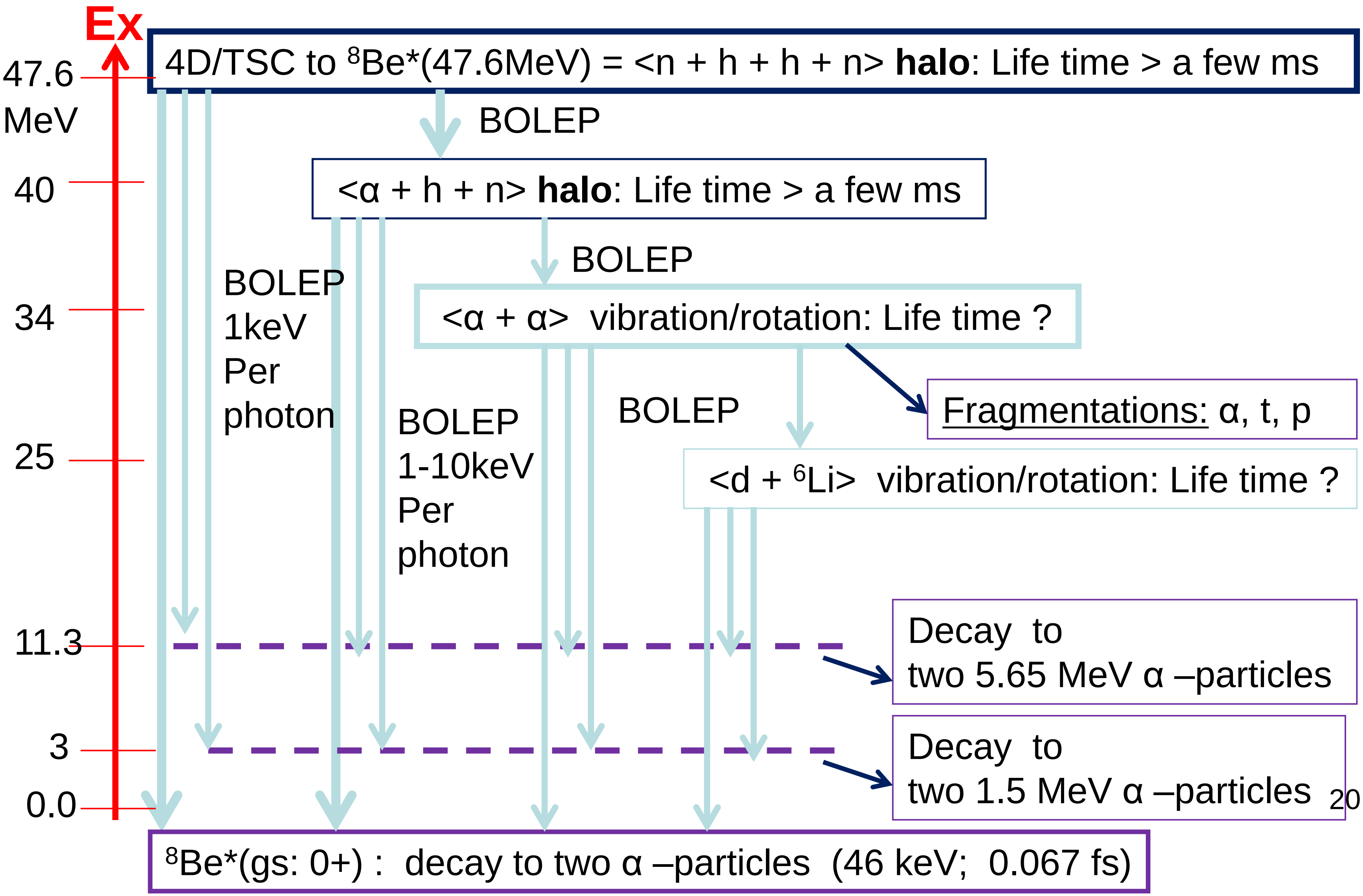
Binding PEF = 6



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

Predicted Final State Interactions of ^{8}Be*(Ex=47.6MeV): BOLEP: burst of Low Energy Photons: will be dominant channels



Ex

47.6 MeV

40

34

25

11.3

3

0.0

4D/TSC to ^{8}Be*(47.6MeV) = <n + h + h + n> **halo**: Life time > a few ms

BOLEP

<α + h + n> **halo**: Life time > a few ms

BOLEP

<α + α> vibration/rotation: Life time ?

BOLEP 1keV Per photon

BOLEP 1-10keV Per photon

BOLEP

Fragmentations: α, t, p

<d + ^{6}Li> vibration/rotation: Life time ?

Decay to two 5.65 MeV α –particles

Decay to two 1.5 MeV α –particles

^{8}Be*(gs: 0+) : decay to two α –particles (46 keV; 0.067 fs)

After TUNL: D. Tilley, et al: Nucl. Phys., A745 (2004) 155

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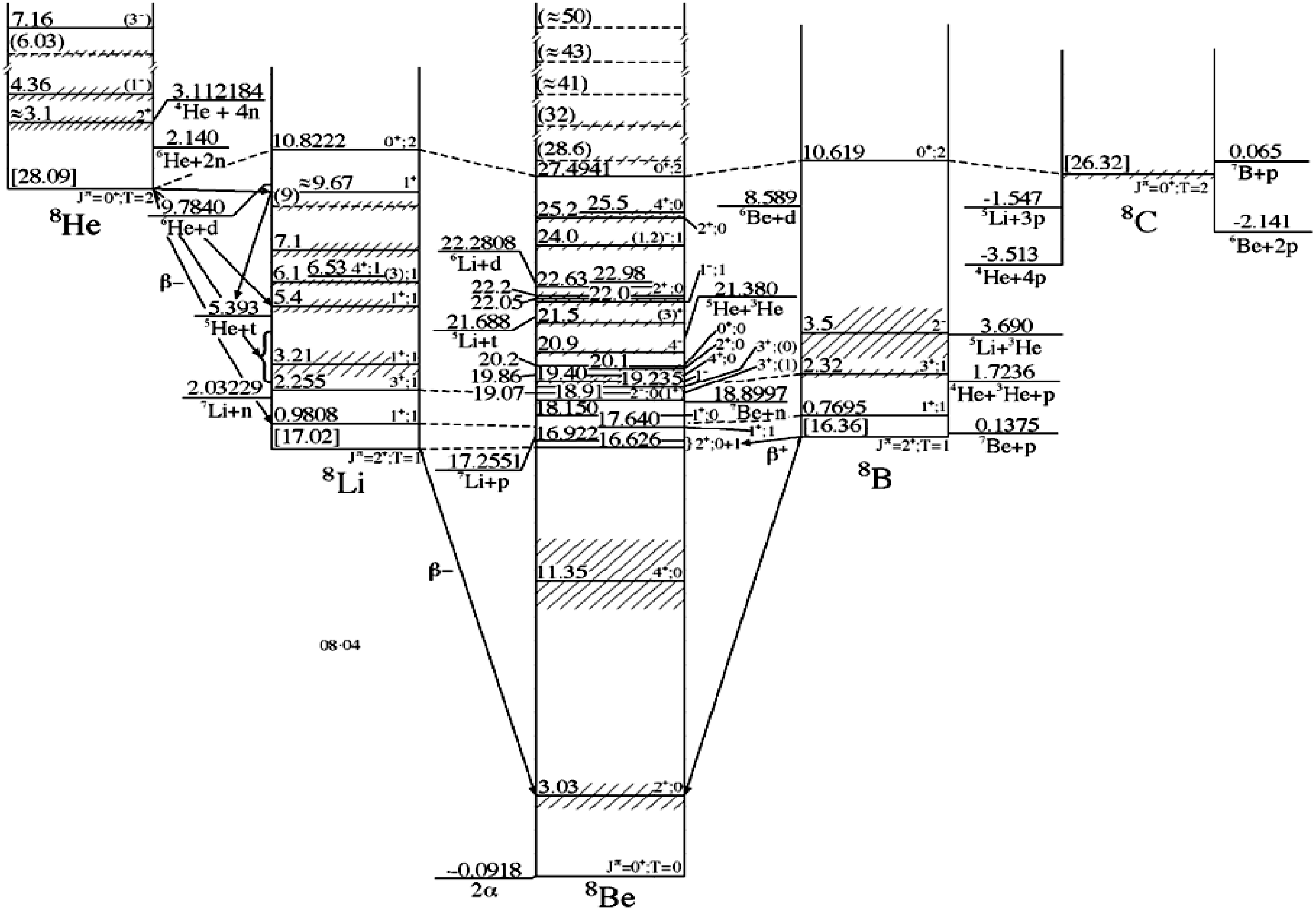

After: RIKEN Nishina Center talk0707 2007

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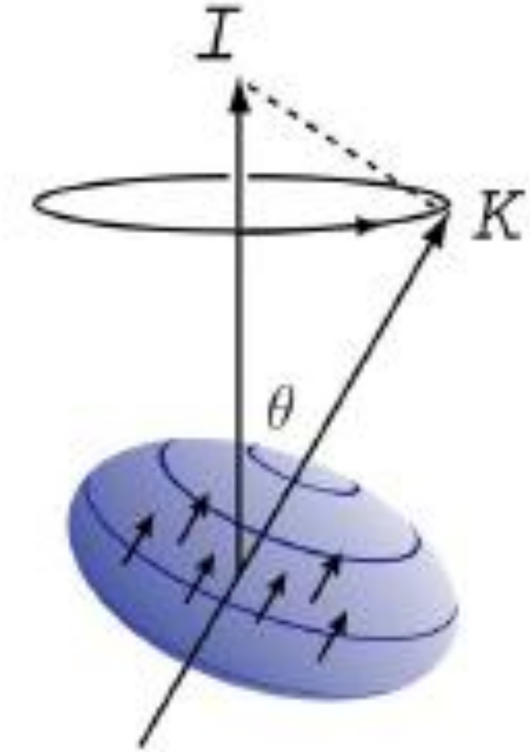
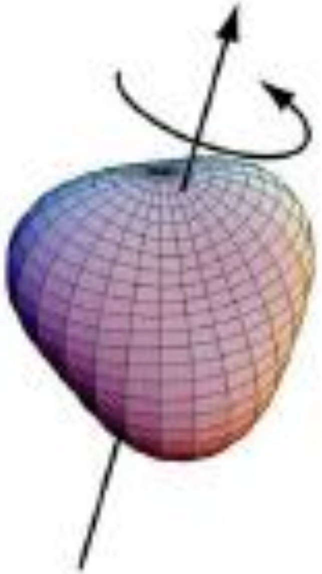
Rotation modes by various deformed nuclei



Beta/gamma Deformation
Vibration/Rotation couple

Banana Deformation



Tetrahedral Deformation

After: RIKEN Nishina Center talk 0707 2007

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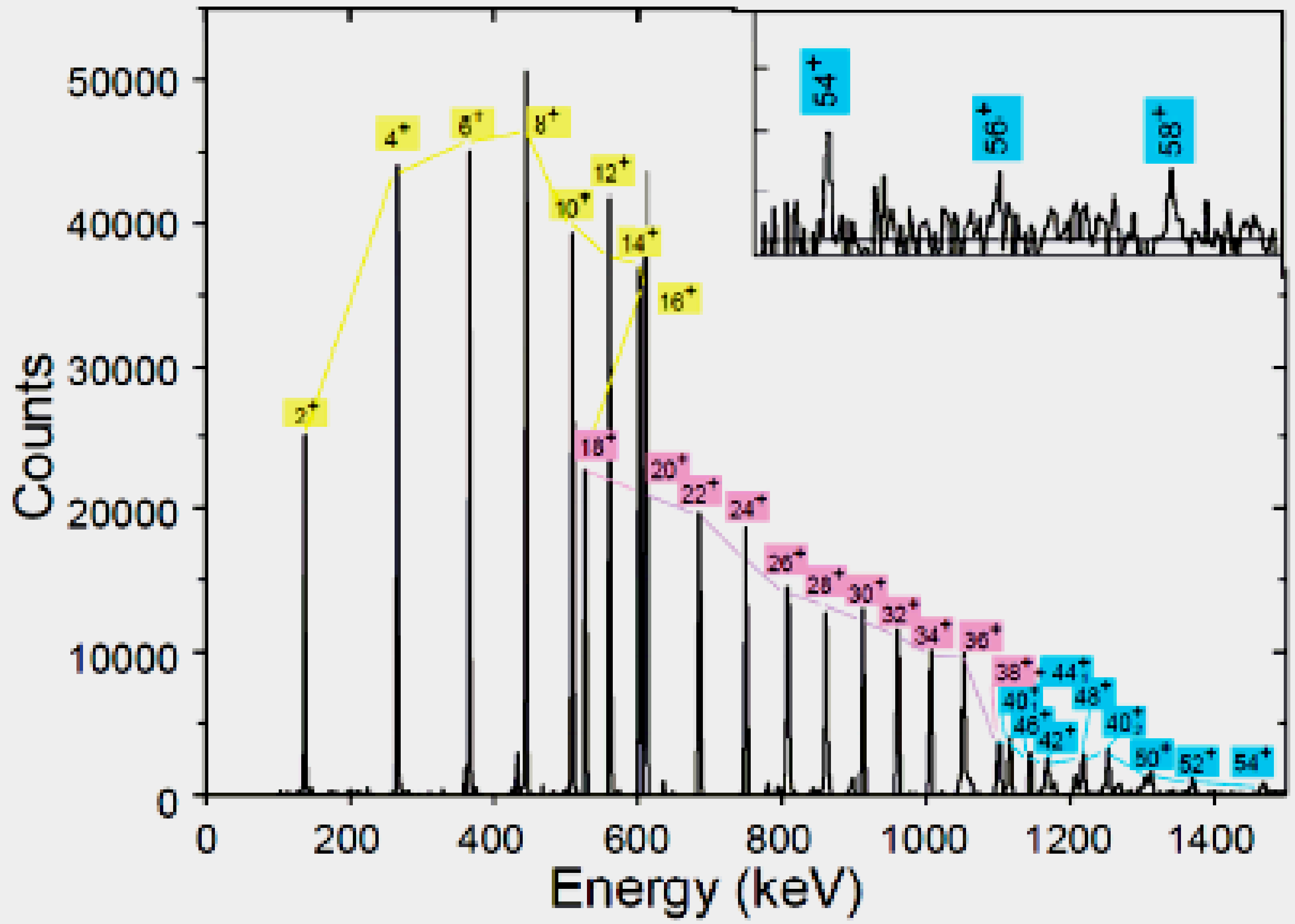
Er 158, high spin sates rotation/vibration levels



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Discussions

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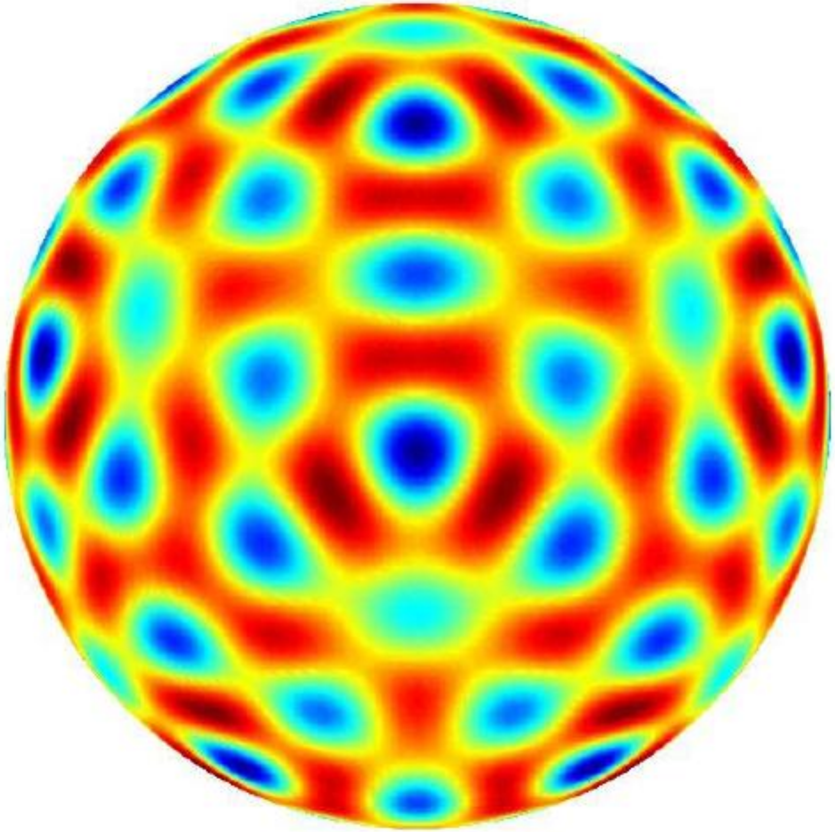
- It is possible to exist a large multipole momentum. Consider, as a rough example 2^((2(incoming tetrahedral)+2(recoil tetrahedral))*2(at least 1 extra transverse node between each incoming and outgoing components)=2^16 (=65,536) pole momentum. Considering that it is possible to describe ~15,000 independent waves, and that each carry a quantum of deformation. We could share 24MeV between 1.5KeV packets, and burst of low energy photons (BOLEP) will happen like as black-body radiation.
- See next slide for ^{8}Be*(47.6MeV) deformation

Skip

L = 16 mode I Vibration –modes by complex deformation, which couple with high spin-state rotation-modes. (m = -16, -15, -14, -13, -12, -11, -10, -9, -8, -7, -6, -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6,7, 8, 9, 10, 11, 12, 13, 14, 15,16)
At least 18 (m) spherical harmonics Y_{lm} solutions:
Tetrahedral symmetry plus point-inversion symmetry; many nodes

Model Image
for ^{8}Be*(47.6MeV)
By deformation
Due to
Nucleon-halo
States
Red: higher altitude
Blue: lower altitude

Bosonic (nuclear phonon)coupling by ca.15,000 nodes of nucleons under binding/scattering: ca. 1.5keV per phonon/photon



After Paul Matthews: PR E 67, 036202 (2003)

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How to formulate?

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- In the basis of alpha-cluster model
- n-, p-, d-halo state of highly (Ex=47.6 MeV) excited state of ^{8}Be*, as very deformed nuclei
- A nucleon-halo admixture will have rotation-vibration combined level states with small level-gap band structure.
- 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.

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How to formulate ?-2

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- Define effective Hamiltonians for four types in slide-3.
- Core oscillator (α-h or α-t) plus n-(or p-) halo rotator makes band structure of E-eigenvalues: rotation/vibration coupled band
- Coupled Schroedinger equations for rotation and vibration, for so many modes.
- Competition with CP (charged particle) fragmentation channels (see the following slides)

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After A. Takahashi, Trans. Fusion Technology 1994

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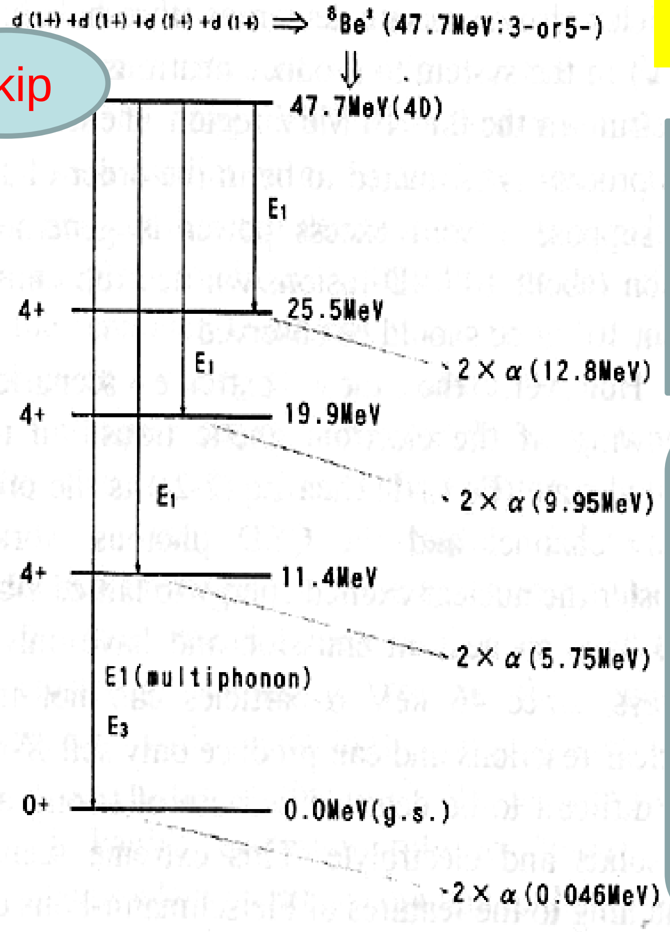
Odd Spin-Parity



.1: Typical decay channels of 4D fusion; E_1 transition may be induced with electromagnetic energy transfer via QED photons to lattice plasma oscillation. Major nuclear products are ^{4}He with specified kinetic energies.

This scenario Was Not Bad

Life-time will be Much larger for n-halo-^{8}Be* by ca. 10^4 photons (1-2 keV per photon)

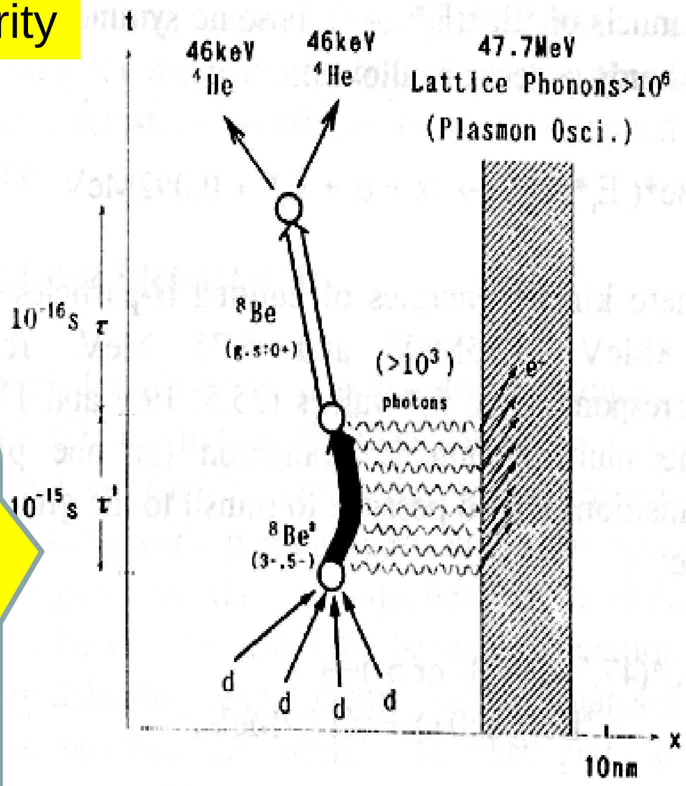


illustration of extreme scenario of decay channel for 4D fusion; final nuclear products are 46 keV α-particles and most energy (47.7MeV) is transferred to lattice vibration via QED photons.

Direct Hadronic Break-up Channels

- Possible hadronic break-ups of ^{8}Be* via
  - Symmetric fragmentation
  - Asymmetric fragmentation
- Cascade break-ups via lower excited states of ^{8}Be* to two α-particles after BOLEP transition
- Competing with main EM transitions (BOLEP: black-body radiation-like mechanism) of nucleon-halo rotation/vibration states to ^{8}Be(gs:0+) which decays to two 46keV α-particles

Fragmentation from ^{8}Be*(Ex=34 MeV)

- $^{8}\mathrm{Be}^{*} \rightarrow {}^{4}\mathrm{He}$ (20.2MeV) + ^{4}He(gs,0+) + 13.8MeV

  (KE=6.9MeV) (KE=6.9MeV)

  $^{4}\mathrm{He}(20.2\mathrm{MeV}) \rightarrow$ p + t (+ 6.9MeV)

  (1.7MeV) ($\underline{5.2\mathrm{MeV}}$)

D + t(5.2MeV) → α + n(9-19MeV) + 22.8MeV: cf. SPAWAR high E neutron

- $^{8}\mathrm{Be}^{*} \rightarrow {}^{4}\mathrm{He}$ (gs,0+)) + ^{4}He(gs,0+) + 34MeV

  (KE=17MeV) (KE=17MeV)

Alpha-peaks by Lipson et al by CR39 spectroscopy

Energies of alpha-particles

- 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.) : see next slide
- Minor triton emission: 5.2 MeV

  (cf. SPAWAR exp.)

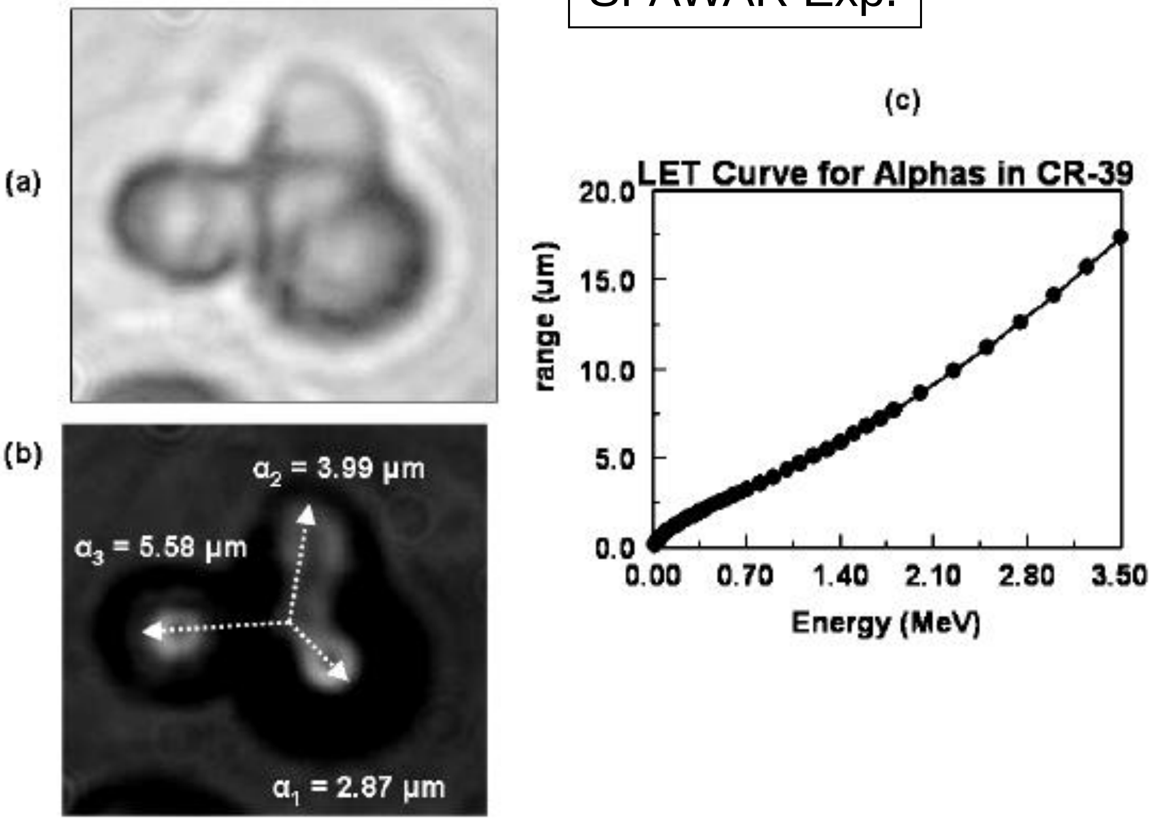
4D → ^{8}Be*(47.6MeV) → BOLEP + ^{8}Be*(34MeV)
and possible intermediate states which decay to 2α
(Note: only 11.4 and 3.04 MeV states are drawn in #18 slide)

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

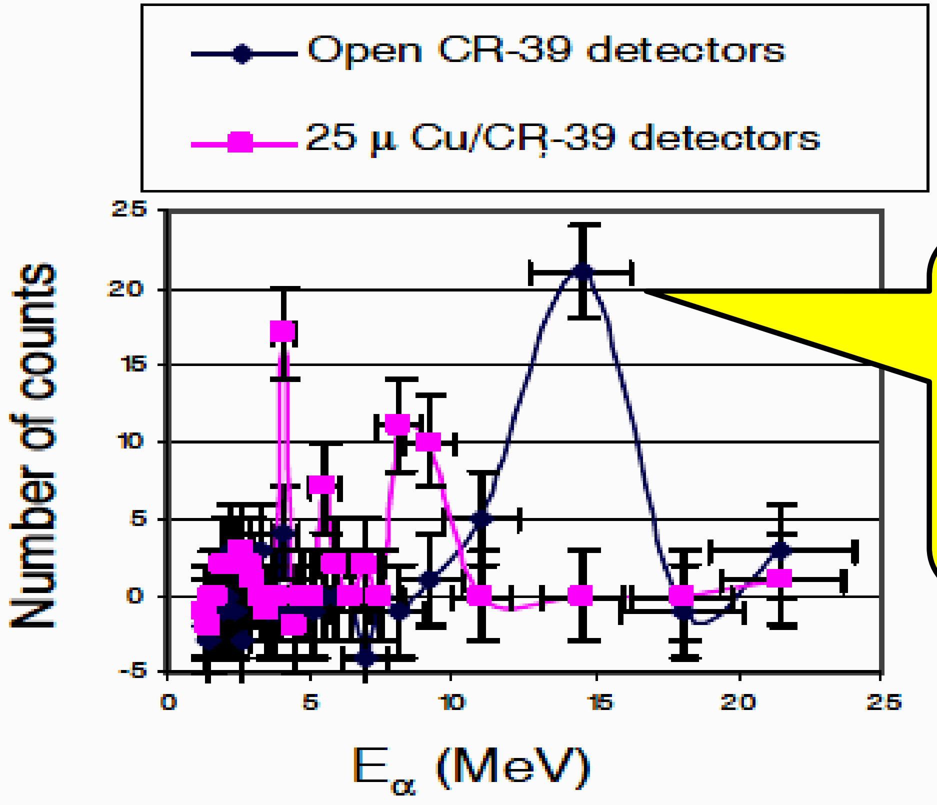
Observed 3-alphas track may be induced by the ^{12}C(n,n’)3α reaction with neutron of En > 16 MeV

P.A. Mosier-Boss et al. / Journal of Condensed Matter Nuclear Science 6 (2012) 13–23

SPAWAR Exp.



Observation of alpha-particles with CR39 detector by A. Lipson et al, ICCF10

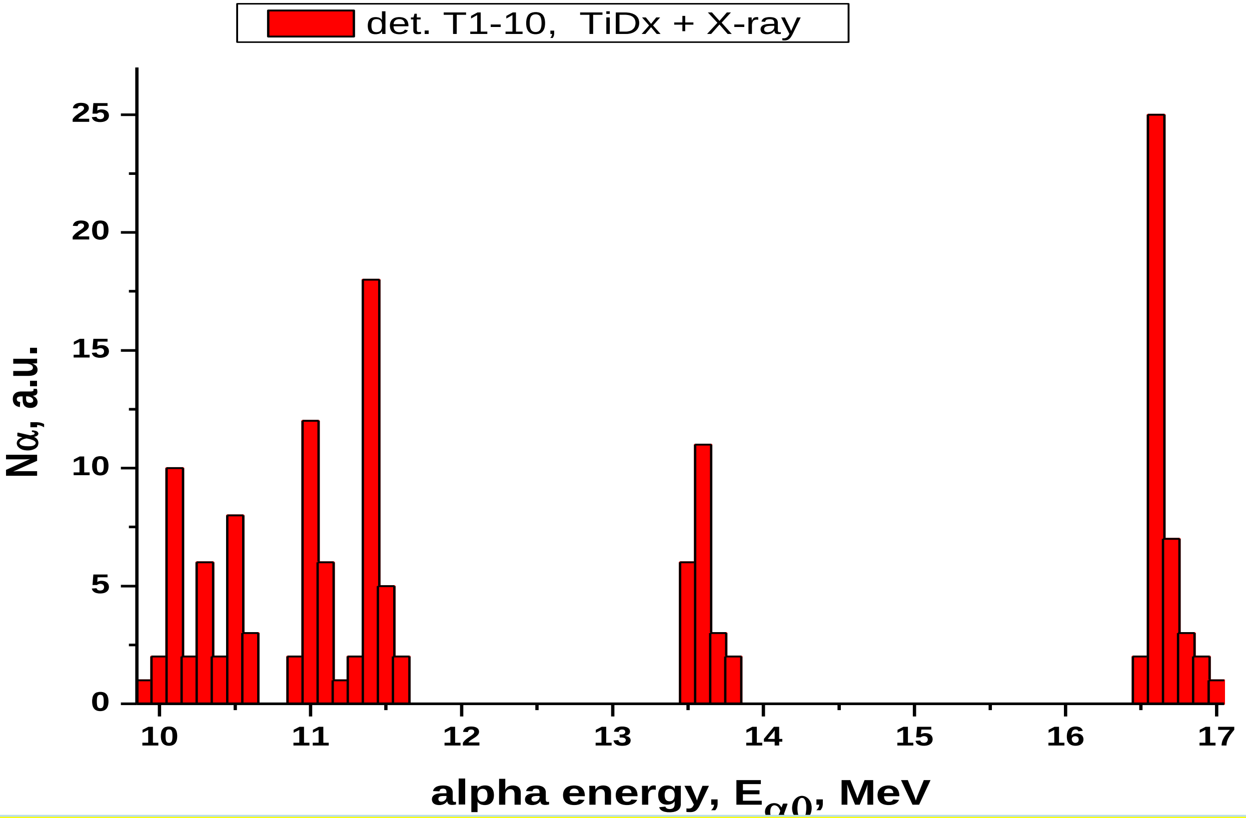


Bunched Peak of 17 MeV and 13.8 MeV

Figure 10. Reconstructed spectra of alpha particles (after background subtraction) deduced from the data obtained during electrolysis with open and Cu shielded CR-39 detectors (3.0 cm^2) attached to the Pd cathode.

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.

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

BOLEP
May
Explain
This

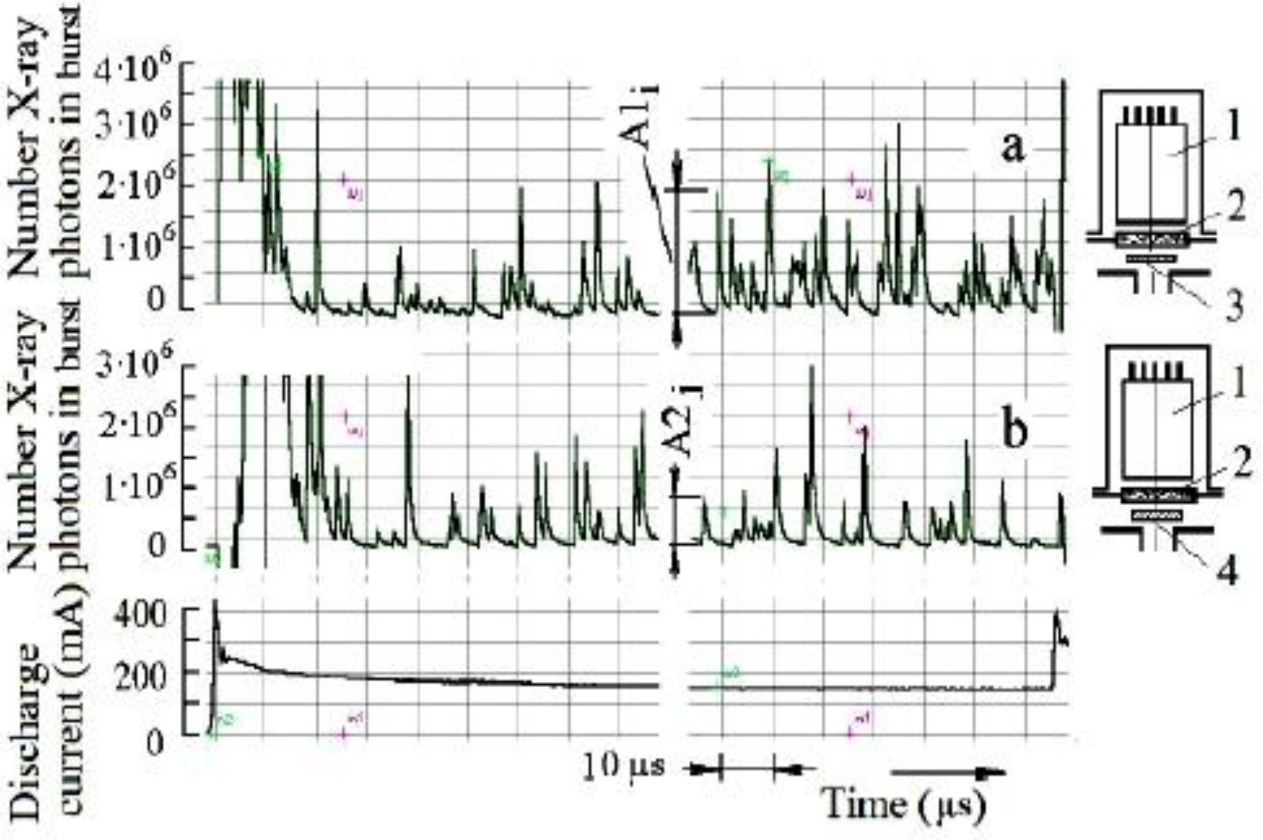


Figure 6. Typical oscillograms of X-ray emission from the PMMA/PM scintillator detector covered with Be foils with different thicknesses: (a) covered with a 15 μm Be foil; (b) covered with a 30 μm Be foil. In this case the cathode was Pd, the gas was D_2, and the discharge current was 150 mA.

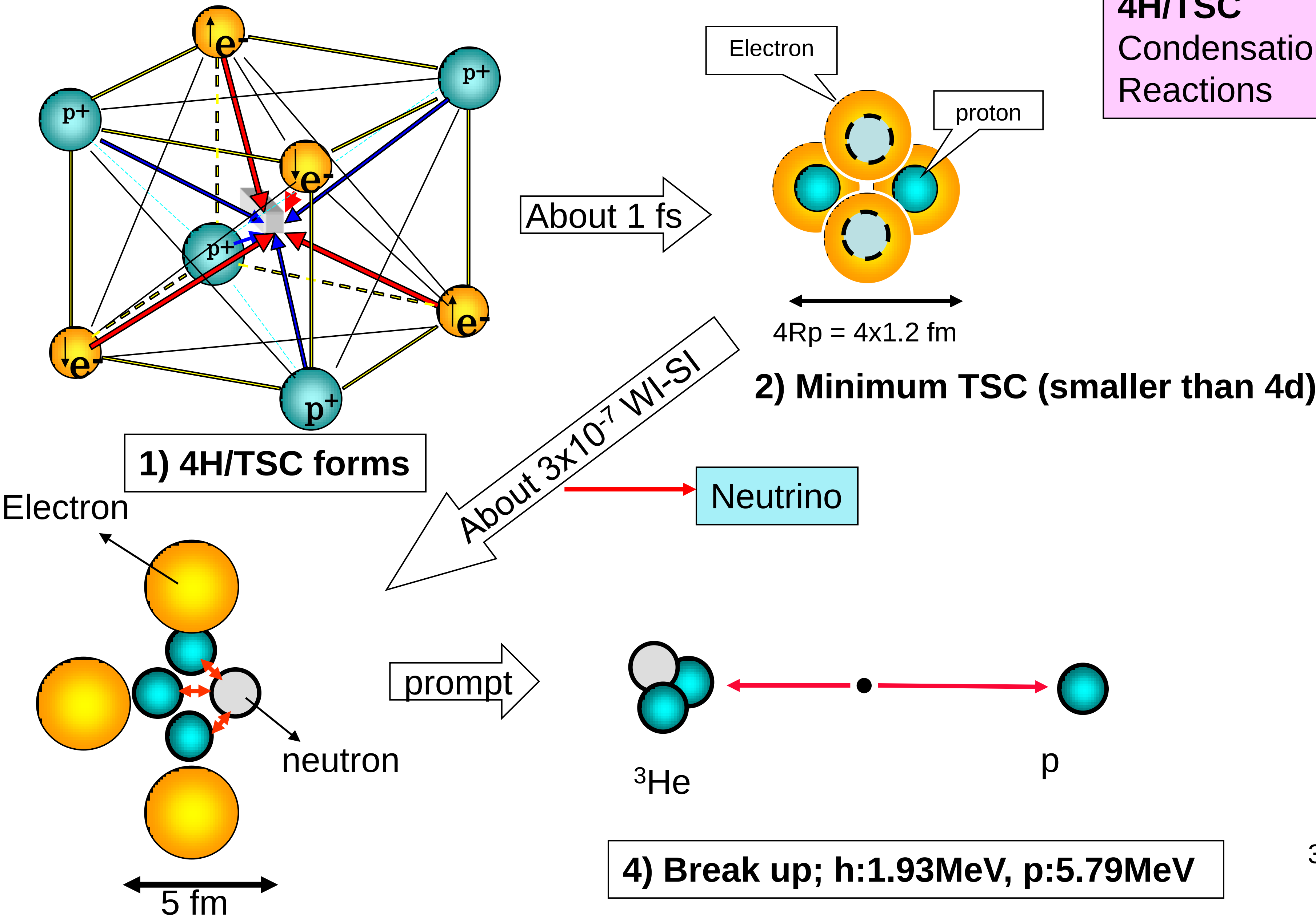
Summary

- The Final State Interactions of ^{8}Be* by 4D/TSC are qualitatively/semi-quantitatively discussed.
- Nucleon-Halo State of ^{8}Be* may have rather long life time as rotation of halo-nucleon coupled with vibration motion of alpha- and h-(t-) cluster, and would have narrow spaced energy-band structure, from where EM transition photons (1-10keV: **BOLEP: agreed with X-ray burst by Karabut exp.**) damp ^{8}Be*(47.6MeV) to ^{8}Be(g.s.:O+), as major channels.
- Direct many hadronic break-up channels may compete with the nucleon-halo state transition, but as minor channels with **discrete α-peaks which agreed very well with Roussetski experiment.**
- Quantitative QM studies are to be expected.

Part-II : MHE

- 4H/TSC WS (Weak-Strong) Fusion
- Final state interactions are simple
- Secondary neutron-yield
- Secondary gamma-yield

4H/TSC Condensation Reactions



1) 4H/TSC forms

2) Minimum TSC (smaller than 4d)

3) ^{4}Li* formation (PEF=3)

4) Break up; h:1.93MeV, p:5.79MeV

Products of 4H/TSC W-S Fusion

- $3p + n \rightarrow {}^{4}\mathrm{Li}^{*}(4.62\mathrm{MeV})$
- $^{4}\mathrm{Li}^{*}(4.62\mathrm{MeV}) \rightarrow$ **$^{3}\mathrm{He}$** $+ p + 7.72\mathrm{MeV}$

  (1.93) (5.79)
- $^{4}\mathrm{Li}^{*}(4.62\mathrm{MeV}) \rightarrow$ **d** $+ 2p + 2.22\mathrm{MeV}$

  (~1MeV)

Main branch?
See next slide

OR

- 5.79MeV proton produces PIXE:

  ca. 8keV for Ni
- 5.79MeV proton energy is smaller than neutron emission threshold for ^{58}Ni (9.5MeV) and ^{60}Ni(6.9MeV), but larger than those for ^{61}Ni(3MeV), ^{62}Ni(4.5MeV) and ^{64}Ni(2.5MeV) . (So, see the slide after the next one.)

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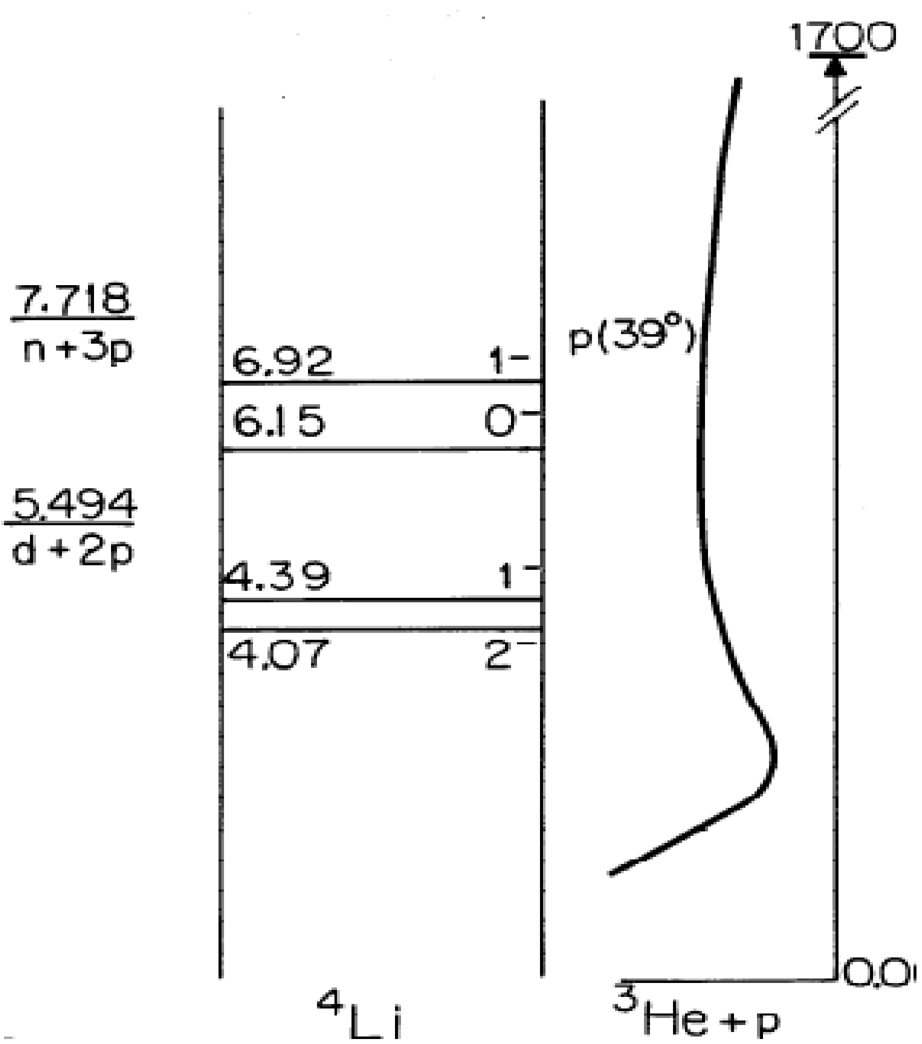
From TUNL library

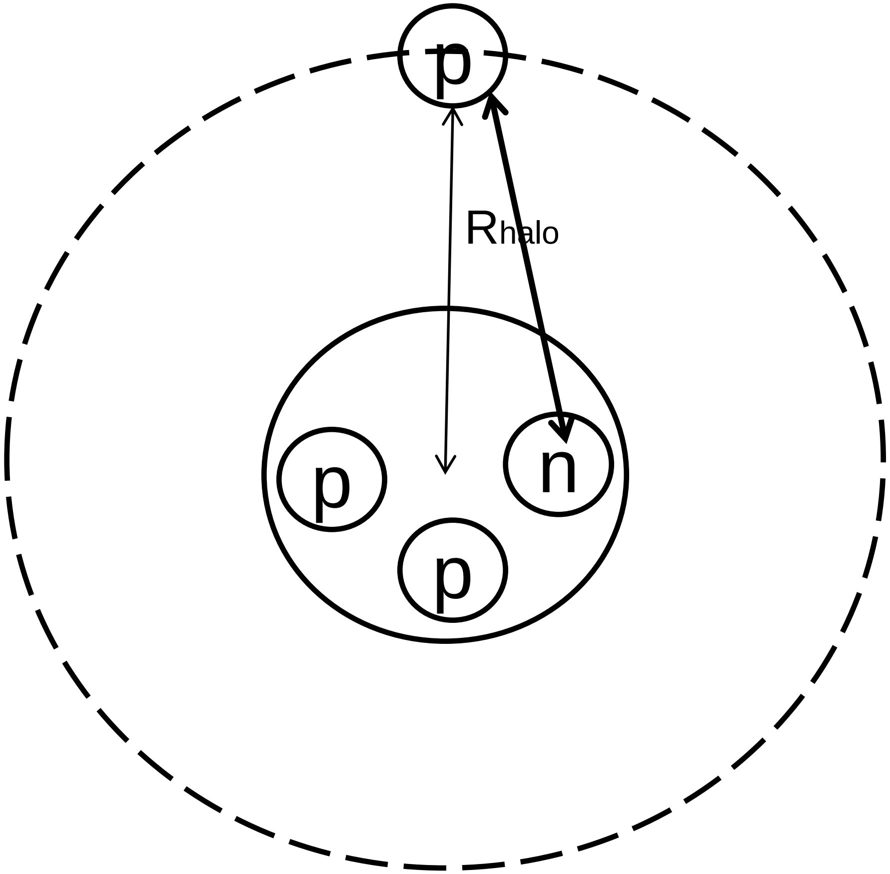
4.62 MeV →



Nucleon Halo Model of ^{4}Li*(Ex=4.62 MeV: J$^{\pi}$)

Excitation with 1 PEFs spring:

No concrete alpha-core may enhance prompt hadronic break-ups



⟷ Binding PEF

Binding PEF = 1

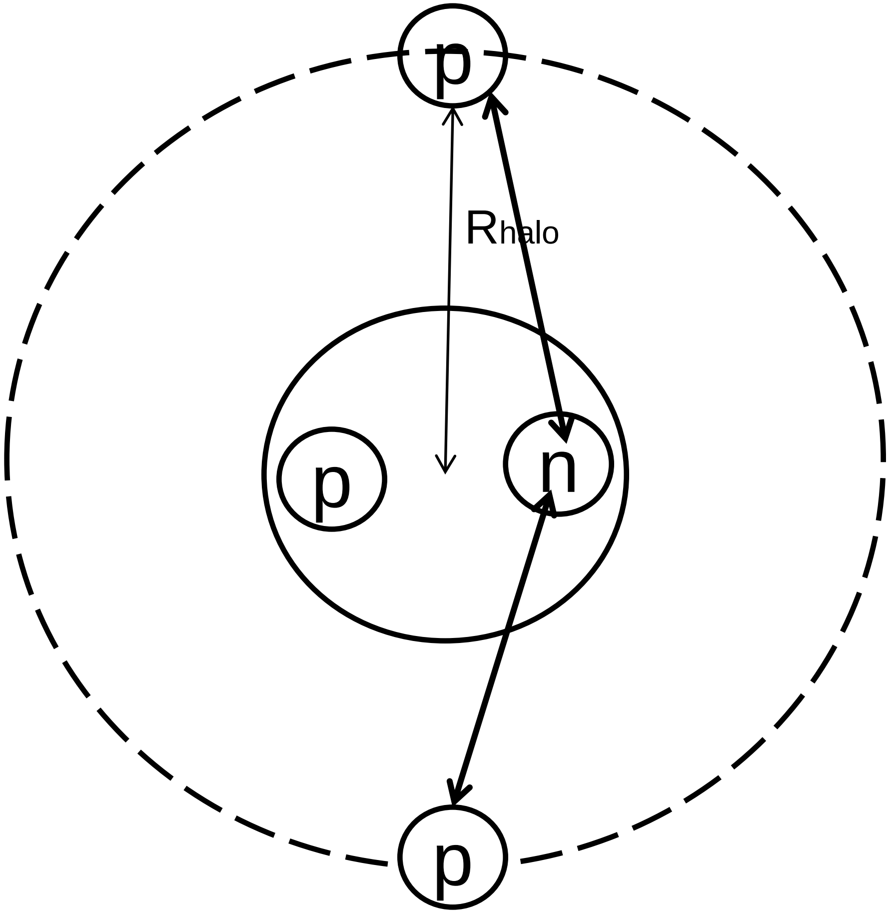
This state breaks up
Promptly in 10^{-22}s
To p + h + 7.73 MeV
Due to no hard alpha-core
And weak binding PEF.

E_x > ca.4.2MeV =
$(1/2)K_1R_{halo}^2$
And prompt break-up

Nucleon Halo Model of ^{4}Li*(Ex=4.62 MeV: J$^{\pi}$)

Excitation with 2 PEFs spring:

No concrete alpha-core may enhance prompt hadronic break-ups



⟷ Binding PEF

Binding PEF = 2

This state breaks up
Promptly in 10^{-22}s
To p + p + d + 2.22 MeV
Due to no hard alpha-core
And weak binding PEF.

E_x < ca.8.4MeV =
2x(1/2)$K_1 R_{halo}^2$
:And prompt break-up,
Mabe minor channel

Skip

Probability of secondary neutrons

- ^{58}Ni + p → ^{58}Cu + n -9.46MeV (68%)
- ^{60}Ni + p → ^{60}Cu + n -6.91MeV (26.2%)
- **^{61}Ni + p → ^{61}Cu + n -3.0MeV (1.1%)**
- **^{62}Ni + p → ^{62}Cu + n -4.5MeV (2.6%)**
- **^{64}Ni + p → ^{64}Cu + n -2.5MeV (0.93%)**

Rough Yield Estimated is 2.5×10^{-13} (n/5.79MeVproton)

- Slowing down of 5.79MeV proton in Ni and Ni(p,n) yield should be estimated.
- Coulomb barrier for Ni + p reaction:

  $28\times1.44/(R_{Ni\text{-}p}=5\text{fm}) = 8$ MeV
- Mean proton energy in slowing down range (5.79 to 2.5 MeV):

  about 4MeV
- Mean barrier penetration probability (STTBA):

  $G = 0.436(1\times6)^{1/2}\times(10-5)=5.3$

  $\exp(-G) = 5\times10^{-3}$
- Yield =

  $(5.6\%)\times5\times10^{-3}\times(3\text{fm}/0.1\text{nm})^{2}$

  $= 2.52\times10^{-(3+10)} = \mathbf{2.5\times10^{-13}}$ **(n/p)**

Ratio of cross sections between nuclear and atomic processes

Conclusions of 4H/TSC WSF

- **Simultaneous (very rapid cascade) weak and strong interaction may be predicted in the final stage of 4H/TSC condensation.**
- About 20 watts (or more)/mol-Ni heat with ^{3}He + d products is predicted (**Clean Heat**).

  (Heat level depends on TSC generation rate.)
- PIXE X-rays (ca. 8keV) will be detected.
- About 0.2 n per one joule heat will be detected. (10^5 neutrons/s per one mega-watt heat level)
- About 4 gammas by Ni(p,γ) per joule will be.

Why so radiation-less results?

	Claims by Experiments	**Predictions by TSC Models**
MDE (Metal Deuterium Energy)	Heat: 24±1MeV/^{4}He (Miles, McKubre, et al) Weak alpha-peaks (Lipson, Roussetskii, etc) Weak neutrons (Takahashi, Boss, etc.) *X-rays burst* (Karabut, et al.)	23.8MeV/^{4}He by 4D/TSC fusion with low-E alphas (46keV) Minor alpha-peaks by nucleon-halo BOLEP minor decay channels High-E neutron by minor triton emission *BOLEP* in ca.1.5keV
MHE (Metal Hydrogen Energy)	Heat w/o n and gamma unknown ash (Piantelli, Takahashi-Kitamura, Celani, etc.)	4H/TSC WS fusion 7-2MeV/^{3}He and d Very weak secondary Gamma and n Ca. 10^{-11} of ^{3}He and d