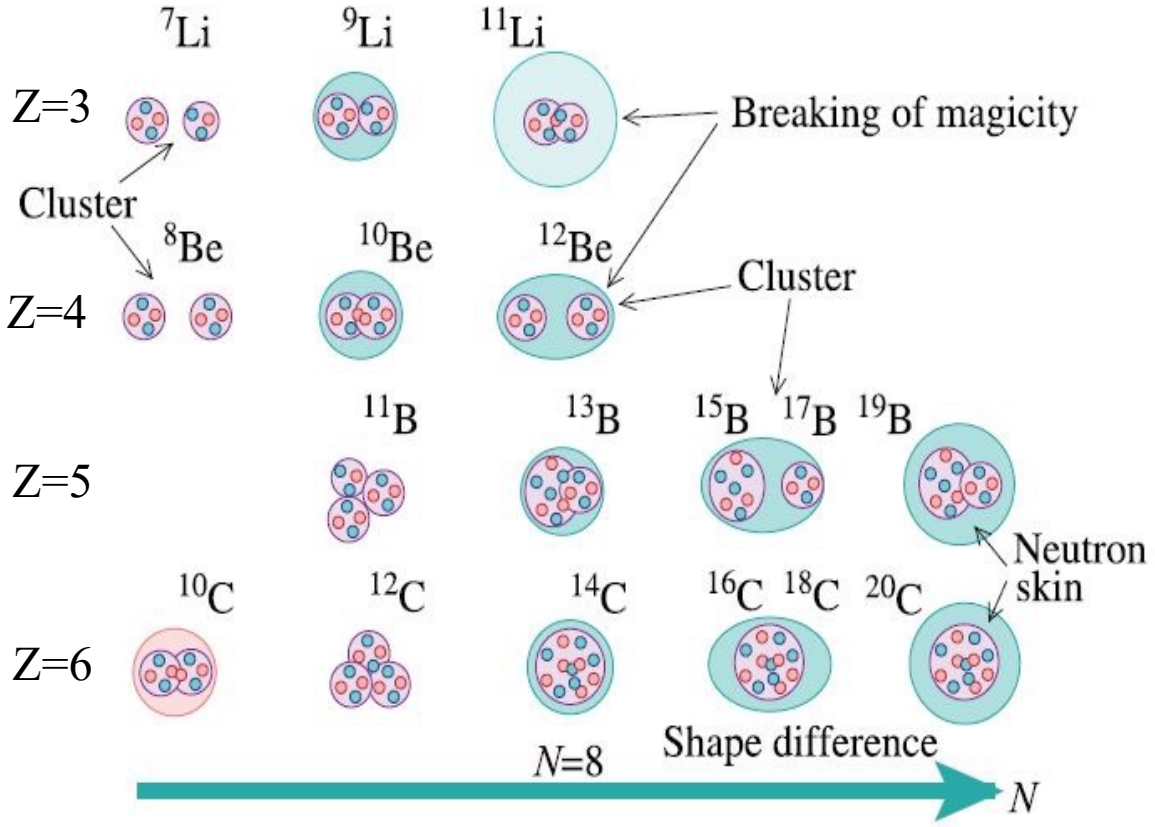
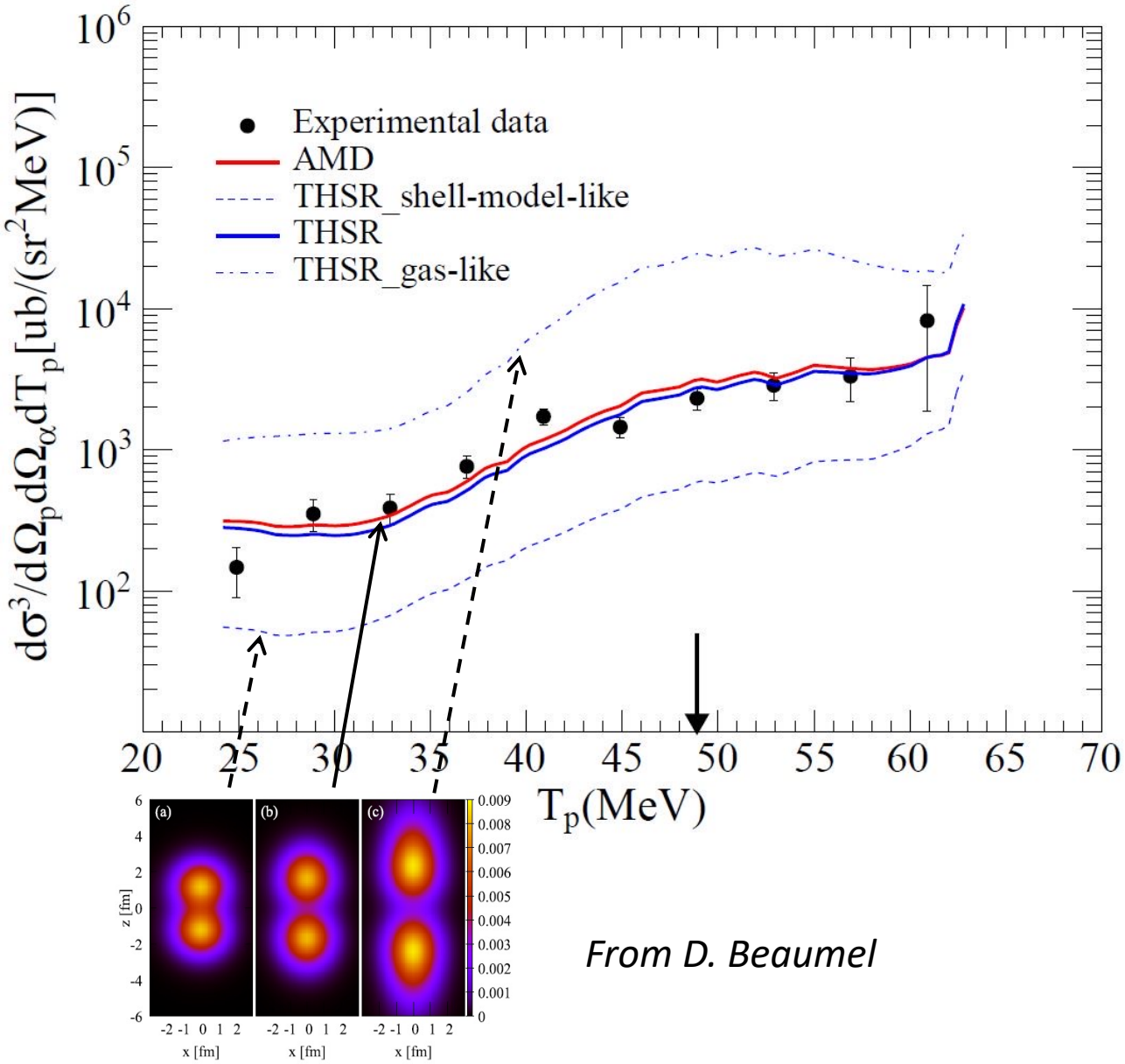
Some ideas related to clustering

Clustering in the g.s. Of light neutron-rich nuclei

Schematic views of g.s. Configurations from AMD calculations



^{10}Be(p,pα) ^{6}He$^{(GS)}$ @ 150 MeV/u to probe molecular cluster

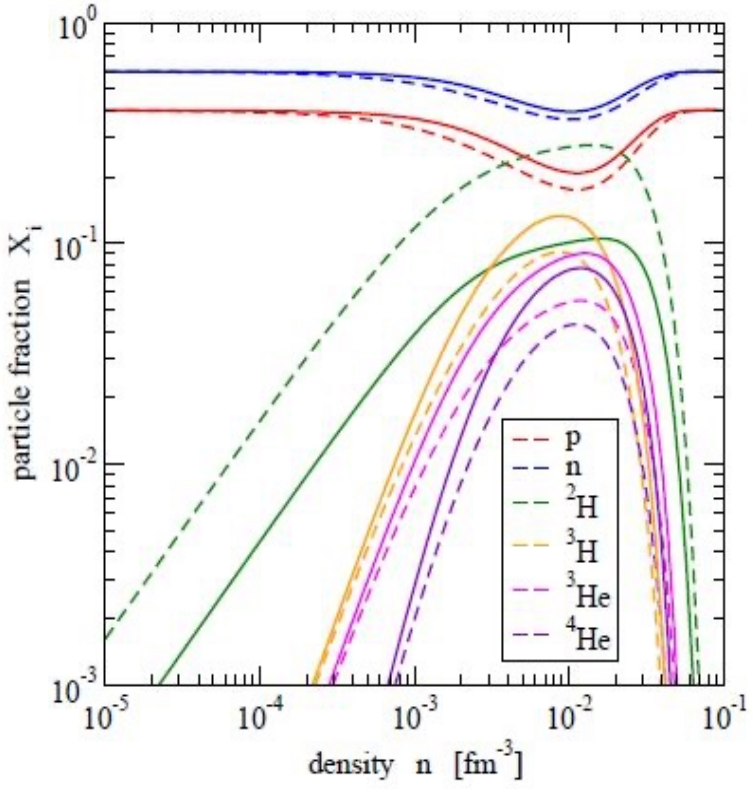


From D. Beaumel

Alpha clustering and beyond: from nuclear matter to nuclei

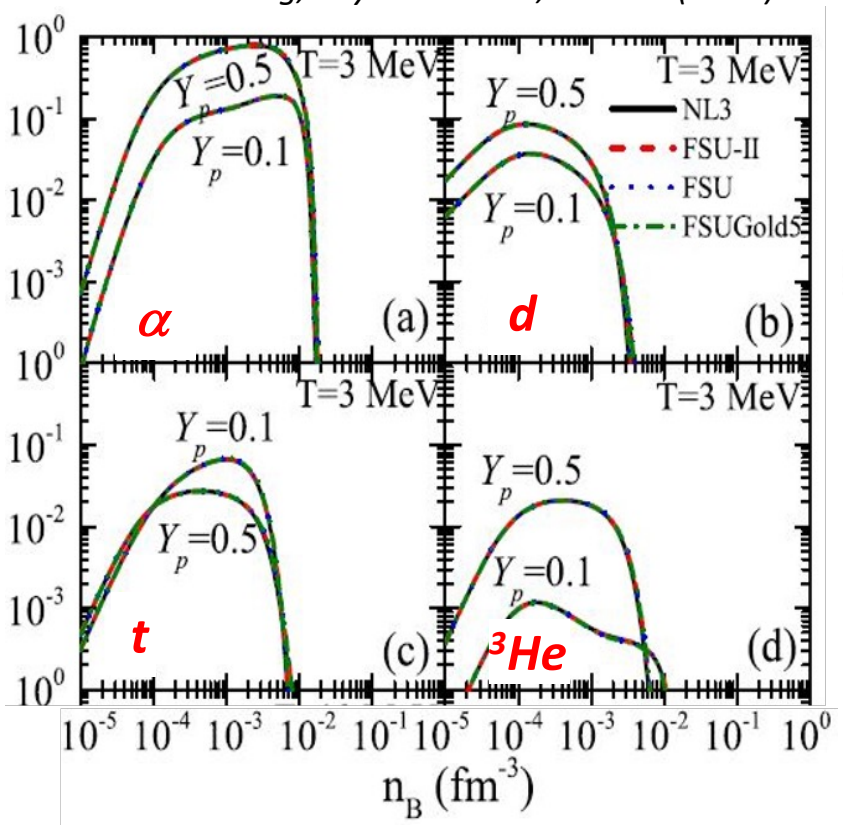
Formation of clusters at low density

S.Typel, J. Phys. Conf. Ser. 420, 012078(2013)

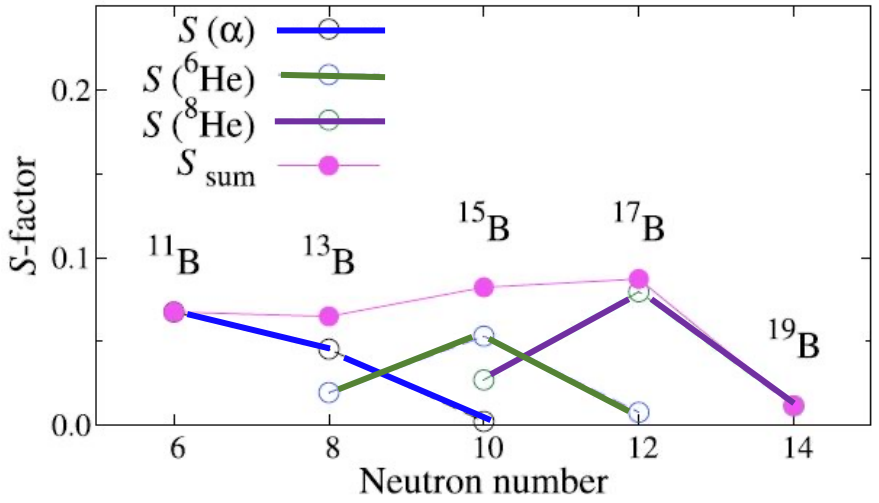


Fraction of clusters with Y_p

Z.-W. Zhang, Phys. Rev. C 95, 064330 (2017)



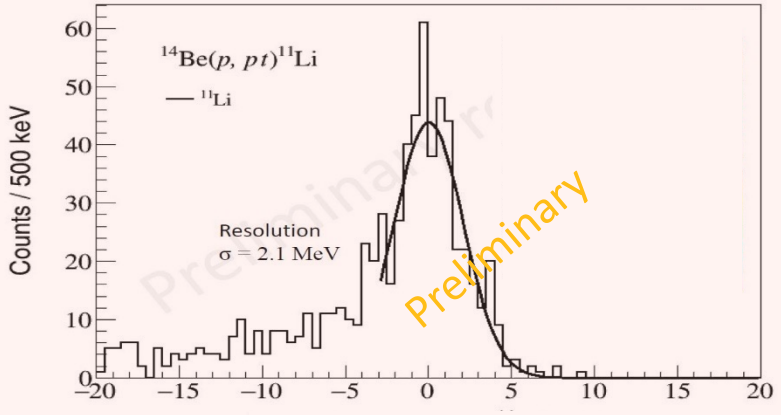
Predicted S- factors for the g.s. of B



Future plans to investigate the presence of clusters
Through knockout or transfer reactions.

From D. Beaumel

Large triton fraction in the **g.s.** of ^{14}Be nuclei from ^{14}Be(p,pt)^{11}Li



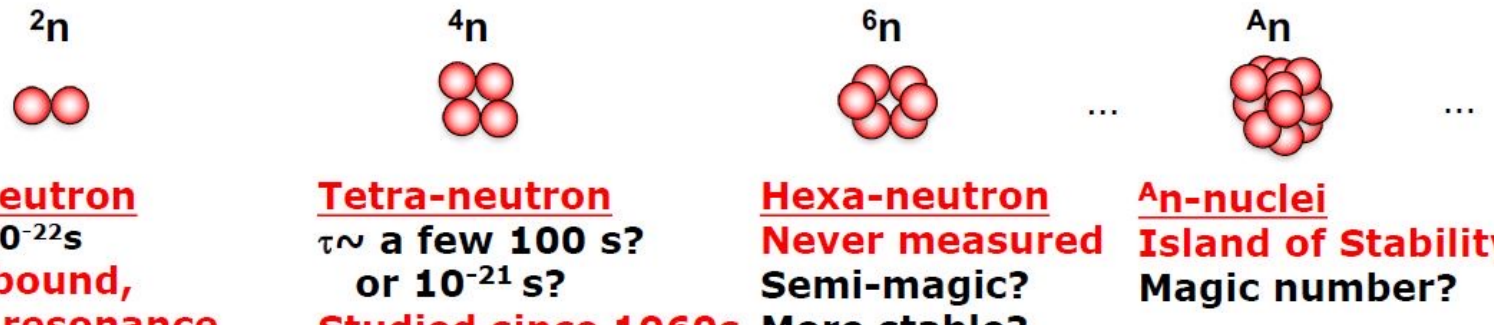
Perspectives on the study of multineutron systems

3n and 4n system

- Data for ^{8}He (p,2p) ^{7}H -> {^{3}H+**4n**} (RIKEN/Samurai) under analysis (LPC Caen)
- t (t, ^{3}He)**3n** (RIKEN/SHARAQ) under analysis (T.Miki)

6n system

- ^{14}Be(p,pa)^{10}He* -> **6n**+alpha - Data from SAMURAI12 under analysis (O.Nasr, IJCLab)
- ^{11}Li(p,2p)^{10}He* -> **6n**+alpha - SAMURAI47 (Sp. T. Nakamura) June 2023
- ^{6,8}He(p,3p) accepted at RIKEN

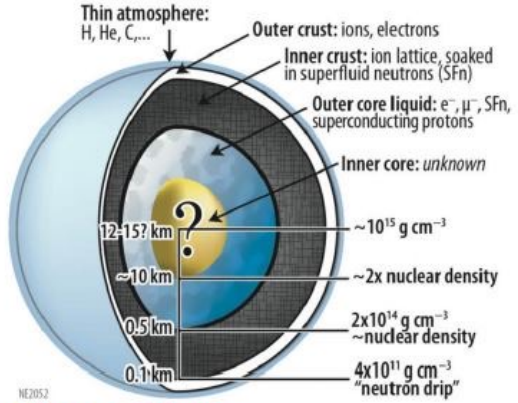


dineutron
τ~10^{-22}s
Unbound,
No resonance
$a_s = -18.9(4)\text{fm}$
Can exist in nuclei

Tetra-neutron
τ~ a few 100 s?
or 10^{-21} s?
Studied since 1960s
Only recently, a few positive results have come out

Hexa-neutron
Never measured
Semi-magic?
More stable?

An-nuclei
Island of Stability?
Magic number?



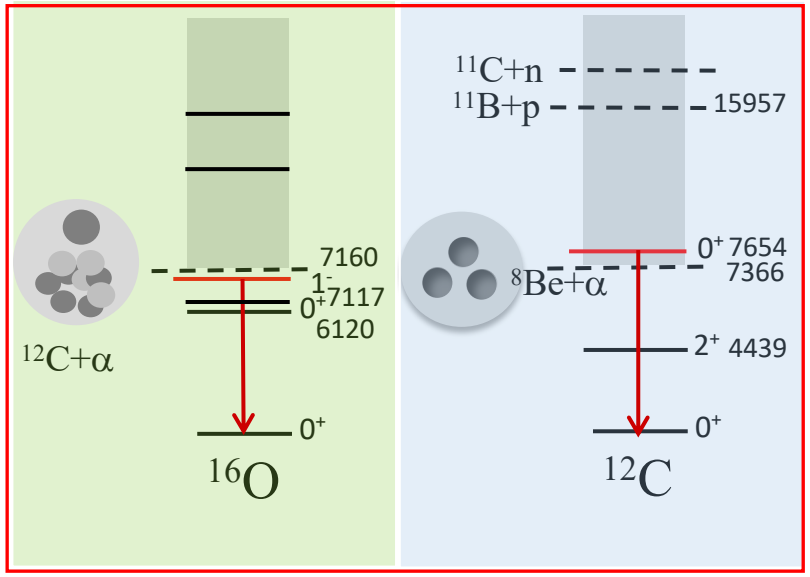
Neutron Star
Still Lots of mistery
Uncertain R_{NS}
Uncertain Max M_{NS}
Uncertain Internal Structure

from T. Nakamura

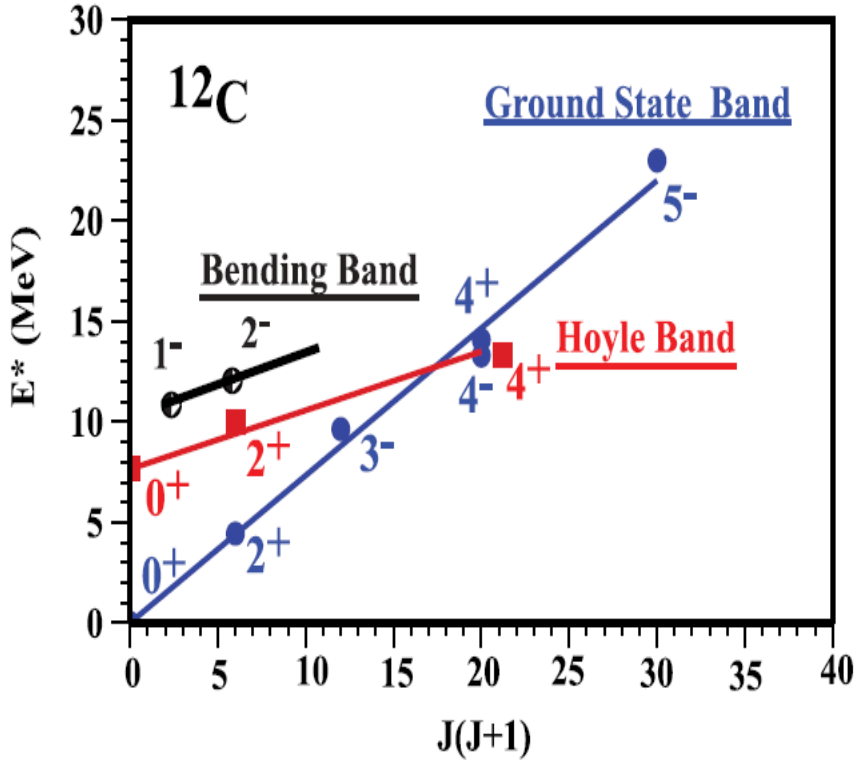
The Ikeda conjecture and its role in nuclear astrophysics

Ikeda conjecture: Systematic identification of narrow resonances close to corresponding emission thresholds

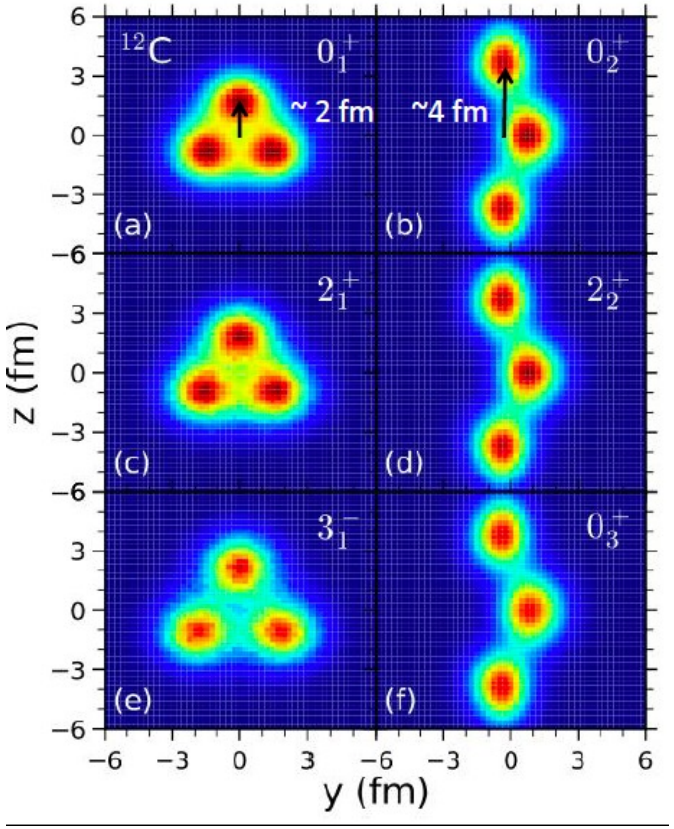
α cluster states



Experiment from Marin-Lambarri, PRL (2014)



Theory From S. Shen



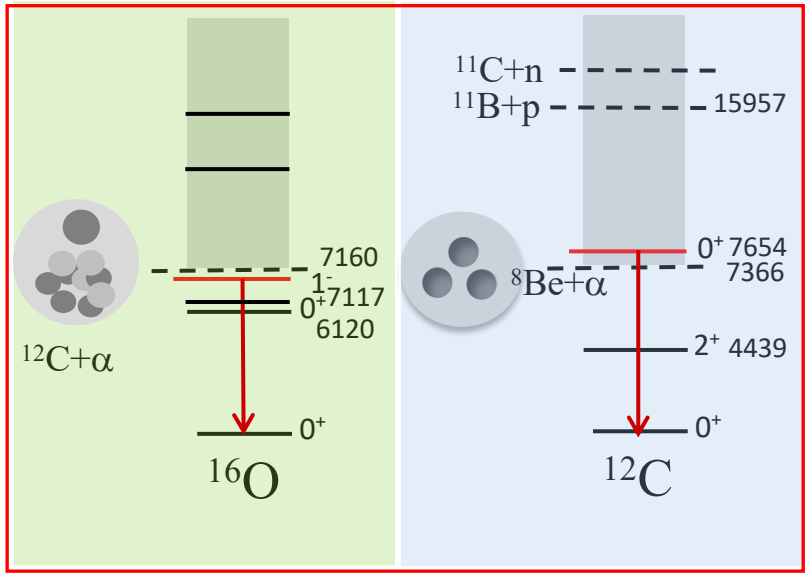
The (3α) Hoyle state in ^{12}C and the (^{12}C+ α) subthreshold resonance in ^{16}O play crucial roles in regulating the ^{12}C/^{16}O ratio in the universe

The γ-decay branch of the Hoyle state allows the ^{12}C to be synthesized

The Ikeda conjecture and its role in nuclear astrophysics

Ikeda conjecture: Systematic identification of narrow resonances close to corresponding emission thresholds

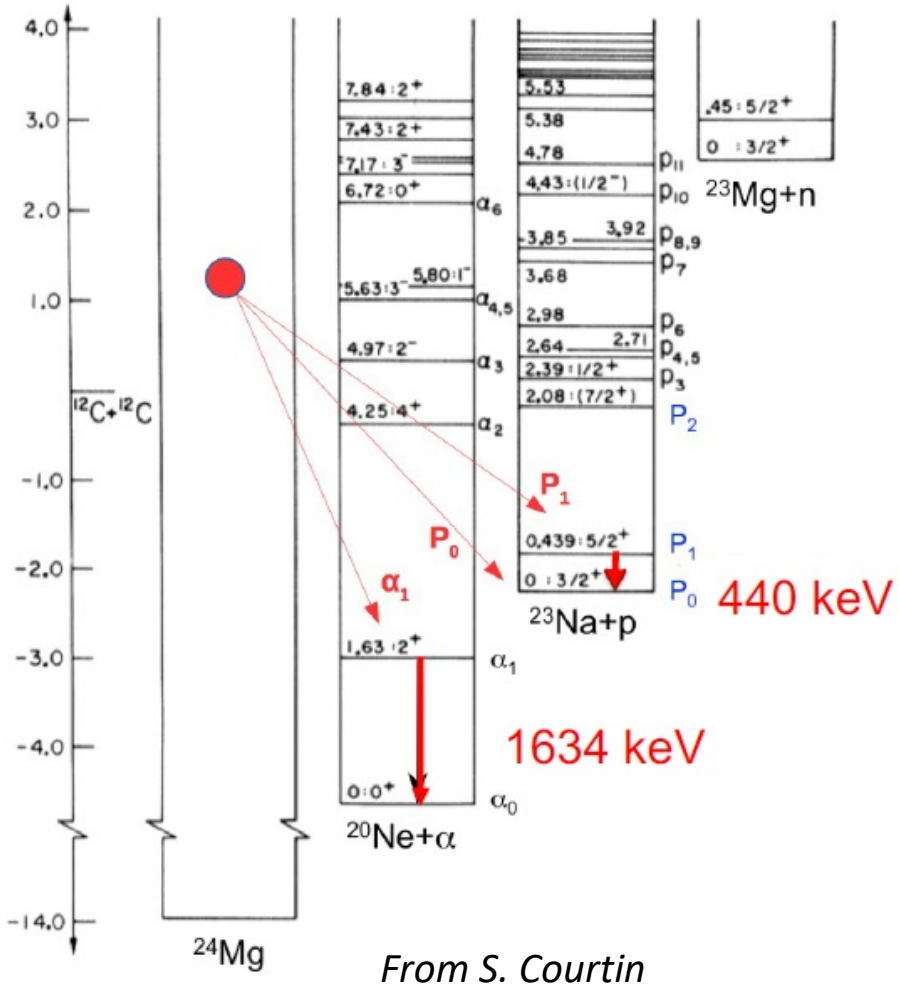
α cluster states



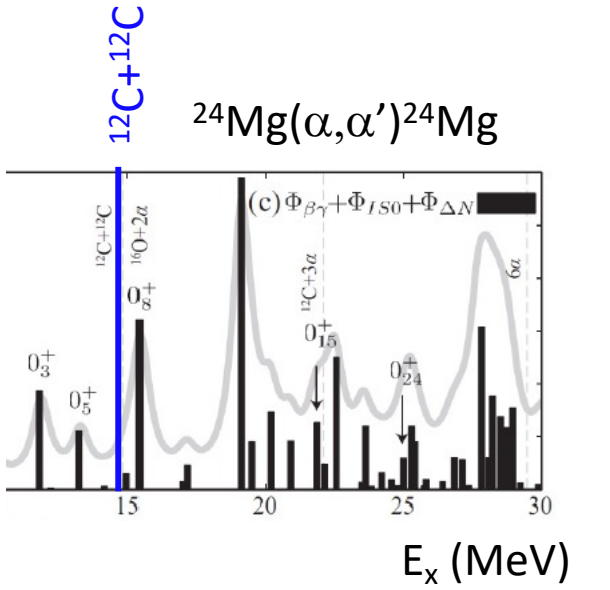
The (3α) Hoyle state in ^{12}C and the (^{12}C+ α) subthreshold resonance in ^{16}O play crucial roles in regulating the ^{12}C/^{16}O ratio in the universe

The γ-decay branch of the Hoyle state allows the ^{12}C to be synthesized

^{12}C + ^{12}C burning direct reaction



From S. Courtin



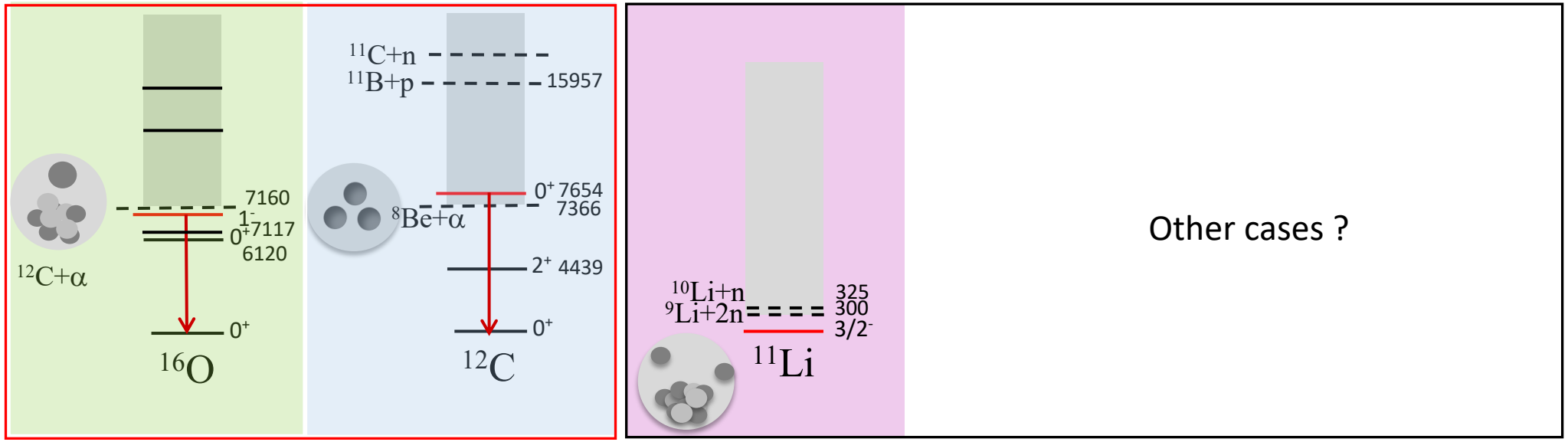
Adsley, Heine et al. PRL (2022)

Can the ikeda conjecture be generalized to 2n-4n clusters ?

J. Okolowicz, et al. Prog. Th. Phys. Supp. 196 (2012)
See also J. Okolowicz; M. Ploszajczak and W. Nazarewicz PRL 124 (2020) 042502

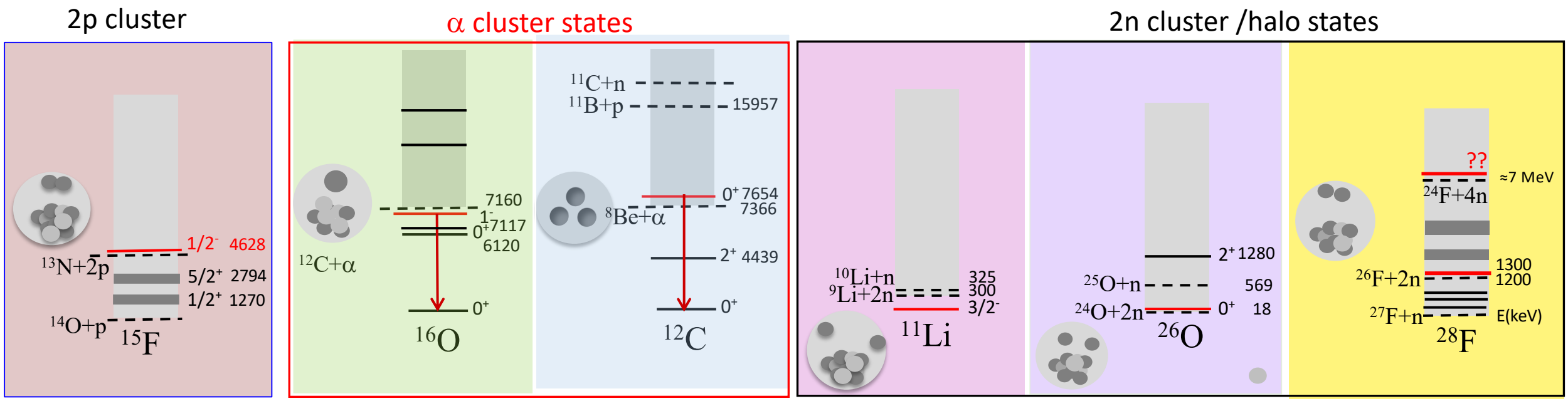
α cluster states

2n cluster /halo states



The 2n-halo ^{11}Li nucleus (bound by 300 keV) was the only remarkable case that fell into a generalized conjecture ...

Generalized Ikeda conjecture to 2n, 2p clusters ?

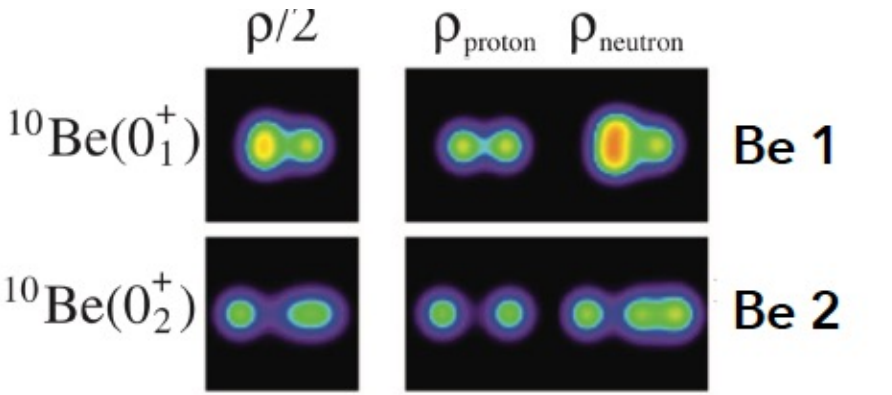


Occurrence for such clusters -> presence of nearby orbits ?
-> Such resonances woulc considerably speed up neutron captures in the r process nucleosythesis
-> Look at the possible competition with gamma decay

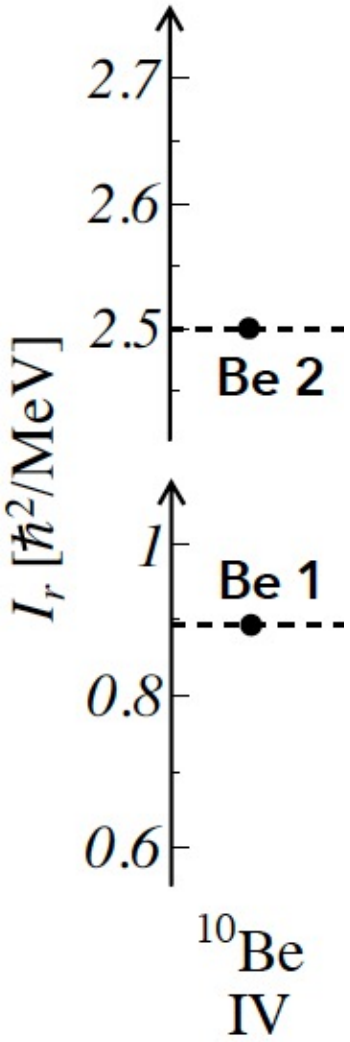
Do they form a compact di-neutron or a dilute one ?
-> Find experimental probes to determine their distances and correlations (transfer, knockout...)

Alpha clustering in the A=10 systems: dependence with isospin

^{10}Be = $\alpha + \alpha$ + 2n, ^{10}B = $\alpha + \alpha$ + n +p, ^{10}C= $\alpha + \alpha$ + 2p



Y. Kanada-En'yo, M. Kimura, A. Ono, PTEP, 01A202 (2012)

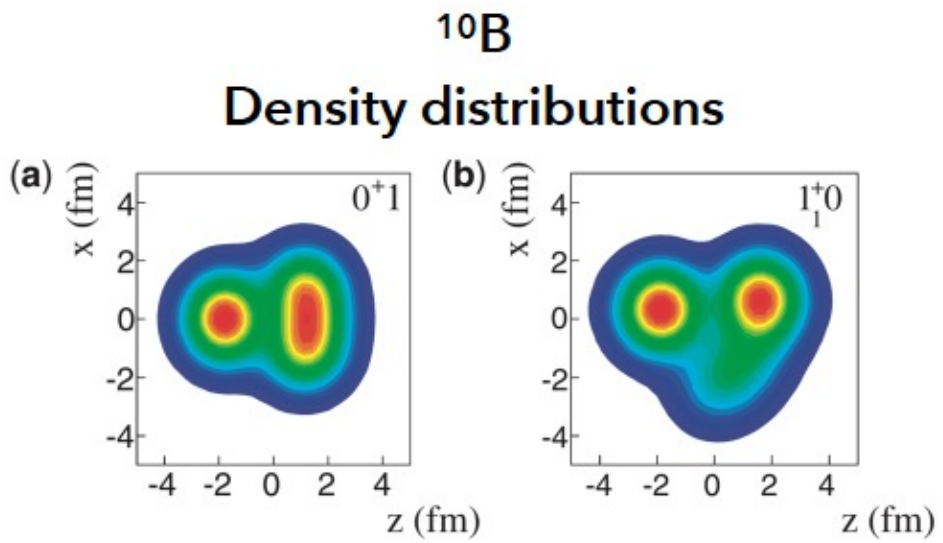


Explore the isospin dependance of rotational bands

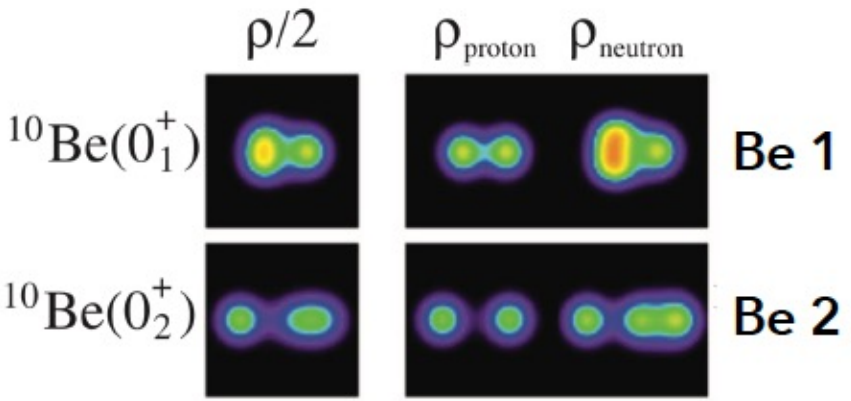
From B. Mauss

Alpha clustering in the A=10 systems: dependence with isospin

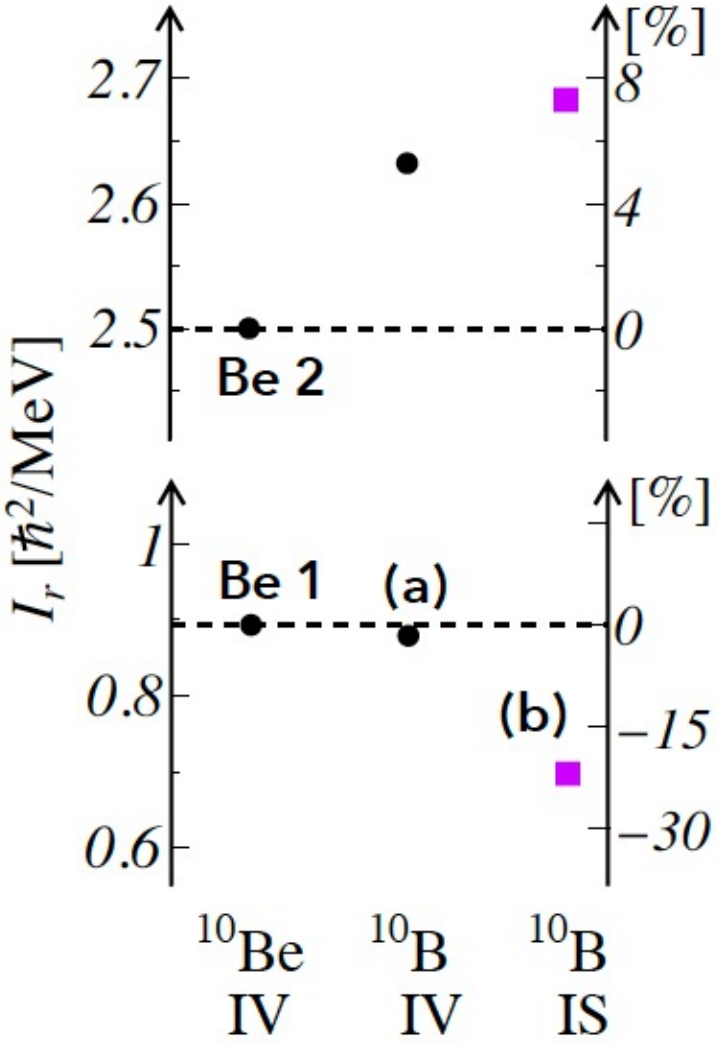
^{10}Be = $\alpha + \alpha$ + 2n, ^{10}B = $\alpha + \alpha$ + n +p, ^{10}C= $\alpha + \alpha$ + 2p



H. Morita and Y. Kanada-En'yo, PTEP 103D02 (2016)



Y. Kanada-En'yo, M. Kimura, A. Ono, PTEP, 01A202 (2012)

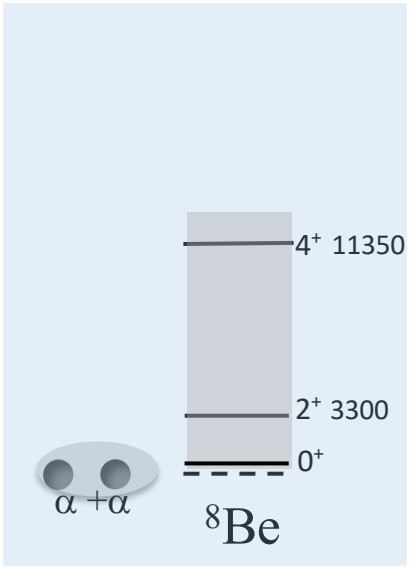


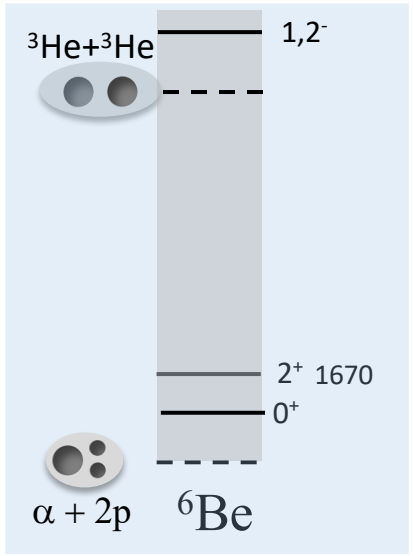
Explore the isospin dependance of rotational bands

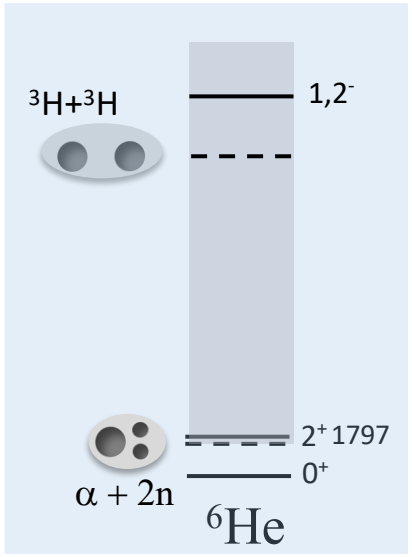
-> missing link is ^{10}C
Role of Coulomb repulsion

From B. Mauss

Generalized Ikeda conjecture to ^{3}He, t clusters ?







Experimental study of ^{3}He and ^{3}H clustering

-> Analogies and differences with clusters of bosons ^{4}He

-> Is there a Hoyle-like state existing ?