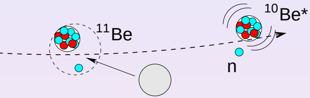
Unraveling the complexity of nuclear systems: single-particle and collective aspects through the looking glass

Possible strategies for merging structure and reaction theories in the study of nuclei close to the dripline

Discussion session

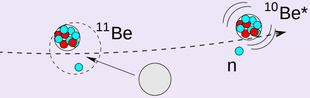
ECT*, Trento, February 2017



Microscopic models

- ✔ Fragments described microscopically
- ✔ Realistic NN interactions (Pauli properly accounted for)
- ✖ Numerically demanding / not simple interpretation.

From the many-body problem to the few-body picture



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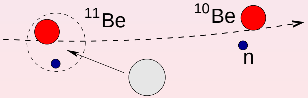

Inert cluster models

- ✖ Ignores cluster excitations (only few-body d.o.f).
- ✖ Phenomenological inter-cluster interactions (aprox. Pauli).
- ✔ Exactly solvable (in some cases).
- ✔ Achieved for 3-body and 4-body (coupled-channels, semiclassical).

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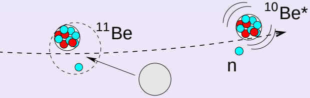

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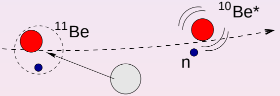
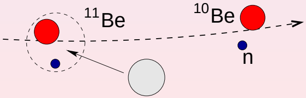
Non-inert-core few-body models



- ✔ Few-body + some relevant collective d.o.f.
- ✔ Pauli approximately accounted for.
- ✔ Achieved for 3-body problems (coupled-channels).

Inert cluster models



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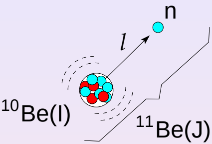
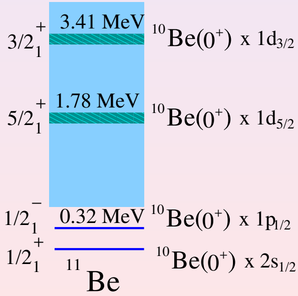
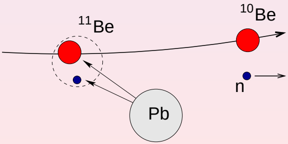
Core excitation in breakup: *frozen-halo* picture

$$\Psi_{JM}(\vec{r},\xi) = \left[\varphi^{J}_{\ell,j}(\vec{r}) \otimes \Phi_I(\xi)\right]_{JM}$$



- $\varphi^{J}_{\ell,j}(\vec{r})$= valence particle wavefunction
- $\Phi_I(\xi)$= core wavefunction (*frozen*)





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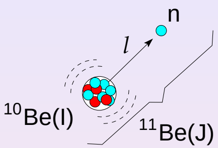

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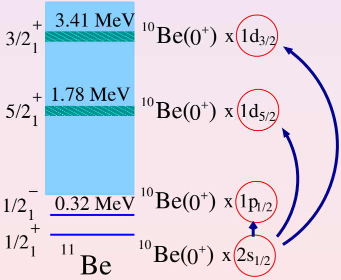
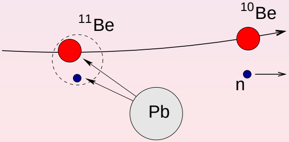
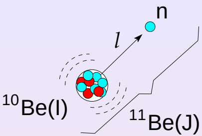
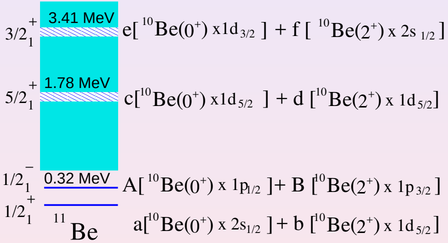


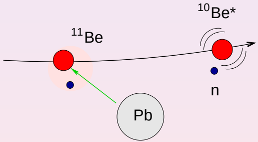


How do core excitations affect the breakup of weakly-bound nuclei?

$$\Psi_{JM}(\vec{r},\xi) = \sum_{\ell,j,I} \left[\varphi^{J}_{\ell,j,I}(\vec{r}) \otimes \Phi_I(\xi)\right]_{JM}$$







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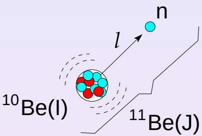
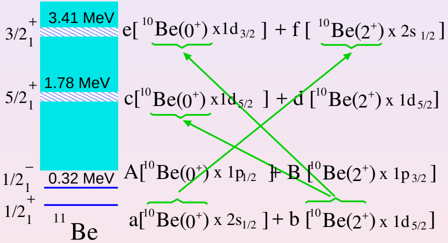
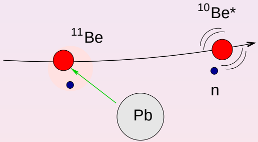


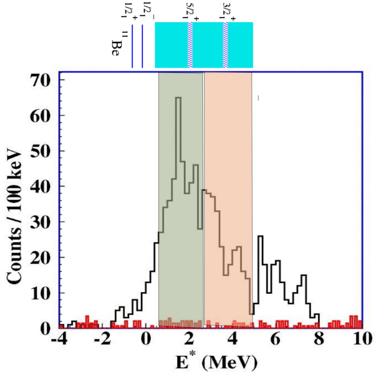


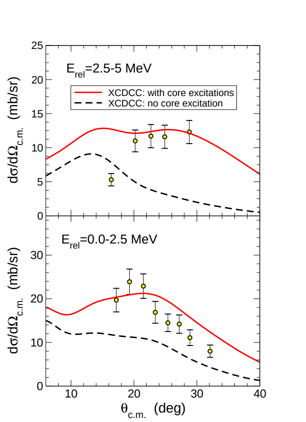


☞ *Core excitations may affect the structure and the dynamics of the reaction*

Evidence of *dynamical* core excitations in p(^{11}Be,p') at 64 MeV/u (MSU)

Data: Shrivastava et al, PLB596 (2004) 54 (MSU)





R.de Diego et al, PRC85, 054613 (2014)

- E_{rel}=0–2.5 MeV contains $5/2^+$ resonance (expected single-particle mechanism)
- E_{rel}=2.5–5 MeV contains $3/2^+$ resonance (expected core excitation mechanism)

⇨ Dynamic core excitations gives additional (and significant!) contributions to breakup

Beyond the particle-plus-core picture

- How to model other nuclei with not so simple two-body structure? (eg. not closed-shell cores)

  Eg.: $^{19}C = {}^{18}C + n$?, $^{31}Ne = {}^{30}Ne + n$

- Some requirements (constraints):
  - At least degrees of freedom entering dynamically (actively)
  - Not too simplistic (eg. particle-rotor)
  - But maybe also not too complicated (need to be used in possibly complicated reaction calculation, and not hinders physics)
  - Usually, we need both bound and continuum states (overlaps, wavefunctions...)