非束縛核 ^{7}B の 4体共鳴状態の構造

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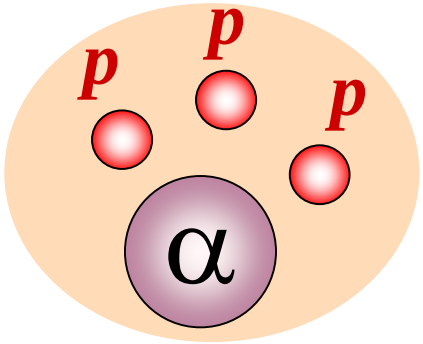


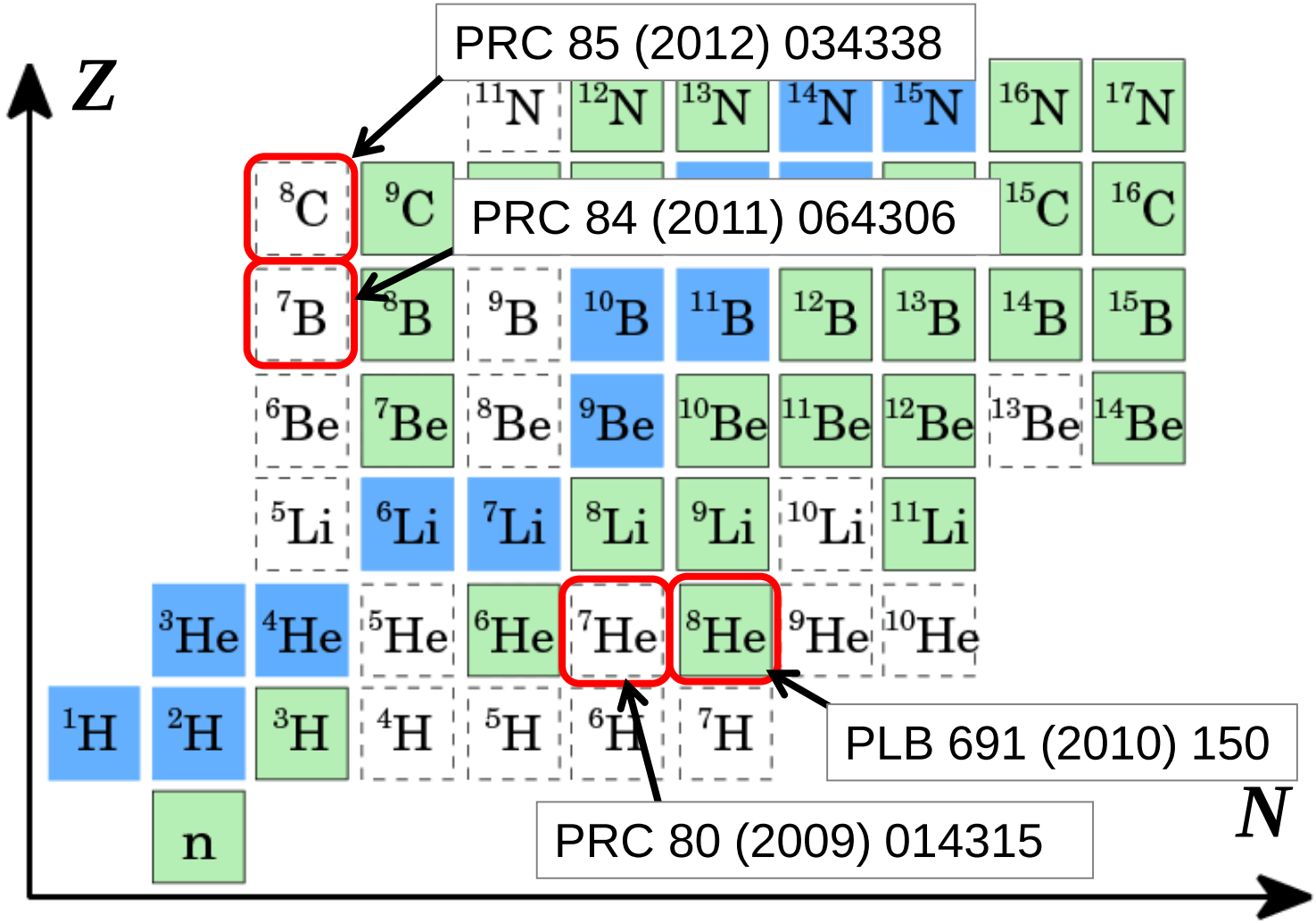
T. Myo, Y. Kikuchi, K. Kato
Physical Review C 84 (2011) 064306.

Osaka Institute of Technology

Why ^{7}B ?

- Proton-rich unbound nucleus
  - ^{4}He-^{5}Li-^{6}Be-^{7}B, decay into α+3*p* 4-body system
- Experiments
  - Only the ground state is observed.
  - L. R. McGrath and J. Cerny, Phys. Rev. Lett. **19**, 1442 (1967).
  - R. J. Charity et al., Phys. Rev. C 84, 014320 (2011).
    ^{9}C beam: ^{7}B, ^{8}B*, ^{8}C, ... @MSU
- NO theory to describe the ^{7}B resonances
- Mirror symmetry of *p*-rich & *n*-rich unstable nuclei
  - ^{7}B vs. ^{7}He : Energy levels, Configurations ,...

Nuclear Chart



Mirror symmetry between A=7 & A=8

Method

- Cluster Orbital Shell Model (COSM)
  - Include open channel effects.
    ^{7}B : ^{6}Be+p, ^{5}Li+2p, ^{4}He+3p,...
- Complex Scaling Method

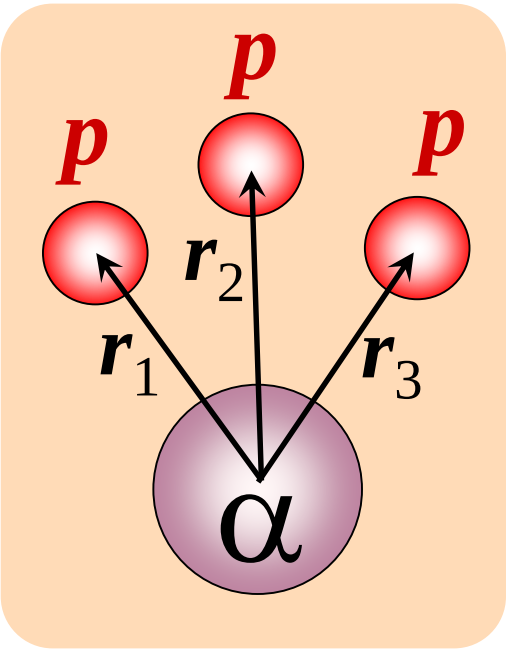
$$\mathbf{r} \to \mathbf{r}e^{i\theta}, \quad \mathbf{k} \to \mathbf{k}e^{-i\theta}$$

  - Resonances with correct boundary condition as **Gamow states**

$$E = E_r - i\Gamma/2$$

  - Give correct continuum level density (resonance+continuum, Green's function)
  - COSM-CDCC+CSM: ^{22}C=^{20}C+n+n Ogata

COSM



S. Aoyama, T. Myo, K. Kato, K. Ikeda, PTP116(2006)1 (review)
C. Kurokawa and K. Kato, PRC71 (2005), 021301 (^{12}C(0^{+}_{3}))
Funaki, Yamada et al.(^{16}O)

Cluster Orbital Shell Model

- A-body System is obtained based on RGM equation

$$H(A) = H(^4\mathrm{He}) + H_{\mathrm{rel}}(N_V\, p) \qquad \Phi(^A\mathrm{He}) = \mathcal{A}\left\{\psi(^4\mathrm{He}) \cdot \sum_{i=1}^{N} C_i \cdot \chi_i(N_V\, p)\right\}$$

valence proton number

i : configuration index

$\psi(^4\mathrm{He})$: $(0s)^4$ ← No explicit tensor correlation

$\chi_i(N_V\, p) = \mathcal{A}\{\varphi_{i1}\varphi_{i2}\varphi_{i3}\cdots\}$ φ_i : $L \le 2$, few-body method with Gaussian expansion

- Orthogonarity Condition Model (OCM) is applied.

$$\sum_{i=1}^{N}\left\langle \chi_j \left| \sum_{k}^{N_V}\left(T_k + V_k^{cp}\right) + \sum_{k<l}^{N_V}\left(V_{kl}^{pp} + \frac{\vec{p}_i \cdot \vec{p}_j}{A_c m}\right)\right| \chi_i \right\rangle C_i = (E - E_{4\mathrm{He}})\, C_j$$

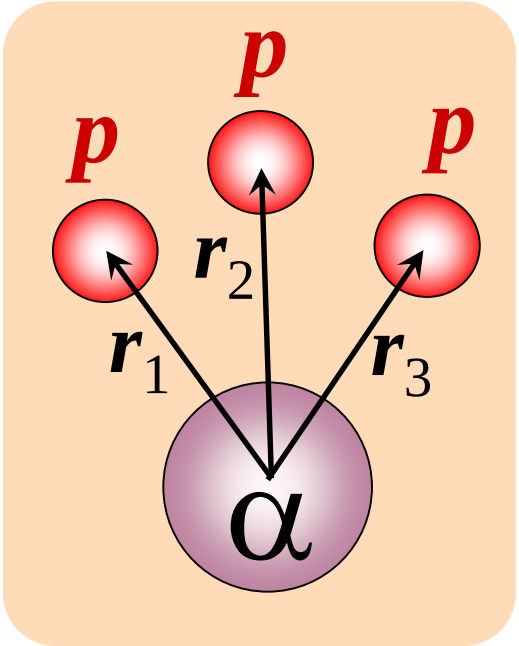
$$\left\langle \varphi_i \middle| \phi_{\mathrm{PF}} \right\rangle = 0 : \text{ Remove Pauli Forbidden states (PF)}$$

Y. Suzuki, K. Ikeda, PRC38(1988)410, H. Masui, K. Kato, K. Ikeda, PRC73(2006)034318

Hamiltonian

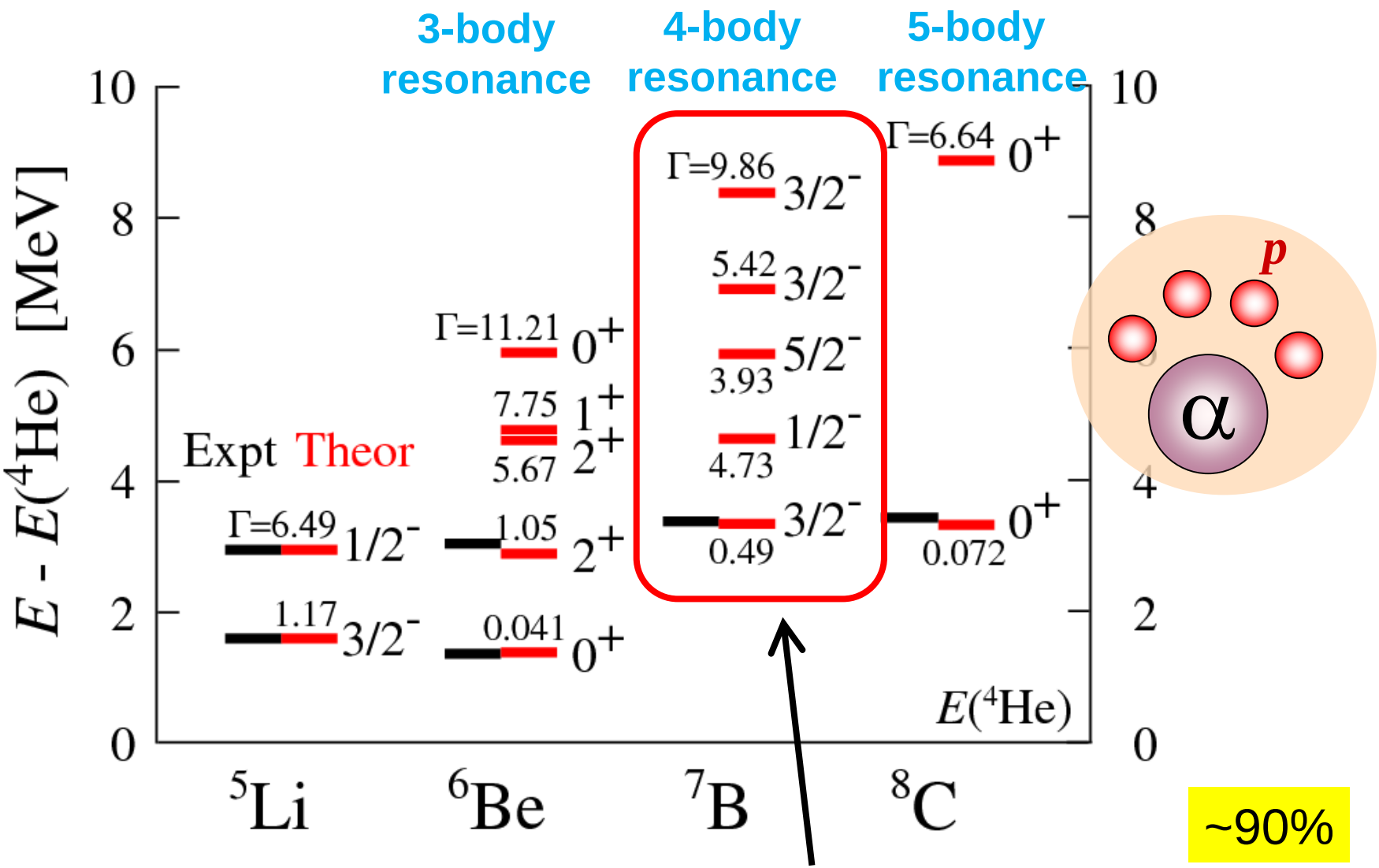
- $V_{\alpha p}$: microscopic KKNN potential + folded α-p Coulomb
  - s,p,d,f-waves of α-p scattering
- V_{pp} : Minnesota potential
  with slightly strengthened
  + p-p Coulomb

Fit $E(^6\mathrm{He}_{GS})$ with αnn



A. Csoto, PRC48(1993)165.
K. Arai, Y. Suzuki and R.G. Lovas, PRC59(1999)1432.
TM, S. Aoyama, K. Kato, K. Ikeda, PRC63(2001)054313.
TM K. Kato, K. Ikeda, PTP113(2005)763.

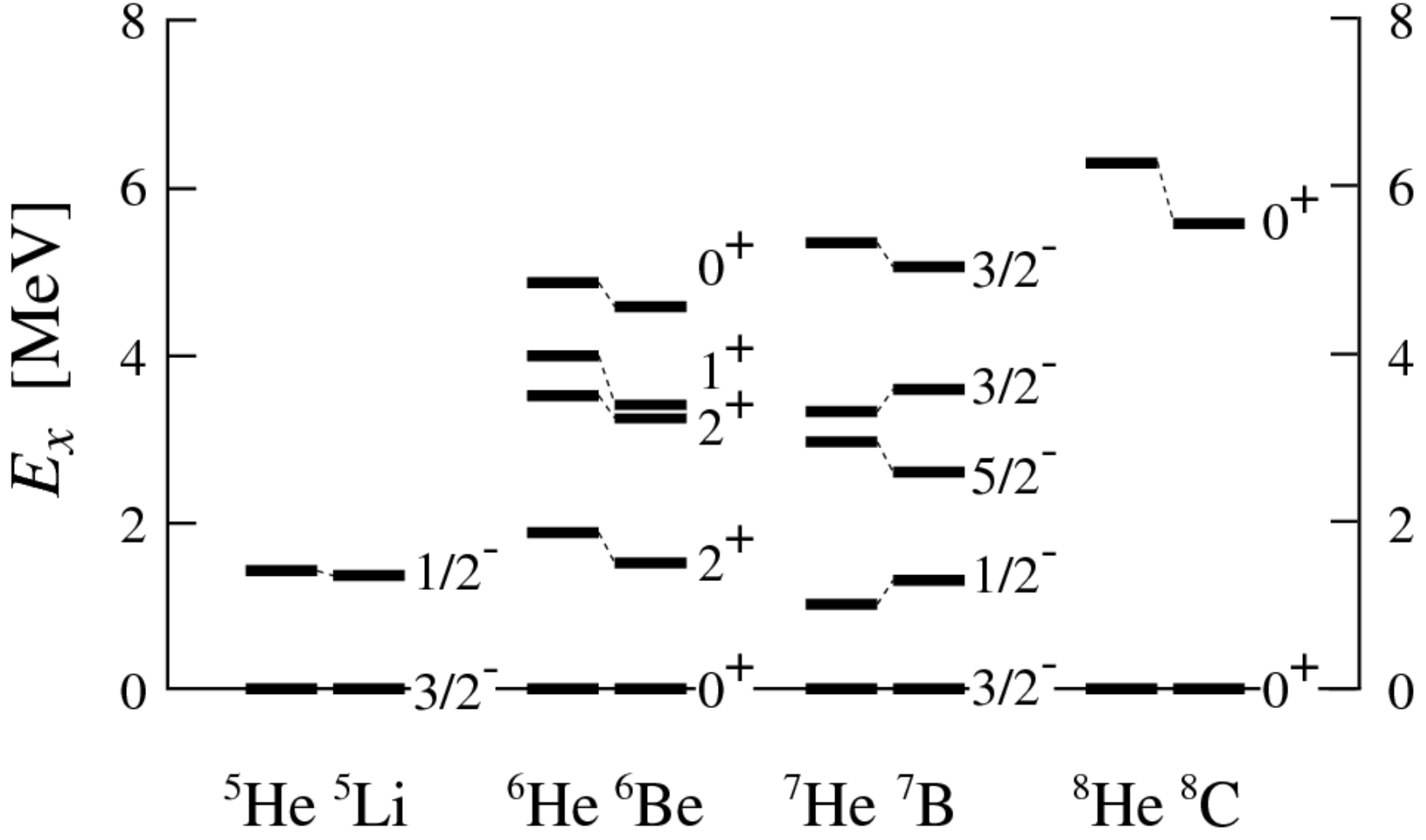
Proton-rich side : ^{4}He+4*p*



mainly, *p*-shell configuration for 3*p*

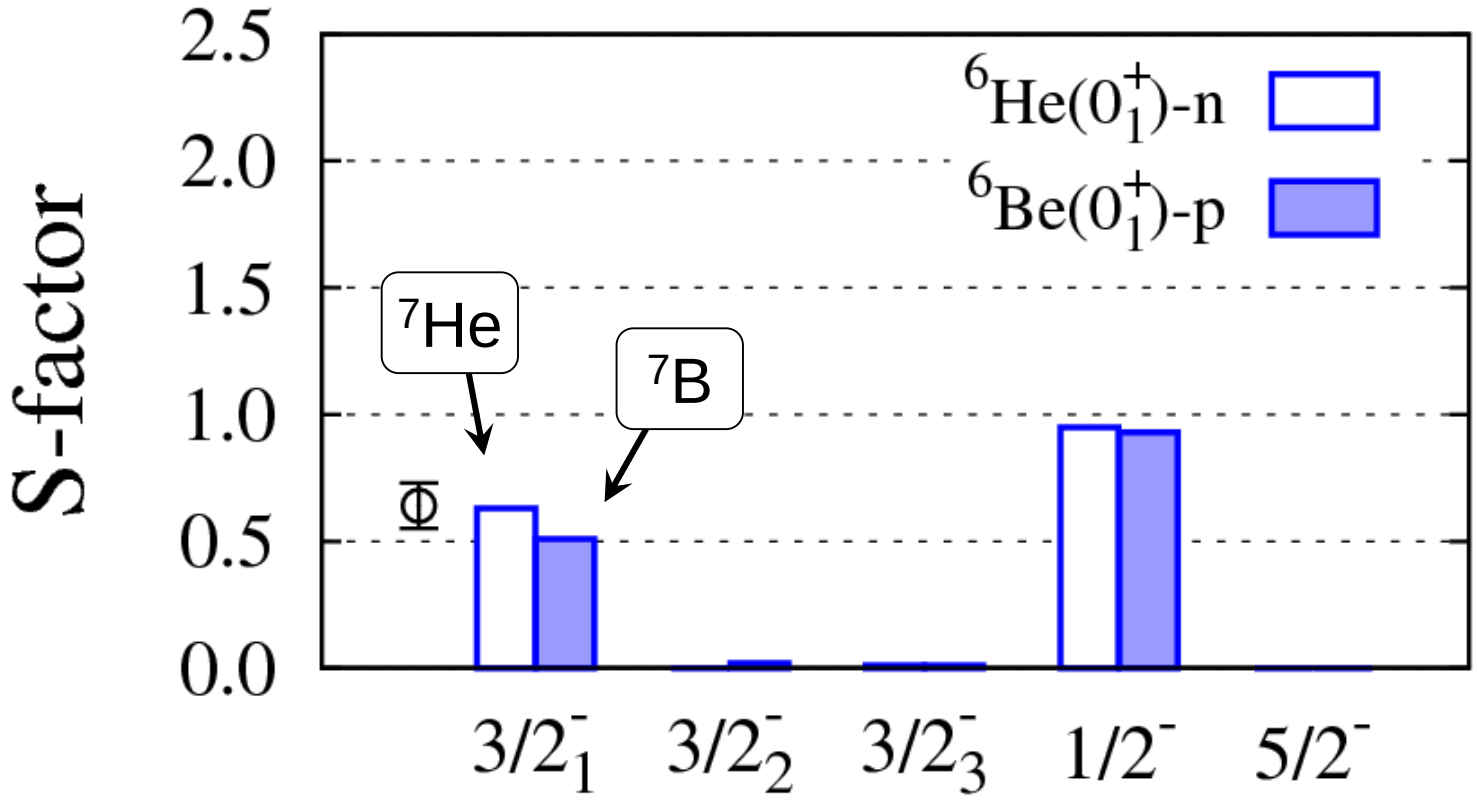
Charity et al. PRC84(2011)014320.
TUNL Nuclear Data Evaluation

Mirror Symmetry



S-factors of ^{7}B & ^{7}He

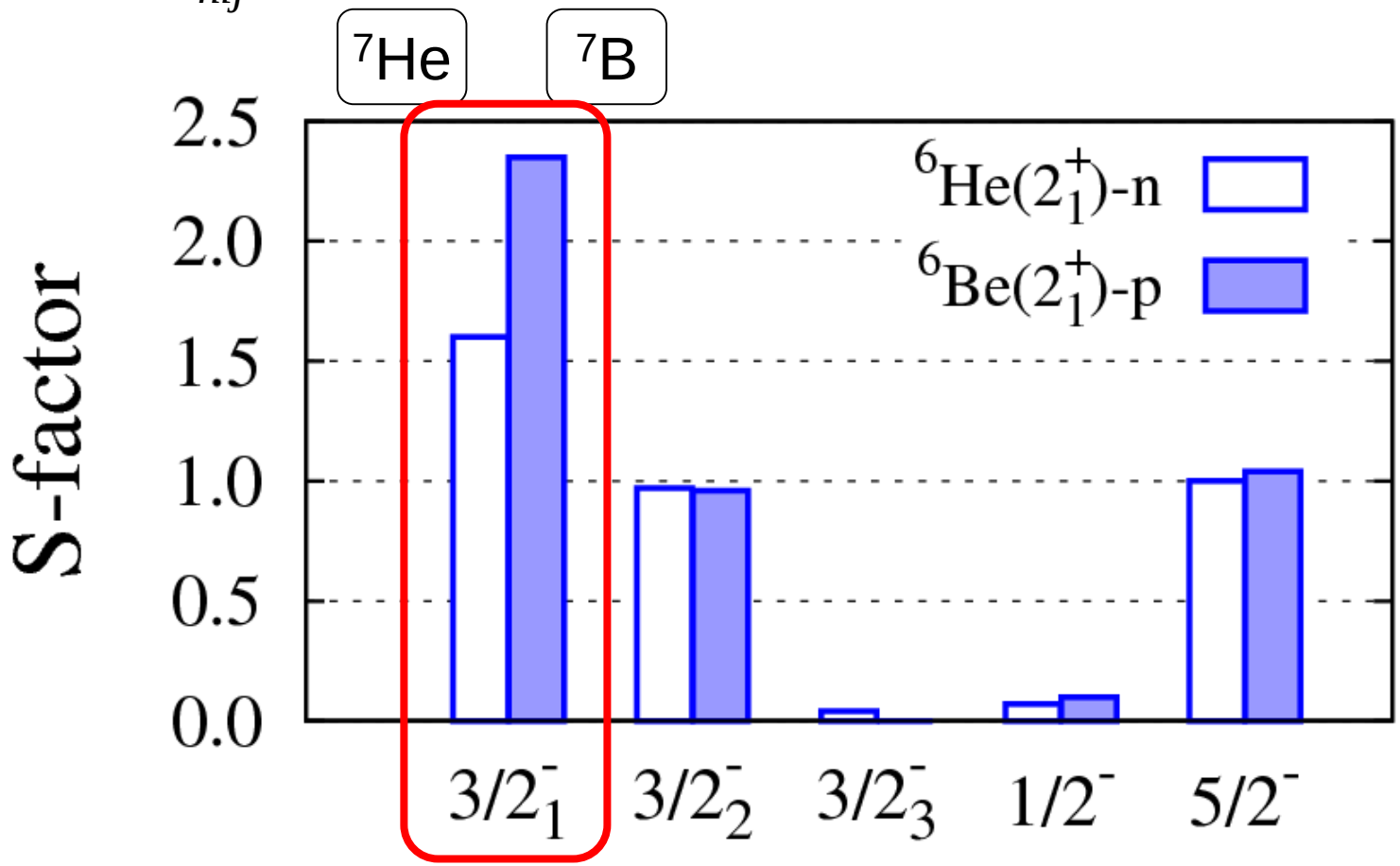
$$S_{J',J} = \sum_{nlj} \left\langle {}^{6}\mathrm{Be}(0^{+}) \middle| a_{nlj} \middle| {}^{7}\mathrm{B}(J^{\pi}) \right\rangle^{2}$$



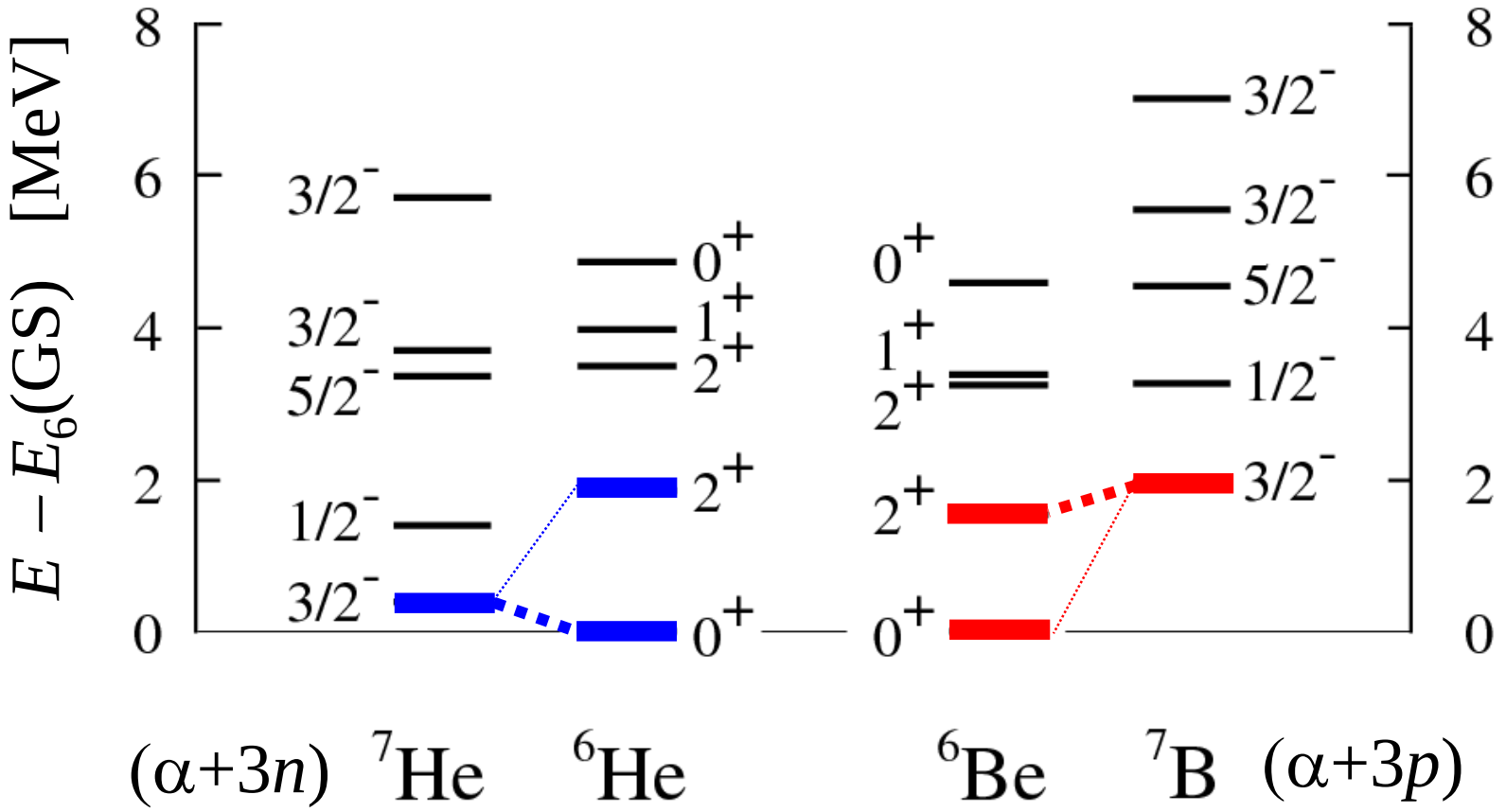
Expt. of ^{7}He($3/2^{-}$) : F. Beck et al., Phys. Lett. B **645** (2007) 128

S-factors of ^{7}B & ^{7}He

$$S_{J',J} = \sum_{nlj} \left\langle {}^6\mathrm{Be}(2^+) \middle| a_{nlj} \middle| {}^7\mathrm{B}(J^\pi) \right\rangle^2$$



Thresholds of "A=6"+N system



"Mirror symmetry breaking" due to the channel coupling effect caused by Coulomb force

Summary

^{7}B

- proton-rich unbound nucleus
- α+3*p* with COSM + complex scaling
- 5 resonances with *p*-shell configurations
- mirror symmetry with *n*-rich ^{7}He
  - 2^{+}(A=6) components are different in ground states
  - Channel coupling effects of "^{6}Be+*p*" & "^{6}He+*n*" caused by Coulomb force

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