Reactions with rare isotopes :
Study of one-neutron knockout : from loosely- to deeply-bound nuclei

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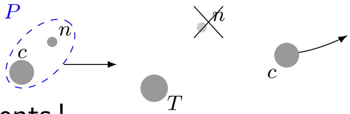
Introduction

Exotic nuclei are often studied through reactions such as elastic scattering, transfer, breakup, **knockout** etc

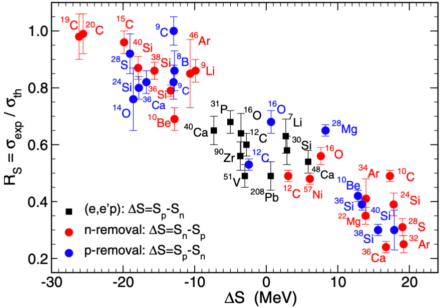


One-neutron knockout :

$P(\equiv c+n)+T \rightarrow c+X$

⇒ more statistics than exclusive measurements !

Cross sections $\sigma_{ko} = \sigma_{bu} + \sigma_{str}$ ① Diffractive σ_{bu} ② Stripping σ_{str}



[J.A. Tostevin and A. Gade. PRC **90**, 057602 (2014)]

Loosely-bound : good agreement

Deeply-bound : strong reduction

→ Asymmetry-dependence not seen in other reactions

⇒ Which part of the wavefunction KO is sensitive to ?

Eikonal model

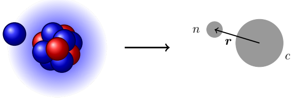
[Hansen and Tostevin Ann. Rev. Nucl. Part. Sc. **53**, 219 (2003)]

$S_n = 0.5$ MeV and 10 MeV

Description of the projectiles

① Realistic ^{11}Be : $1/2^+$ g.s. $S_n = 0.5$ MeV (one-neutron halo nucleus)

Halo-EFT : uses the separation of scale to expand low-energy behavior with $R_{\text{core}}/R_{\text{halo}} \sim 0.4$



[H.-W. Hammer *et al.* JPG **44**, 103002 (2017)]

→ At LO effective potential only in the partial-wave $s1/2$

$$V_{s1/2}(r) = V^{(0)}_{s1/2} e^{-\frac{r^2}{2r_0^2}} \qquad \text{with } r_0 \text{ cutoff}$$

We constrain $V^{(0)}_{s1/2}$ with separation energy S_n

[C.H. and P. Capel, PRC **100**, 054607 (2019)]

② Irrealistic ^{11}Be : $1/2^+$ g.s. $S_n = 10$ MeV (5 MeV, 20 MeV)

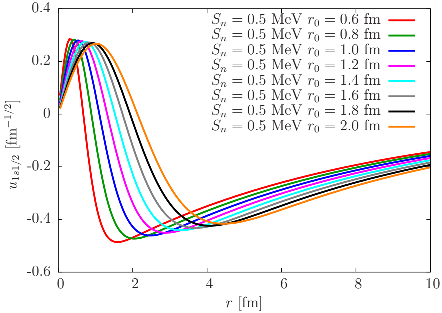
Beyond Halo-EFT : use a similar potential $V_{s1/2}$ that we fit to S_n

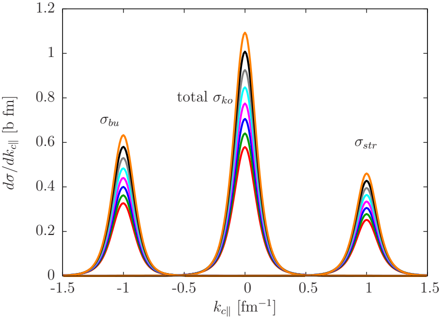
(suggestion of D. Bazin and F. Nunes)

Test case $^{11}\text{Be(g.s.)} + ^{12}\text{C} \rightarrow ^{10}\text{Be} + X$ @ 68A MeV

Generation of different g.s. wavefunctions with various r_0

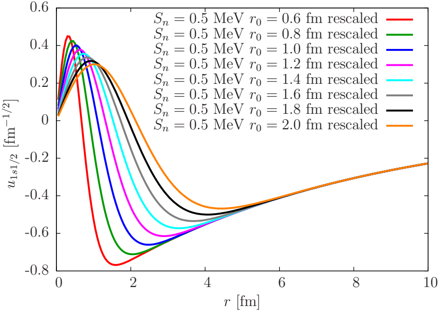
Loosely-bound case $S_n = 0.5$ MeV

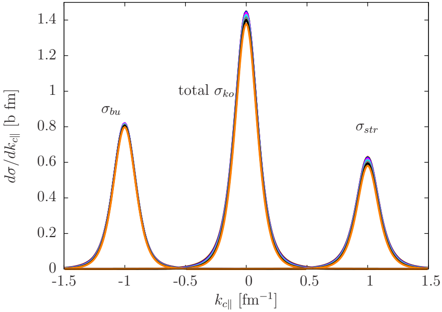




- Larger r_0 → larger ANC
  → increase in the σ_{bu} and σ_{str} (with $\sigma_{bu} \sim \sigma_{str}$)

Loosely-bound case $S_n = 0.5$ MeV

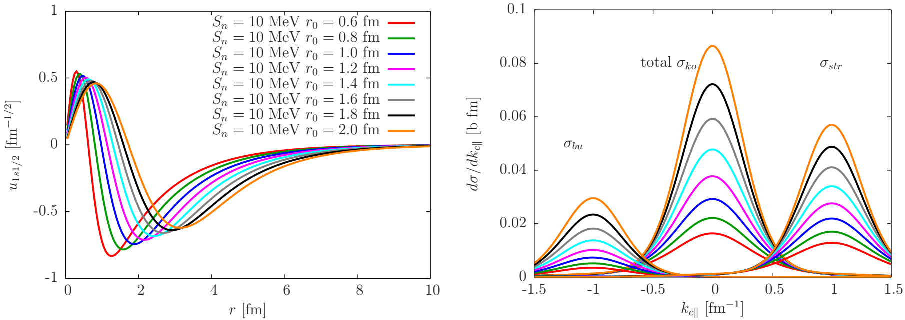




- Larger r_0 → larger ANC
  → increase in the σ_{bu} and σ_{str} (with $\sigma_{bu} \sim \sigma_{str}$)
- Rescale with the ANC → same asymptotics but SF=2.5–1.26
  → σ_{bu} and σ_{str} scale almost perfectly

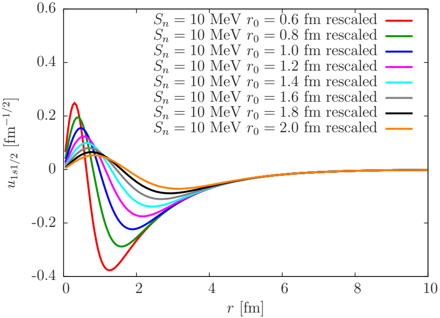
⇒ Suggests that the good agreement for loosely-bound nuclei might be explained by a fair reproduction of the ANC

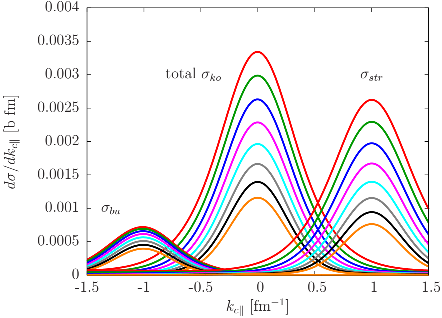
Deeply-bound case $S_n = 10$ MeV



- Larger r_0 → larger ANC → larger σ_{str} and σ_{bu} (with $\sigma_{str} > \sigma_{bu}$)

Deeply-bound case $S_n = 10$ MeV





- Larger r_0 → larger ANC → larger σ_{str} and σ_{bu} (with $\sigma_{str} > \sigma_{bu}$)
- Rescale with the ANC → same asymptotics but SF=0.2–0.01

  σ_{bu} : smaller spread → stays mainly peripheral

  σ_{str} : no scaling and exhibit different shapes

  → σ_{str} **is sensitive to the inner part of the wavefunction**

  ① From which c-n distance is σ_{str} sensitive ?

  ② How does it depend on the normalization ?

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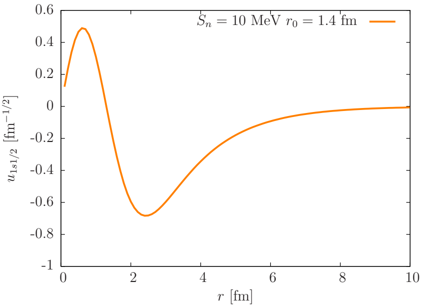

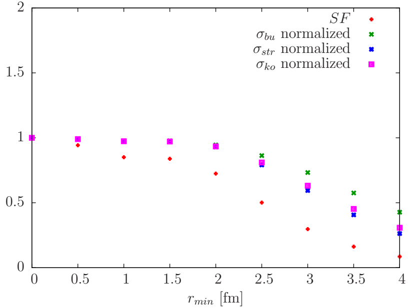

$$u^{r_{min}}_{1s1/2}(r) = \begin{cases} 0 & \text{if } r < r_{min} \\ u_{1s1/2}(r) & \text{if } r \geq r_{min} \end{cases} \qquad SF = \int_{r_{min}}^{+\infty} |u^{r_{min}}_{1s1/2}(r)|^2 \, dr$$

⇒ σ_{ko} **insensitive to** $r < 1.5$ **fm (decrease of only 3%)**

⇒ **non-linear dependence of** σ_{ko} **on the normalization SF**

Conclusions and prospects

Knockout : Asymmetry-dependence of the agreement th-exp.

⇒ Which part of the projectile's wavefunction KO is sensitive to ?

① Loosely-bound $S_n = 0.5$ MeV : $\sigma_{bu} \sim \sigma_{str}$

- σ scales with ANC^2 and is insensitive to the inner part of the g.s.
  → Th.-exp. agreement is probably due to a fair ANC

② Deeply-bound $S_n = 10$ MeV : σ_{str} **dominant**

- σ_{bu} stays mainly peripheral
- σ_{str} is sensitive to the inner part **above** 1.5 fm
  → what determines this range ? r_0 ?
- Non-linear dependence of σ_{ko} on the normalization
  → Validity of the single-particle approximation ?
  → How is it related to the asymmetry plot ? To be continued...

Thank you for your attention