

Nuclear cluster and nuclear molecule

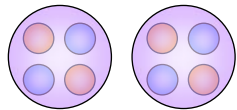
"Nuclear clusters and nuclear molecules",
W. von Oertzen, M. Freer and Y. K-E.,
Phys. Rep. 432 (2006) 43.

cluster structure

Clustering in light stable nuclei

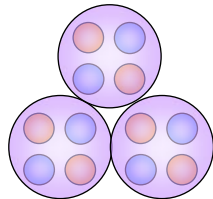
cluster structure sometimes appears in light nuclei. Some nucleons form a sub group in a nucleus.

^8Be



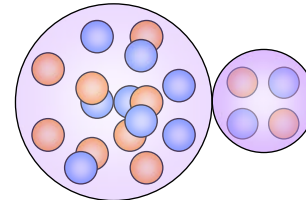
$\alpha + \alpha$

^{12}C



3α

^{20}Ne



$^{16}\text{O} + \alpha$

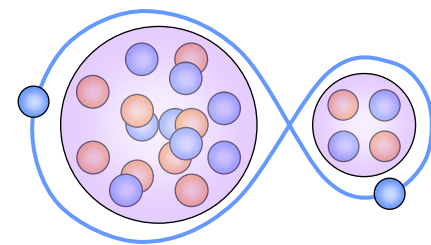
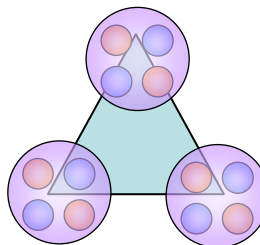
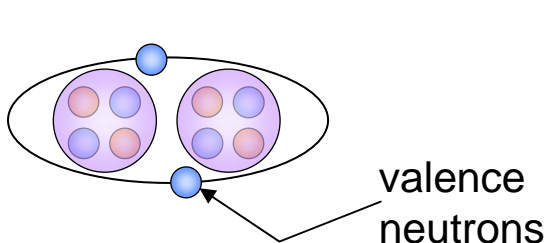
Recent progress of physics of unstable nuclei

a new type of cluster structure has been suggested:

:unbalanced ration of proton and Neutron. A nucleus with excess Neutrons Is called "neutron-rich nucle"

Molecular orbital structure in excited(ground) states

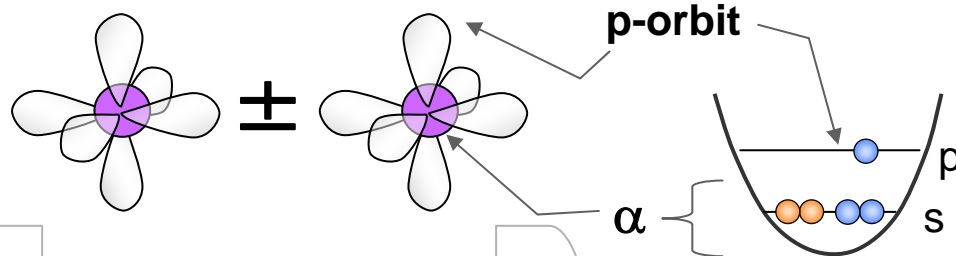
clusters + surrounding neutrons



Nuclear molecule: Molecular orbital structure in Be

Idea of molecular orbitals in 2α +neutrons systems

Okabe et al., Seya et al., Dote et al, Y.K. et al, W. von Oertzen, Itagaki et al.



molecular orbital around 2α is formed by linear combination of p -orbitals

Nucleus is described by cluster cores
And surrounding neutrons.

Lowest allowed orbital
around a α -cluster is p -orbital.

^{10}Be

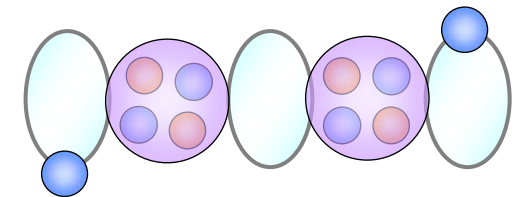
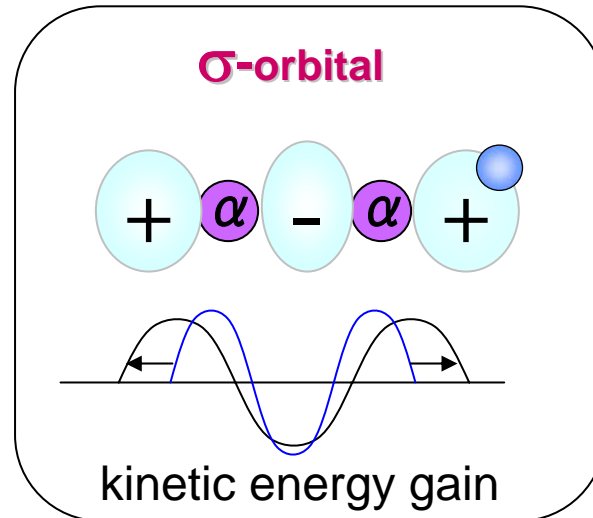
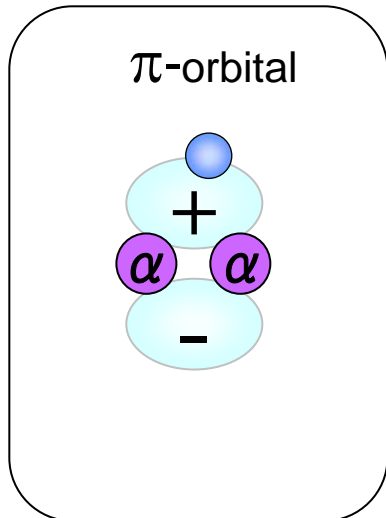
Excited states

$2\alpha+2n$

^{12}Be

Ground states

$2\alpha+4n$



The molecular orbital structure in Be is now established because various properties of Be can be well described by the molecular orbital picture.

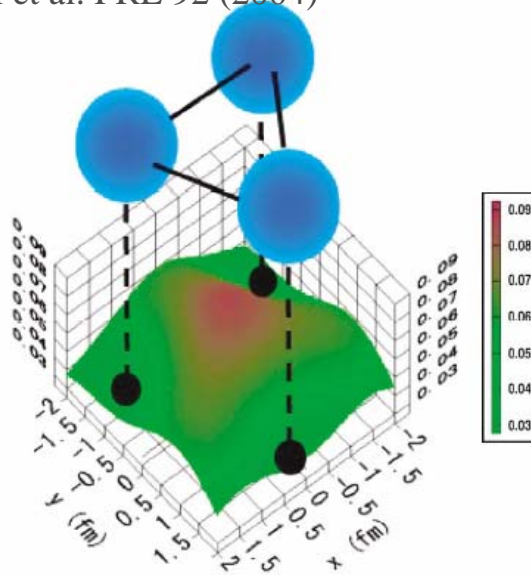
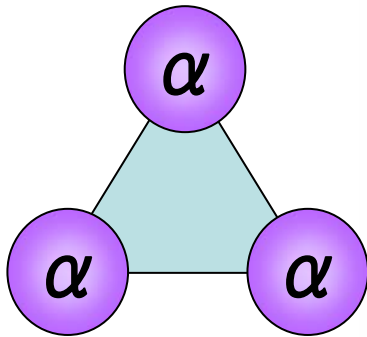
Suggestion of cluster structures in excited states

Press release
in Tokyo univ. and RIKEN

^{14}C

Equilateral triangular shape

Itagaki et al. PRL 92 (2004)



This topic was reported in
press release in Tokyo Univ.
and RIKEN.

$^{14}\text{C}, ^{16}\text{C}$

Linear-chain ?

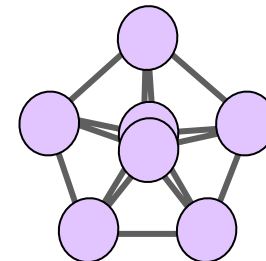


Itagaki et al. PRC 64 (2001)
Price et al. PRC 75 (2007)

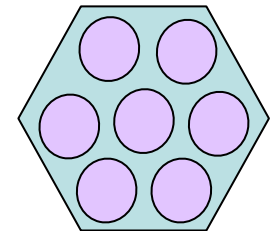
2-dim. and 1-dim Config. ?

Si

Z=14 7 α -core ?



D_{5h}

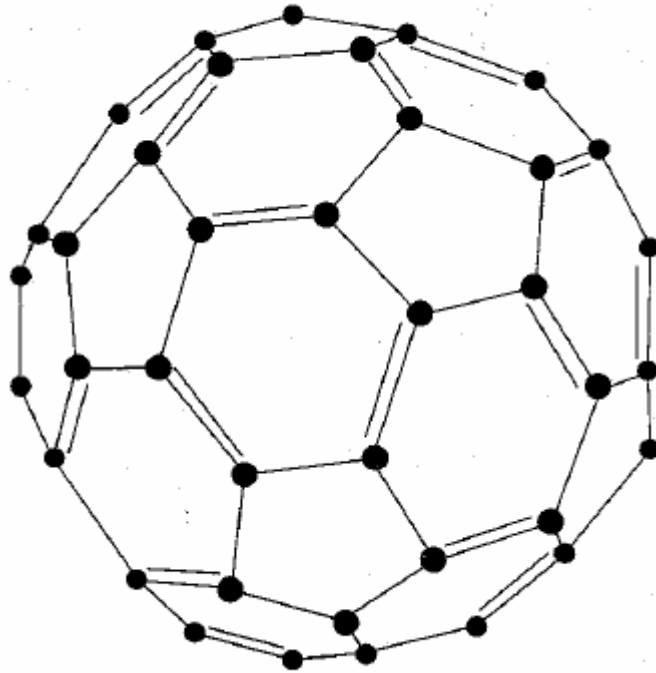


D_{6h}

Okabe et al.

Speculation of exotic clustering

Greiner, PTP 146 (2002)



Analogy of ^{60}C fullerene:

replace C atoms \rightarrow alpha's, electrons \rightarrow neutrons

\Rightarrow superheavy nuclei: $^{292}_{120}\text{120}(Z=120, N=172)$