Reaction dynamics of slow collisions in light neutron excess systems

—Unified studies from bounds to continuum in Be isotopes

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I. Introduction

II. Framework

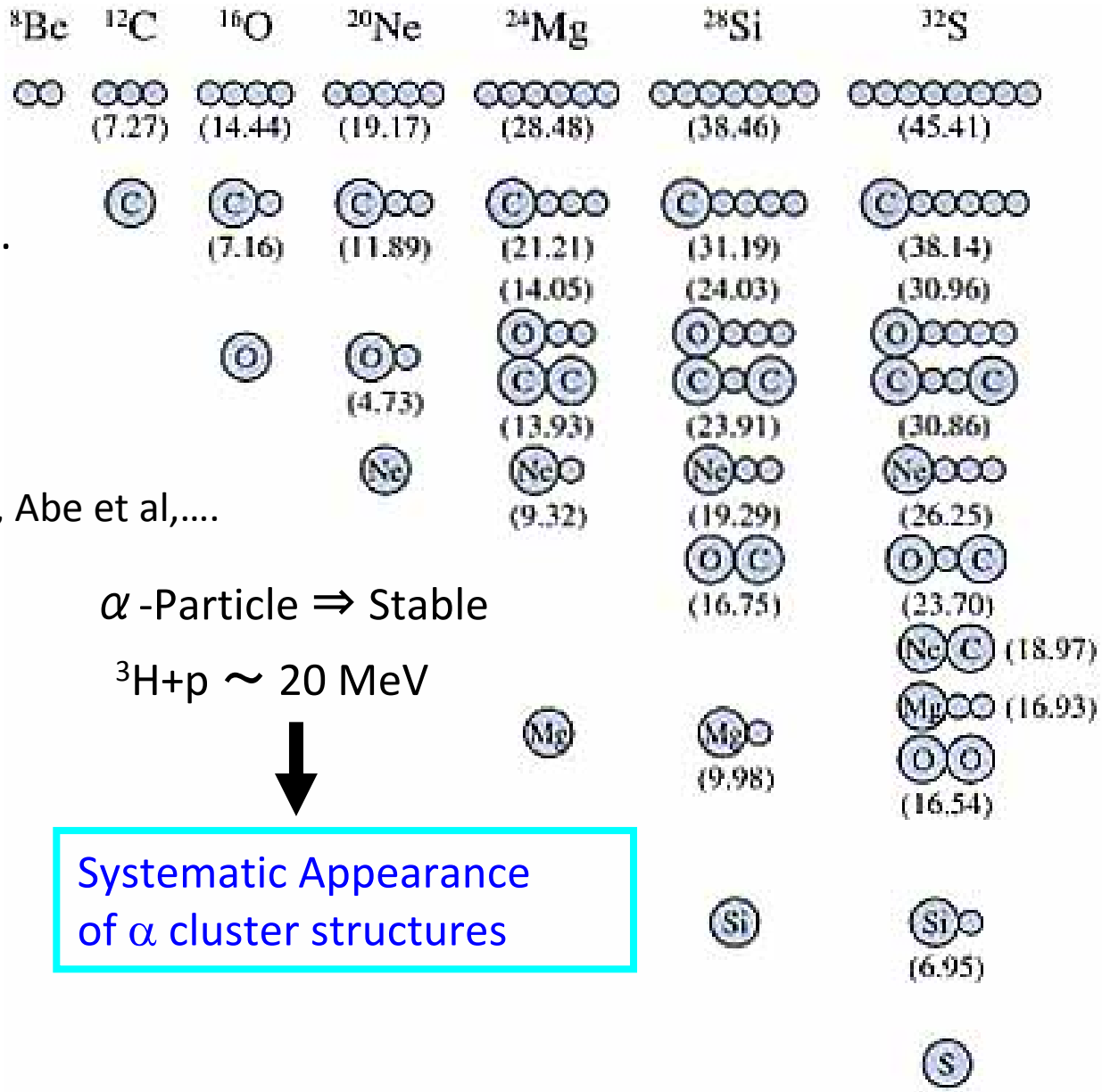
III. Varieties of structures in ^{12}Be and Be isotopes

IV. Enhancements induced by large amplitude motions

V. Summary and feature plan

Cluster structures in 4N nuclei

IKEDA Diagram

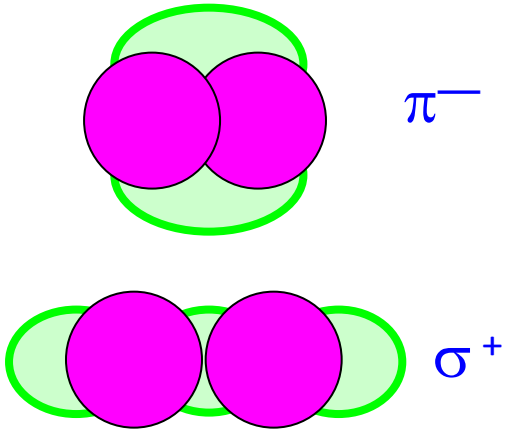


[Ikeda's Threshold rules](#)

Molecular structures will appear close to the respective cluster threshold.

Be isotopes

Molecular Orbital : Itagaki et al., Abe et al,….



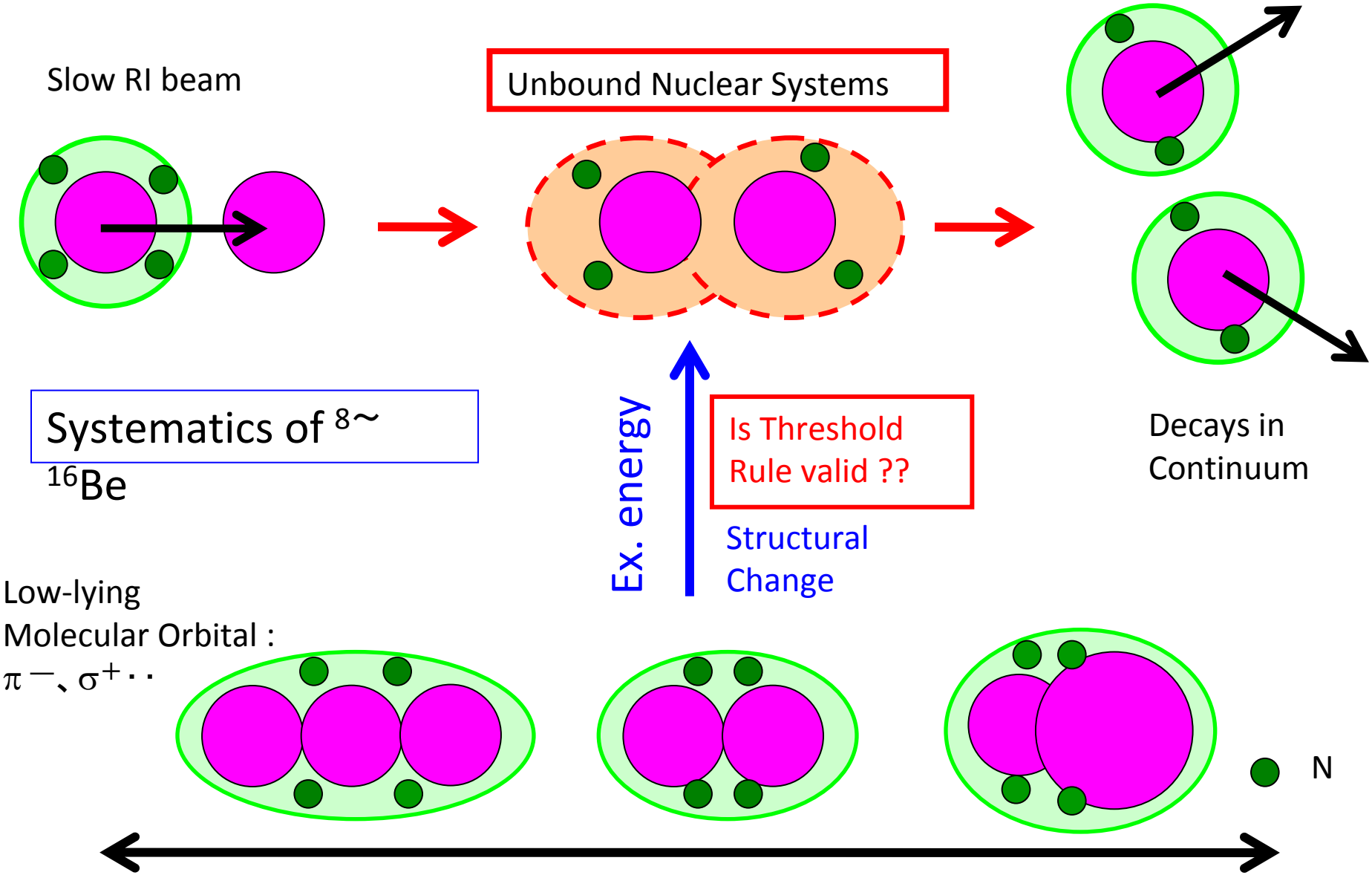
α-Particle ⇒ Stable

^{3}H+p ～ 20 MeV

Systematic Appearance of α cluster structures

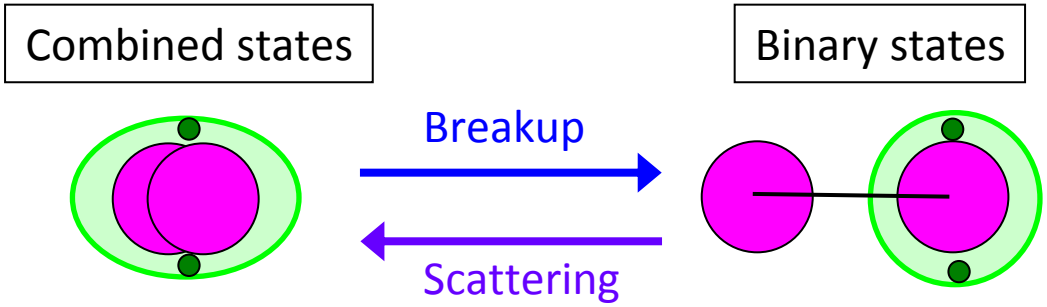
PRC61,62 (2000)

Studies on Exotic Nuclear Systems in (E_x,N, Z,J) Space



Interests from the viewpoints of large amplitude collective motions

Reactions are extreme limits of large amplitude collective motions !



How to characterize …

Reaction path in adiabatic energy surfaces (AESs)

Subjects

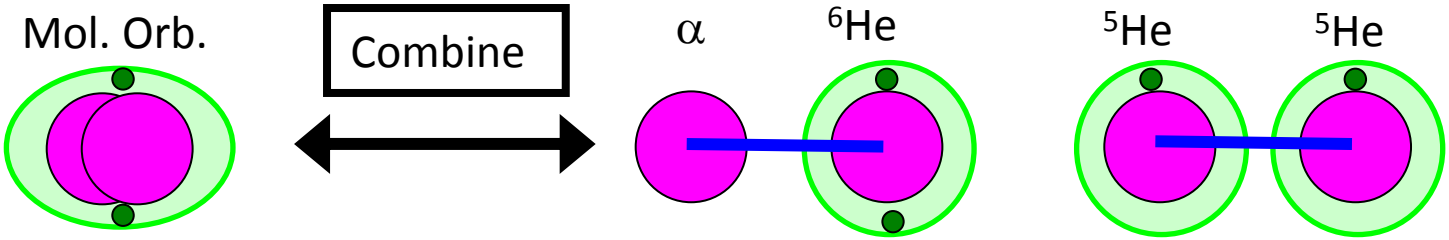
1. Pursuit of structural changes over a wide region in AESs
2. Investigation of reaction path in AESs and enhancements in connection to AESs structures

Today's report

1. Global features of structures in ^{12}Be and Be isotopes
2. Non-adiabatic phenomena in large amplitude reactions

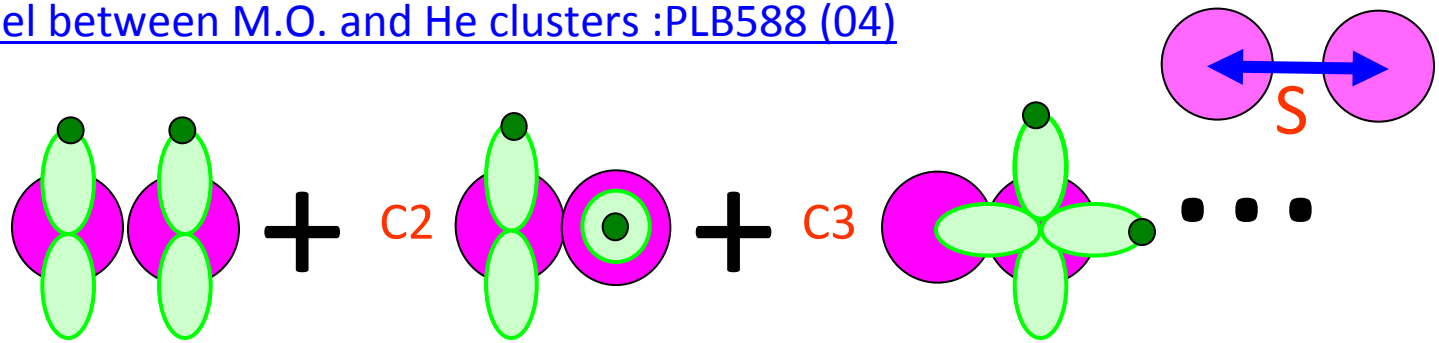
Extension of microscopic cluster model (Test calculation for ^{10}Be)

^{10}Be=α+α+N+N



Unified model between M.O. and He clusters :PLB588 (04)

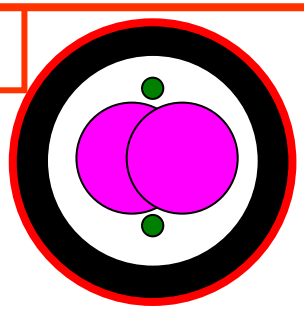
$$\Psi = C1 + C2 + C3 + \cdots$$



0Pi (i=x,y,z) Coupled channels with Atomic orbitals

S, Ci : Variational PRM.

Absorbing B.C.



−i W(R)

Decay widh
PTP113 (05)

Scattering B.C.

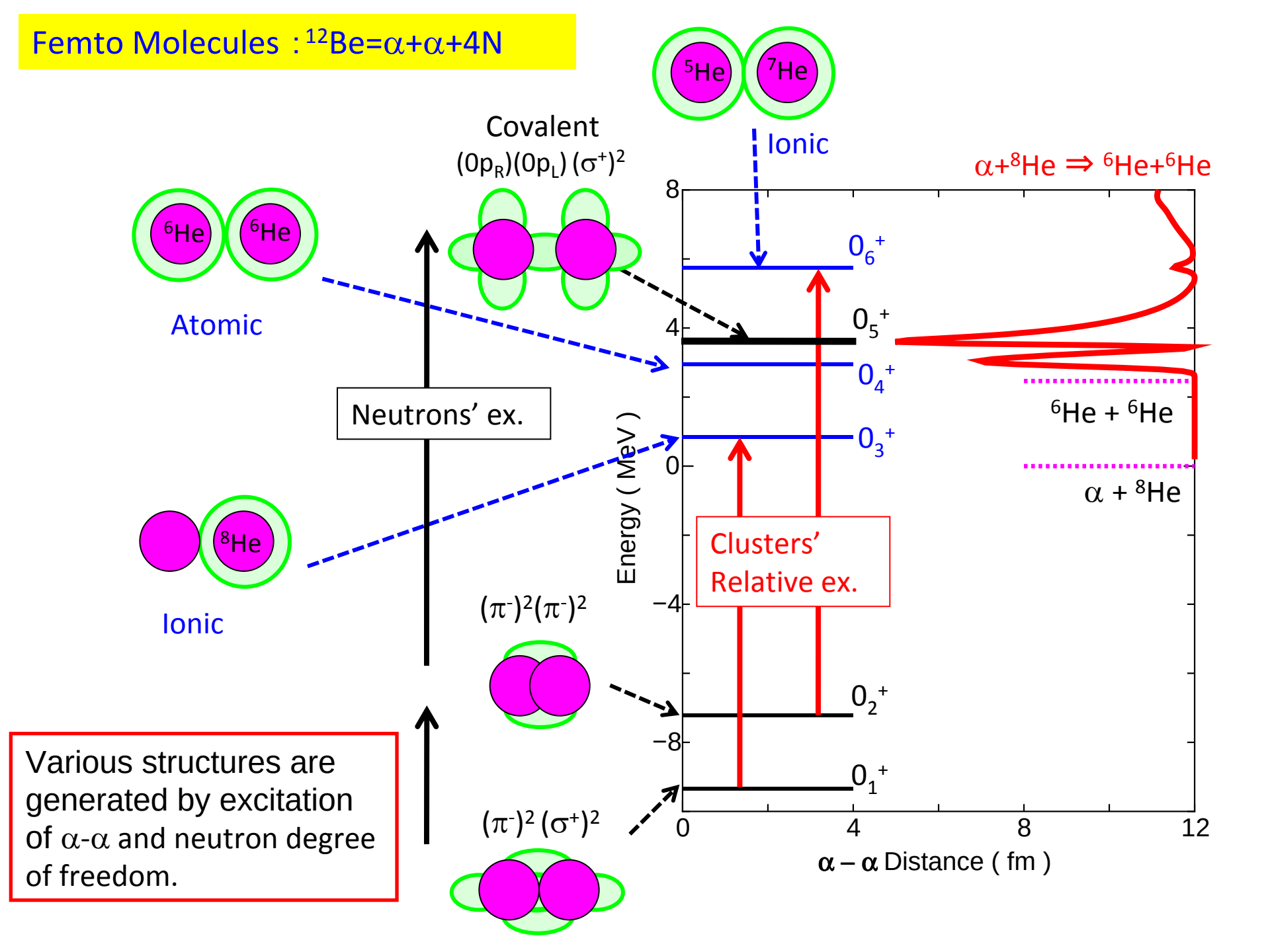
α+^{6}He Cross sections
PLB636 (06)

Tr. densites

$\langle \Psi \mid \rho \mid \Psi \rangle$

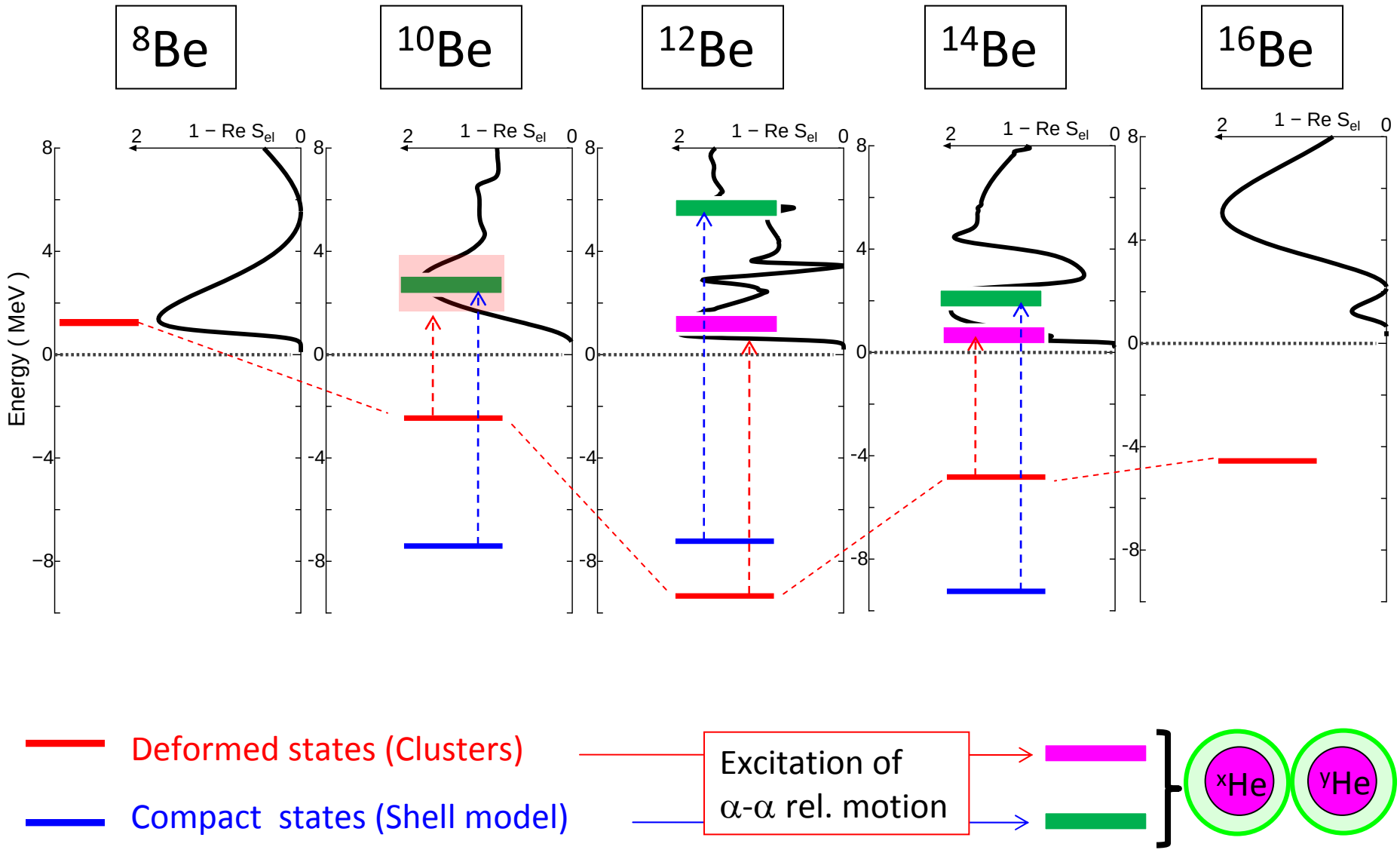
^{10}Be → α+^{6}He
Breakup

Femto Molecules : ^{12}Be=α+α+4N

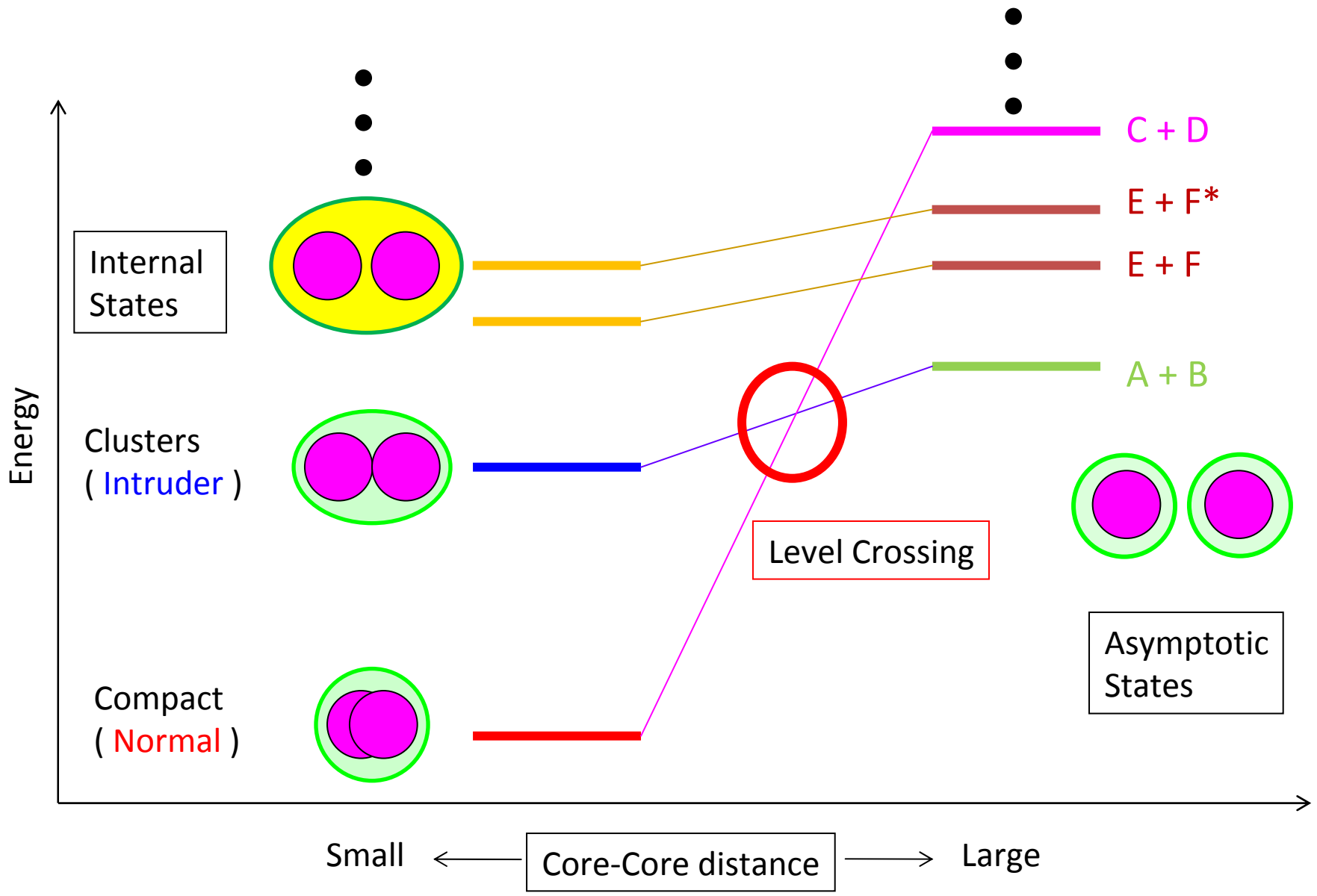


Various structures are generated by excitation of α-α and neutron degree of freedom.

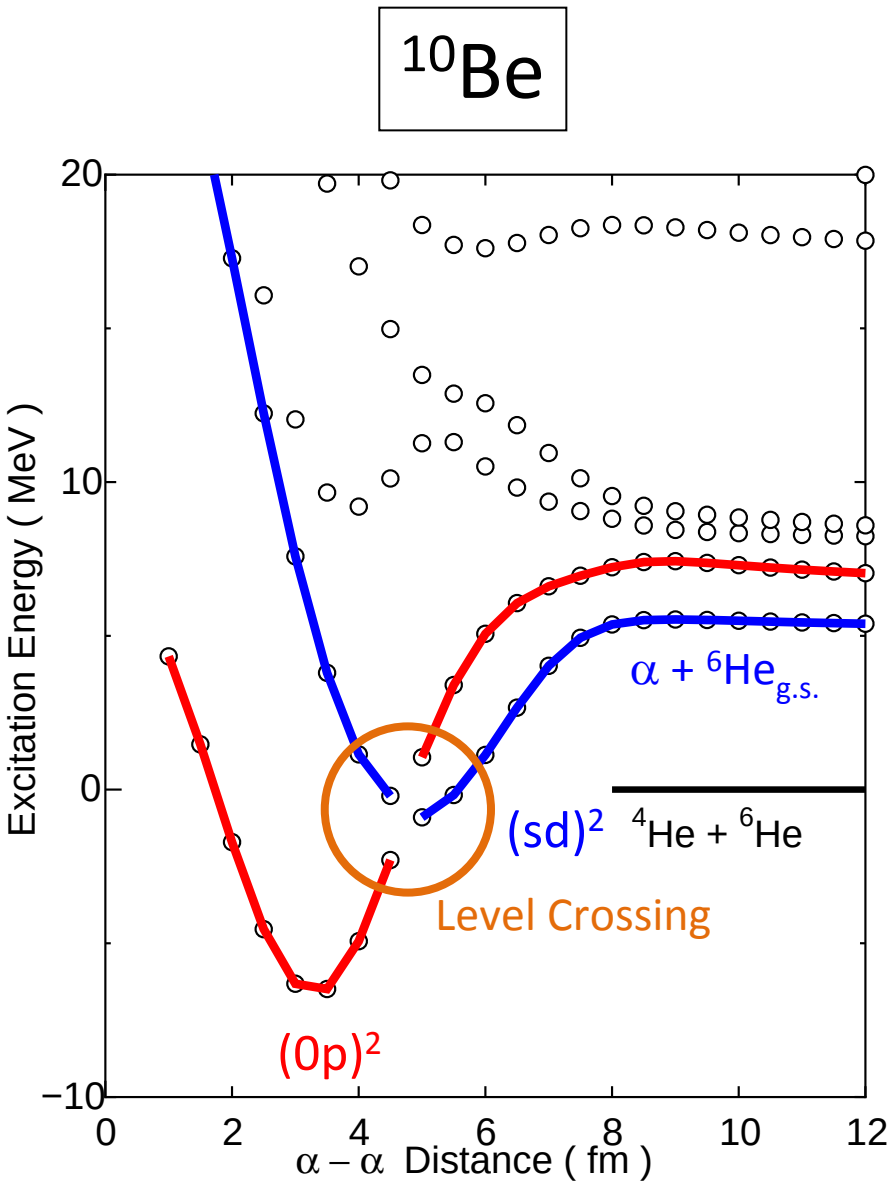
Be isotopes from bounds to continuums : $J^{\pi} = 0^{+}$

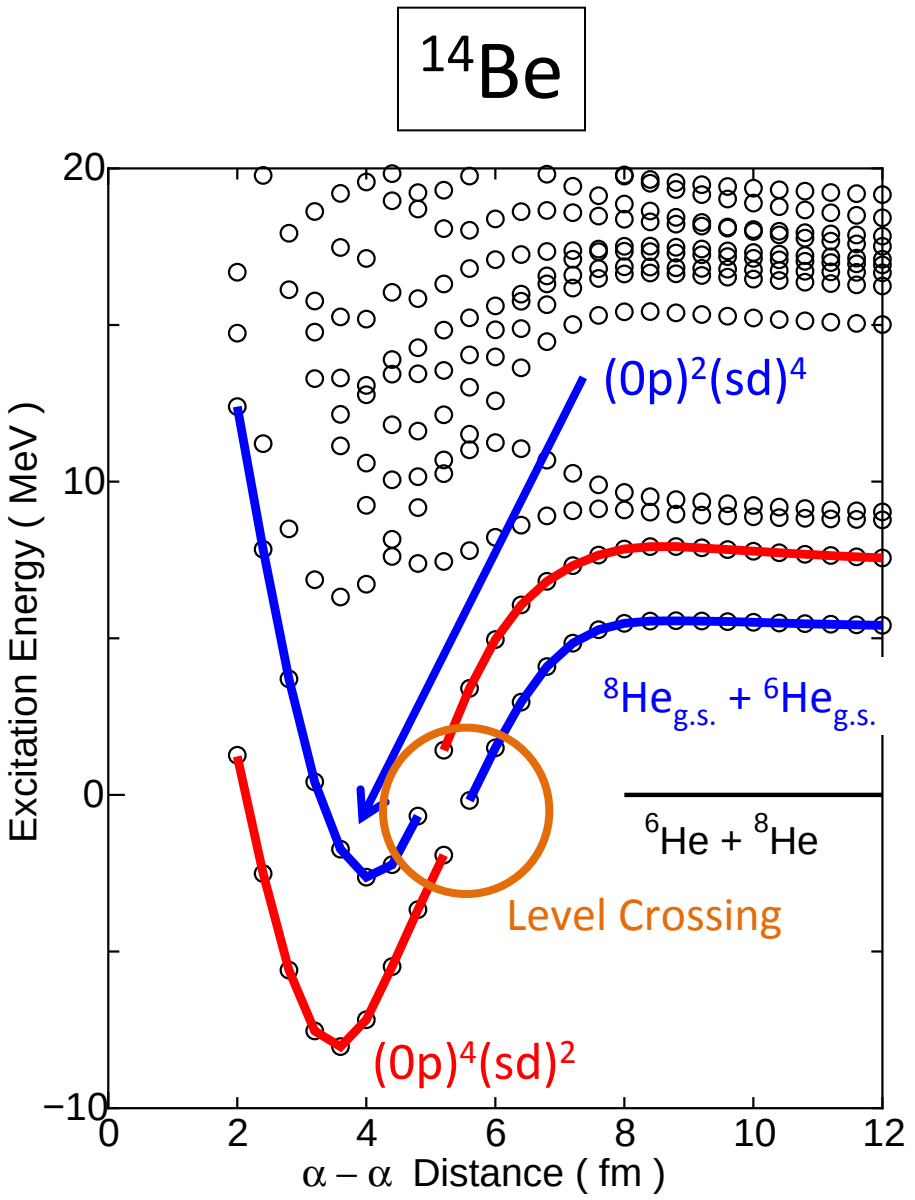


Global behaviors of Level Crossings in Be isotopes



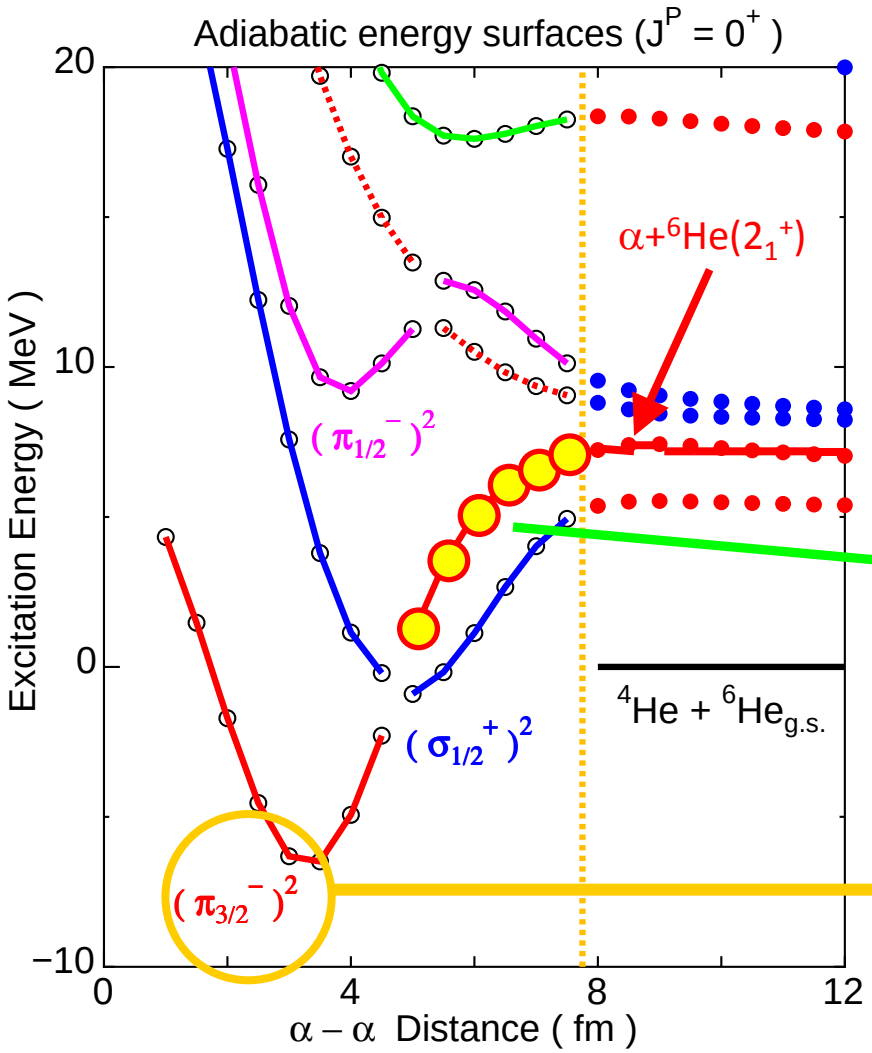
Level Crossings in ^{12,14}Be=α+α+XN (X=2,6)



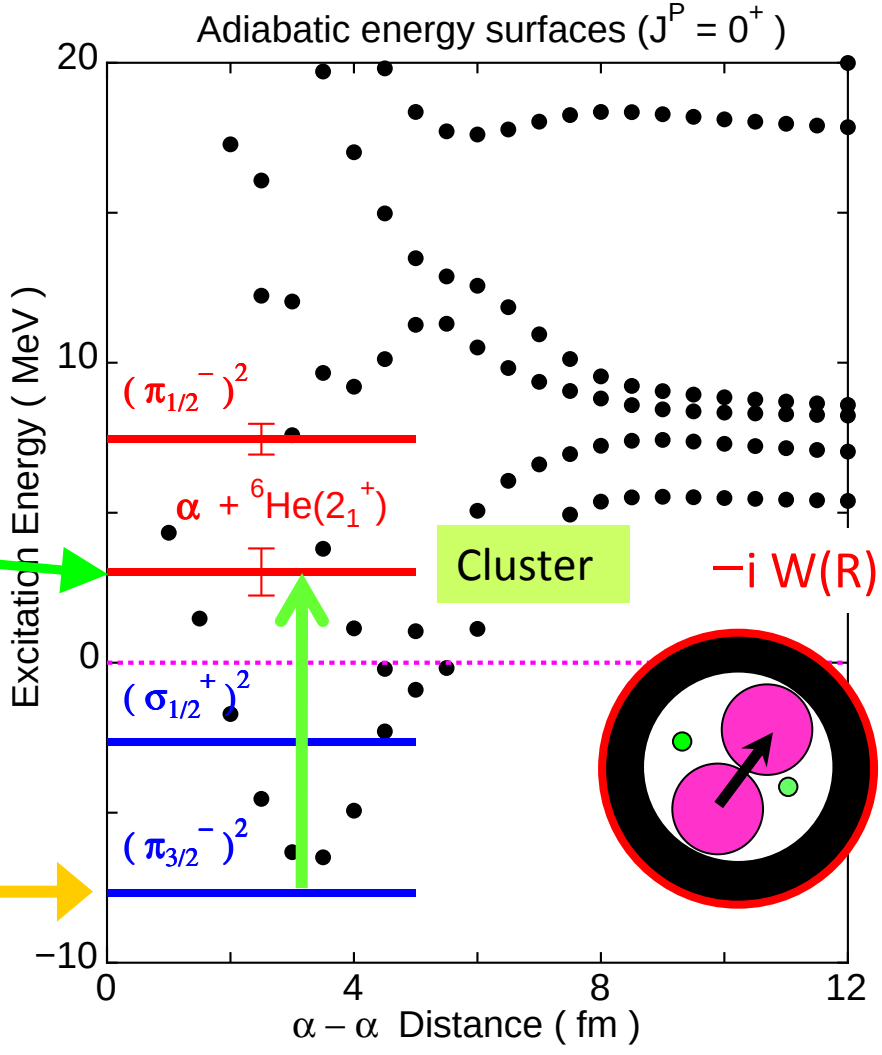


^{10}Be (0+) case : M.I., PLB636, 236 (2006)

Adiabatic surfaces ($J^\pi = 0^+$)



Energy spectra ($J^\pi = 0^+$)



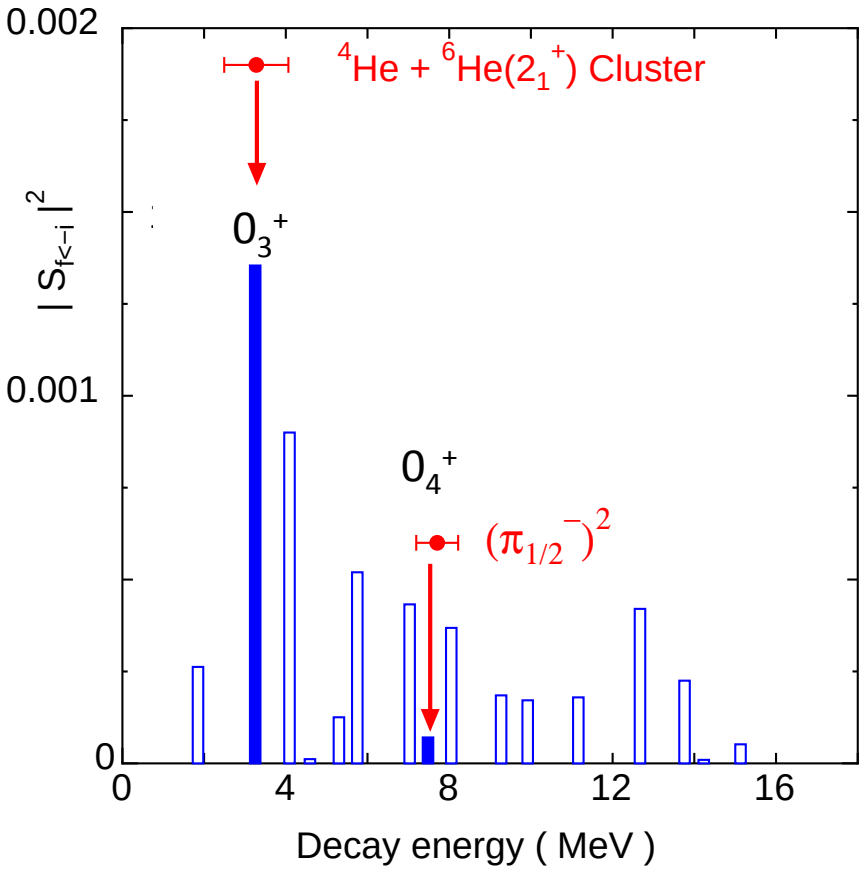
Nuclea breakup : $^{10}Be + ^{12}C \Rightarrow {}^{10}Be(0^+ \text{ conti.}) + {}^{12}C$ (CDCC cal.)

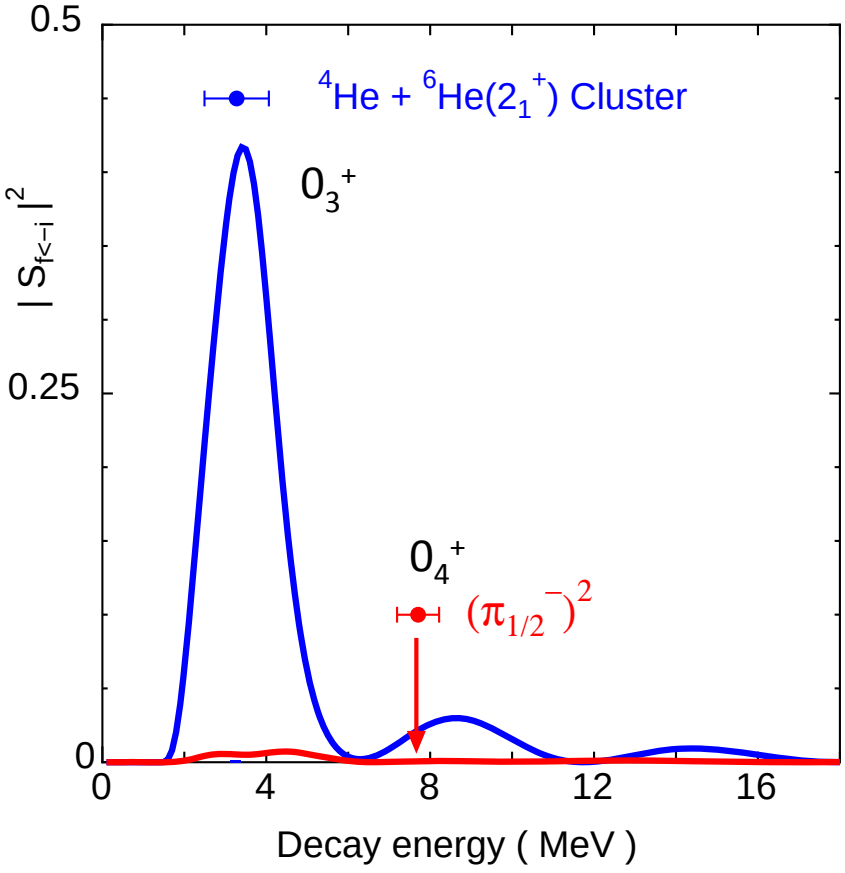
Smat.(Conti.←G.S.)

Smat.(Poles ← G.S.)

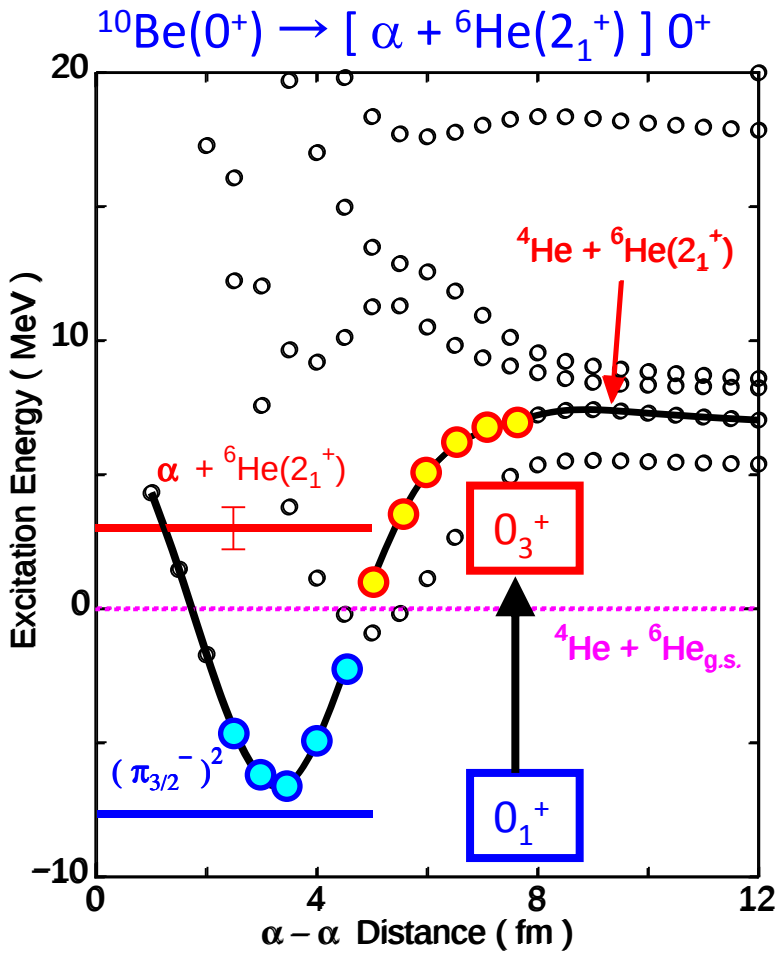
S-matrices to continuums

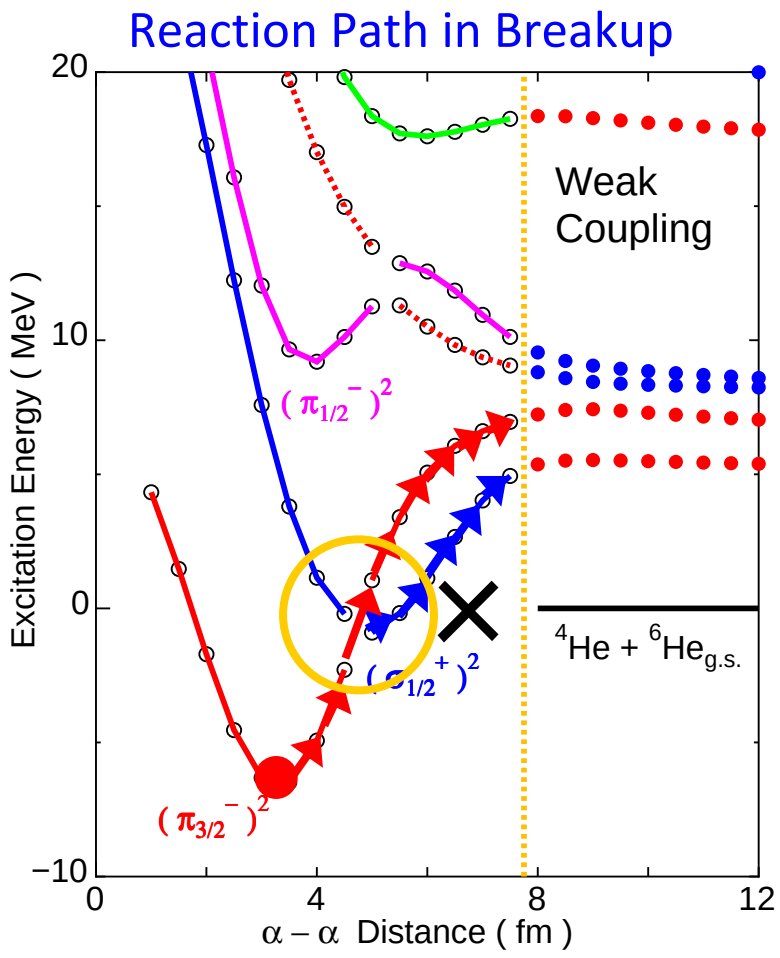
S-matrices to Poles





Reaction path in ^{10}Be → ^{x}He + ^{y}He Breakup reaction (Positive Parity)

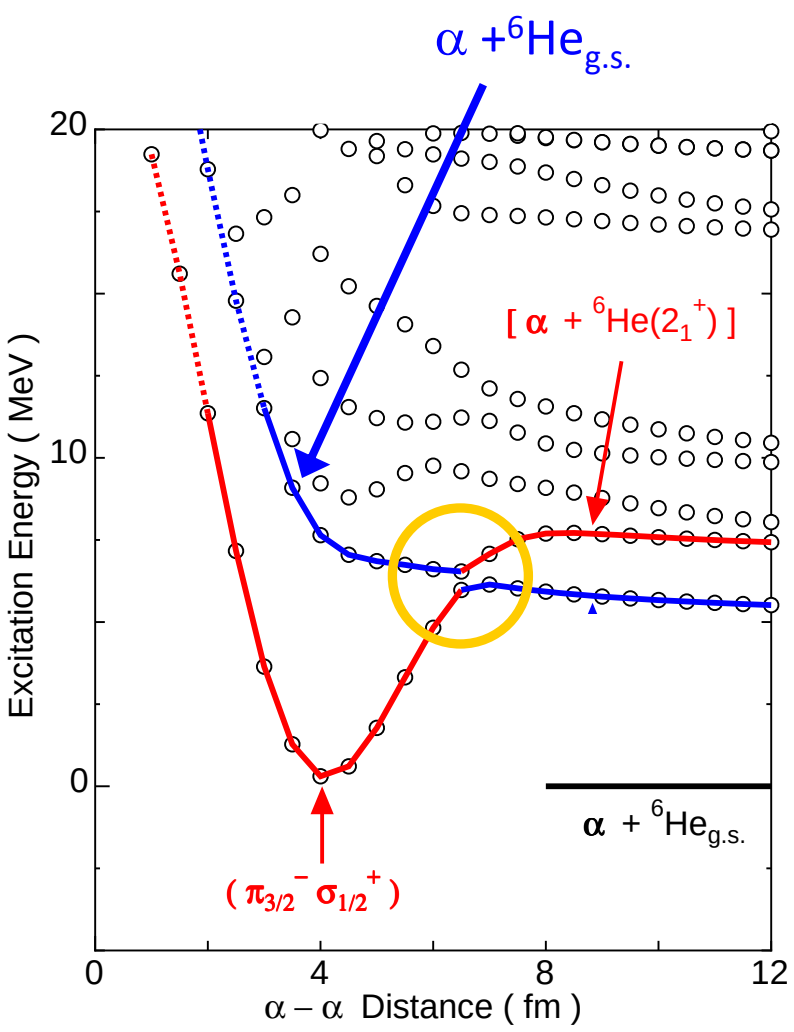




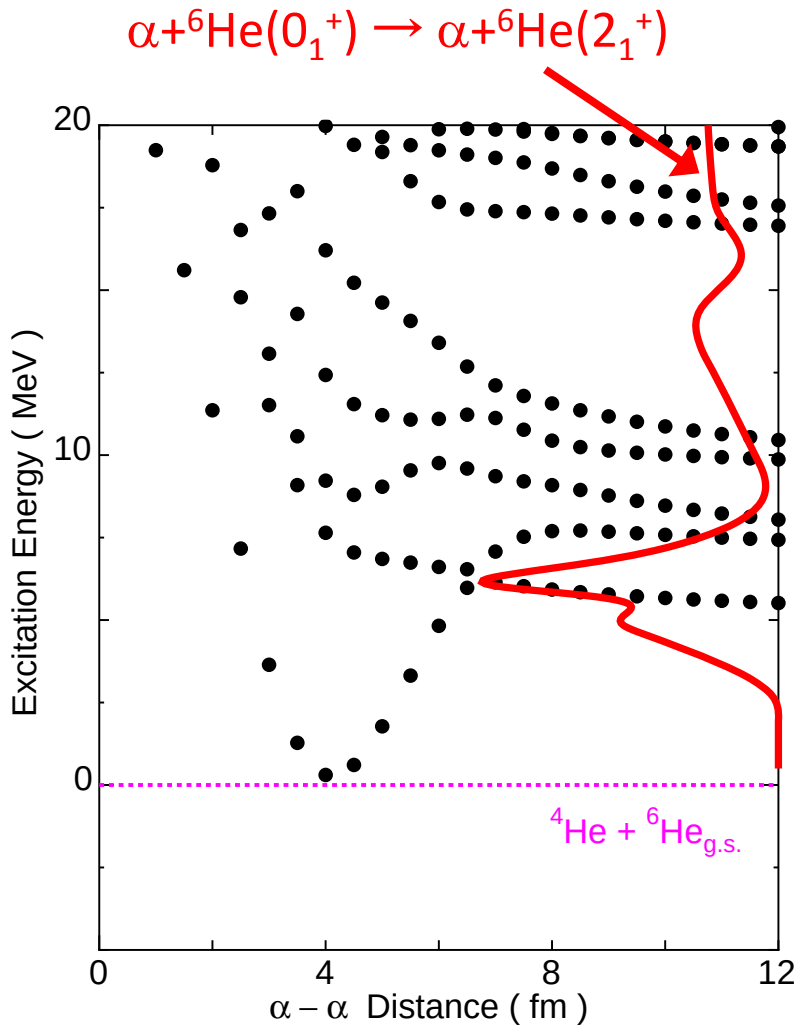
$0_1^+ \rightarrow 0_3^+$ is the dominant transition.

Non-adiabatic path is main process.

$\alpha + {}^{6}He_{g.s.} \Rightarrow \alpha + {}^{6}He(2_1^+)$ scattering (Negative Parity)

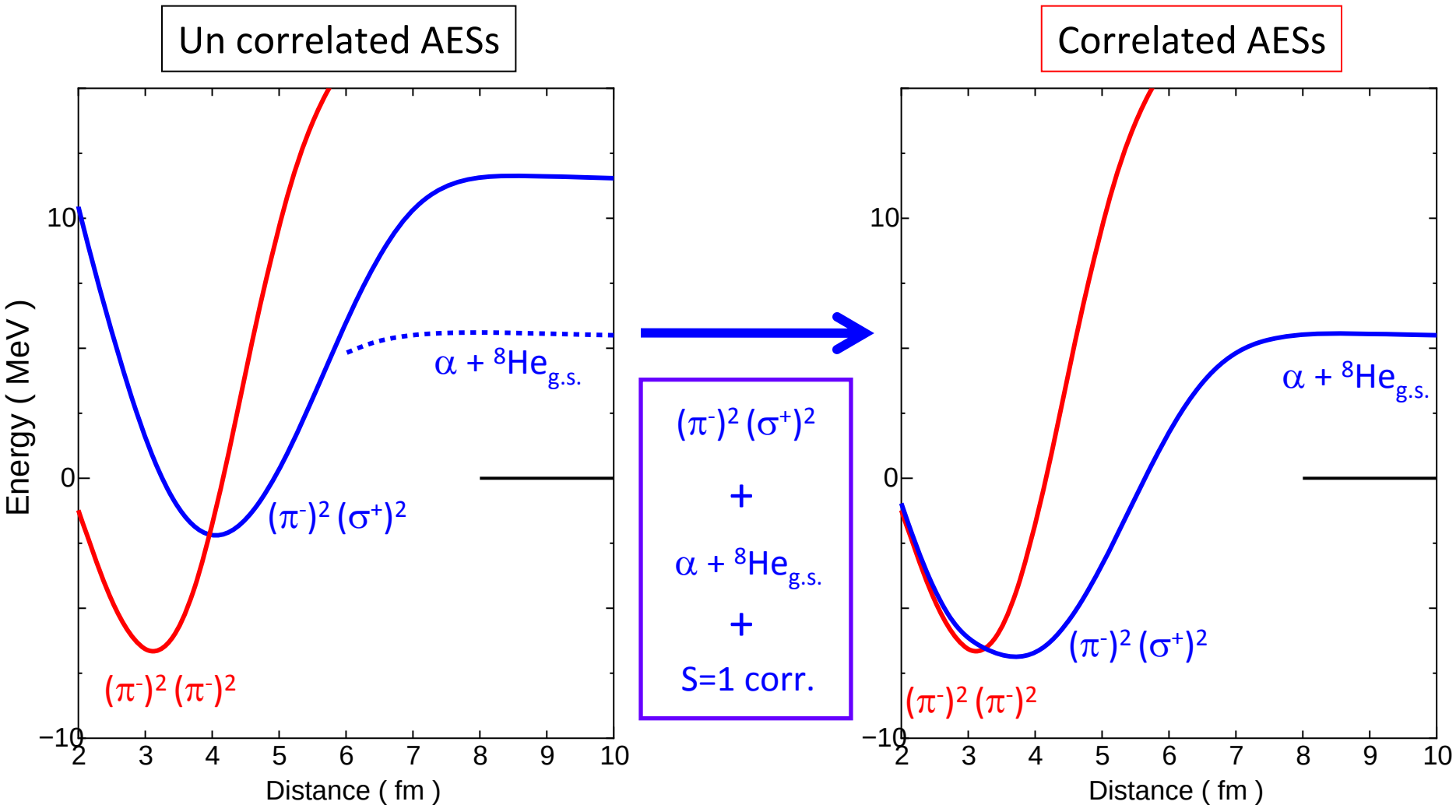


Avoided crossing at the surface



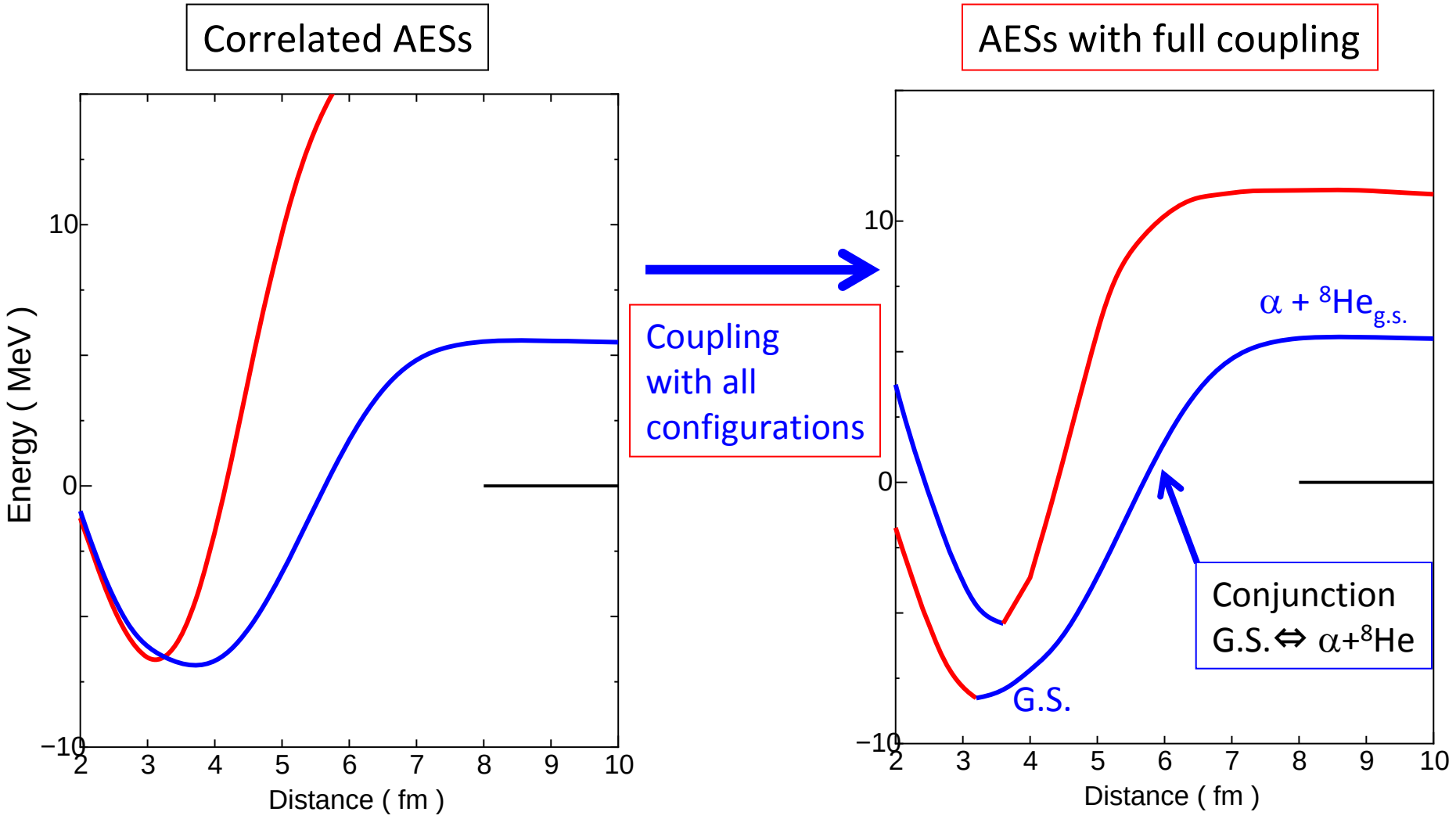
Landau-Zener type enhancement

Level Crossing in ^{12}Be (1)



Two AESs are almost degenerated due to correlations ⇒ Crossing occurs at inner region !

Level Crossing in ^{12}Be (2)

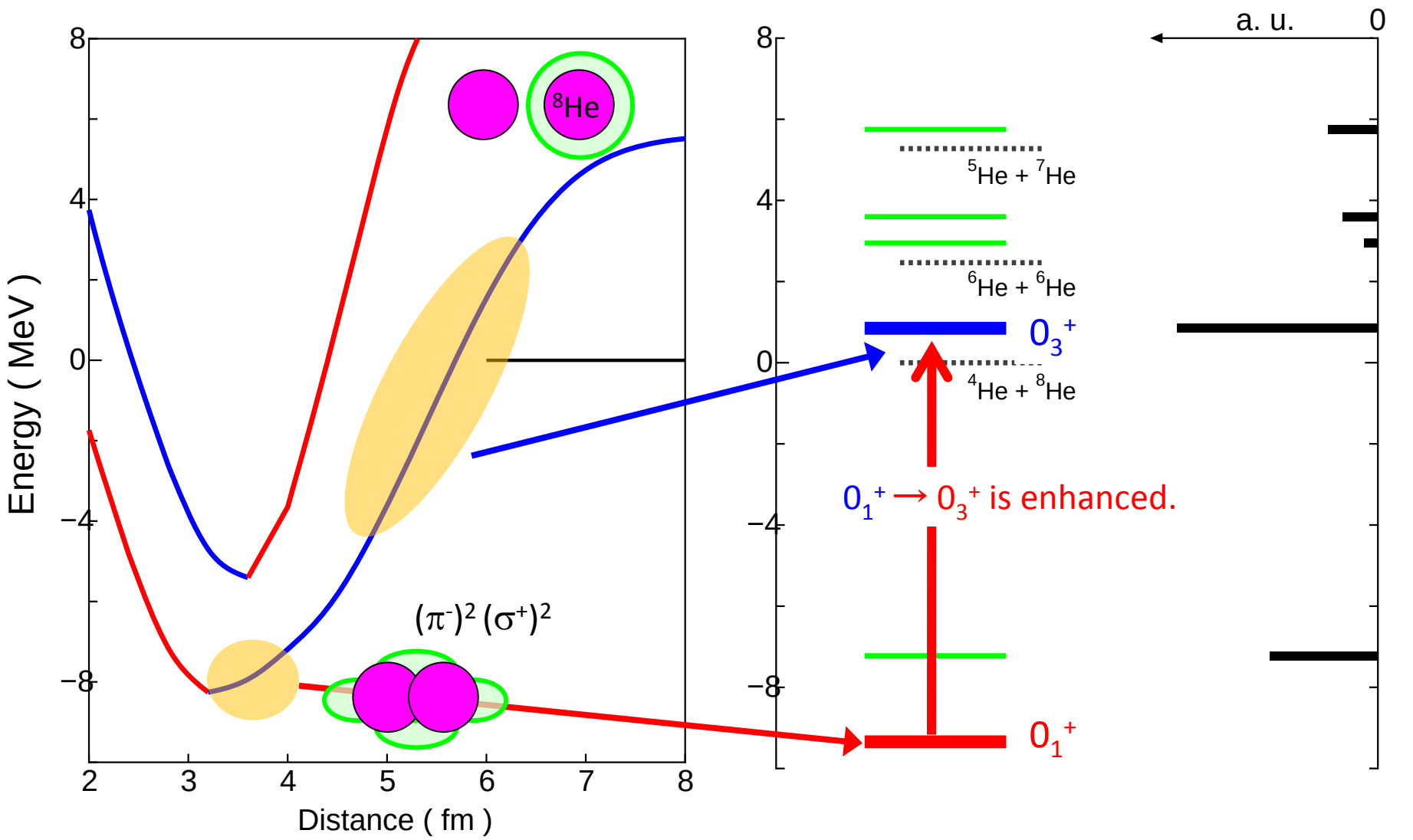


Lowest minimum smoothly connected to $\alpha+^{8}He_{g.s.}$ ⇒ Formation of adiabatic conjunction

Monopole transition of ^{12}Be

$$M(E0, IS) = \left\langle 0_f^+ \left| \sum_{i=1}^{A} r_i^2 \right| 0_1^+ \right\rangle$$

Adiabatic conjunction enhances the monopole transition !



Contents of present report

1. Unified studies form bounds to continuums in Be isotopes
2. Reactions with large amplitudes in connection to adiabatic energy surfaces

Results

1. There appears a wide variety of structures in excited states (Cluster + excess N)
2. Enhancements occur depending on the structures of AESs.

^{10}Be : Non-adiabatic path is dominant in monopole breakup and slow scattering.

^{12}Be : Adiabatic path is dominant in monopole b.u. (Formation of conjunction)

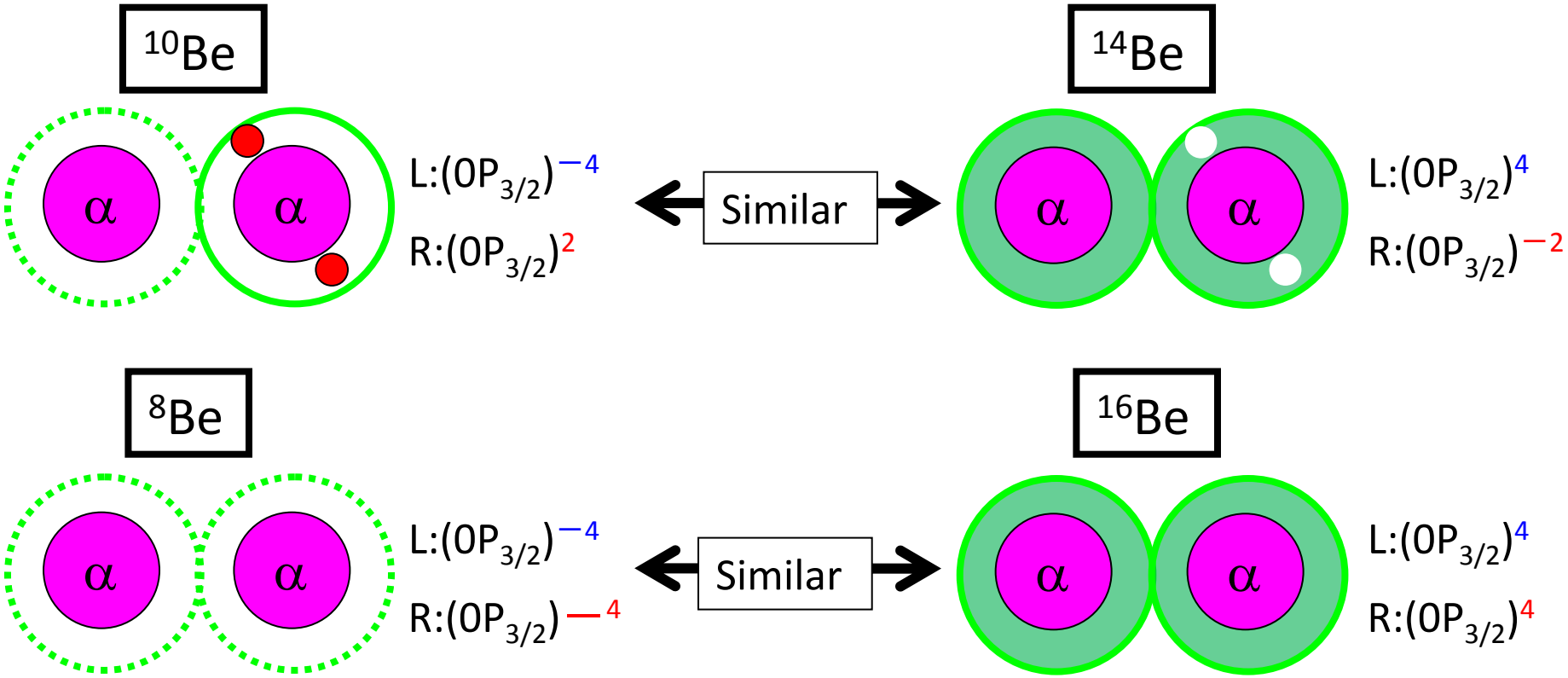
Feature studies

Recently, we have just succeeded in extending the model to general two centers.

Extension to SD shell ⇒ O=α+^{12}C+XN、Ne=α+^{16}O+XN

Generalities and Specialities : hybrid structures of clusters + excess neutrons in O and Ne

Systematics based on the Cluster Picture



We are now analyzing wave functions.

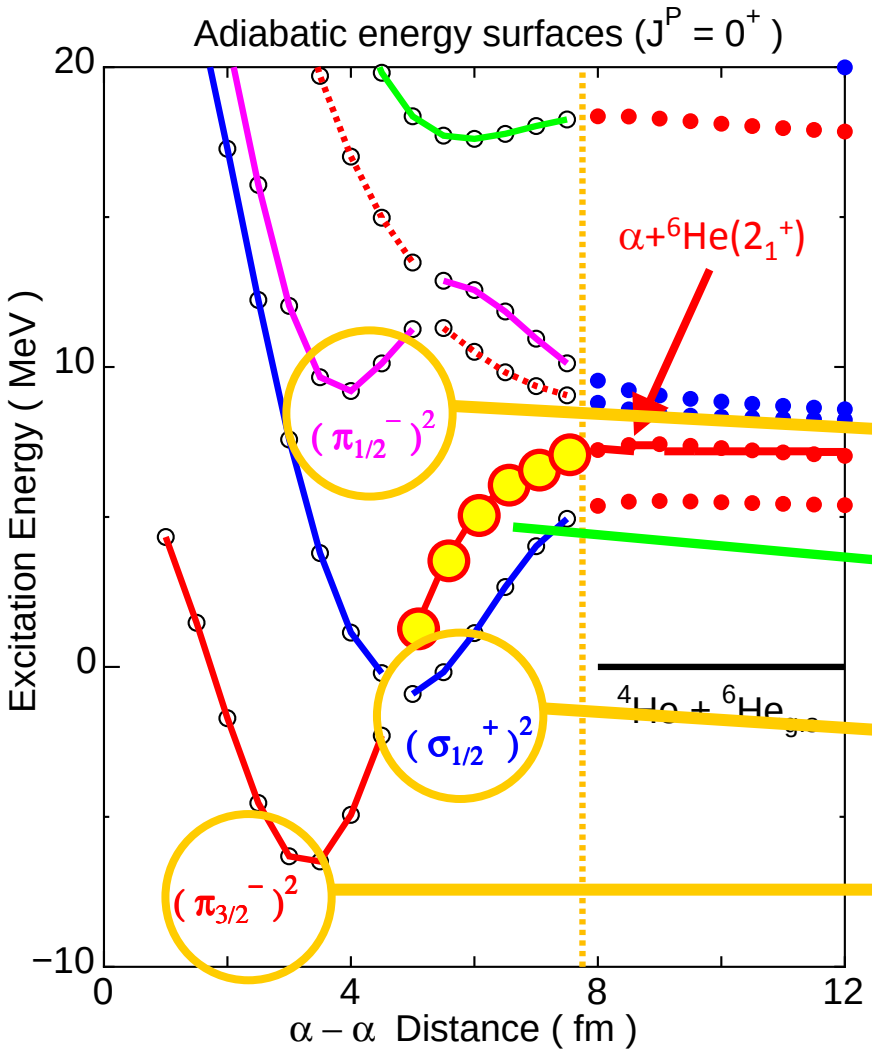
Special feature in ^{12}Be

^{12}Be=^{6}He+^{6}He, α+^{8}He is a self conjugate when atomic p-h are exchanged.

⇒ This is a special nucleus in even Be isotopes

GTCM + Absorbing Boundary Condition : PLB (2006)

Adiabatic surfaces ($J^\pi = 0^+$)



Energy spectra ($J^\pi = 0^+$)