テンソル最適化反対称化分子動力学による核構造の解析

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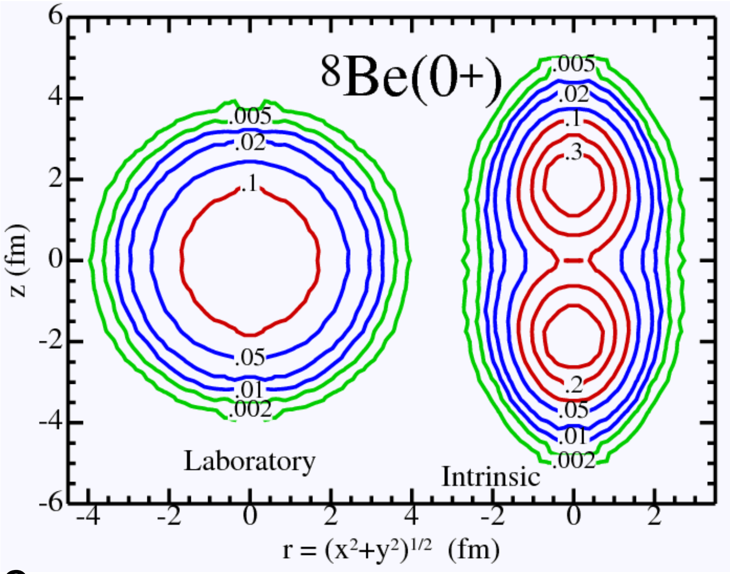
日本物理学会分科会 於 京都産業大学, 2012. 9

Outline

- **Role of V_{tensor}** in the nuclear structure by describing strong tensor correlation explicitly.
- Tensor Optimized Shell Model (TOSM)
  - TM, A.Umeya, H. Toki, K. Ikeda
    PRC86 (2012) 024318 (Li isotopes)
- Tensor Optimized Few-body Model (TOFM)
  - **K. Horii**, H.Toki, TM, K. Ikeda, PTP127(2012)1019
- **Tensor Optimized AMD (Tensor-AMD)**
  - clustering and tensor force

Clustering and tensor force

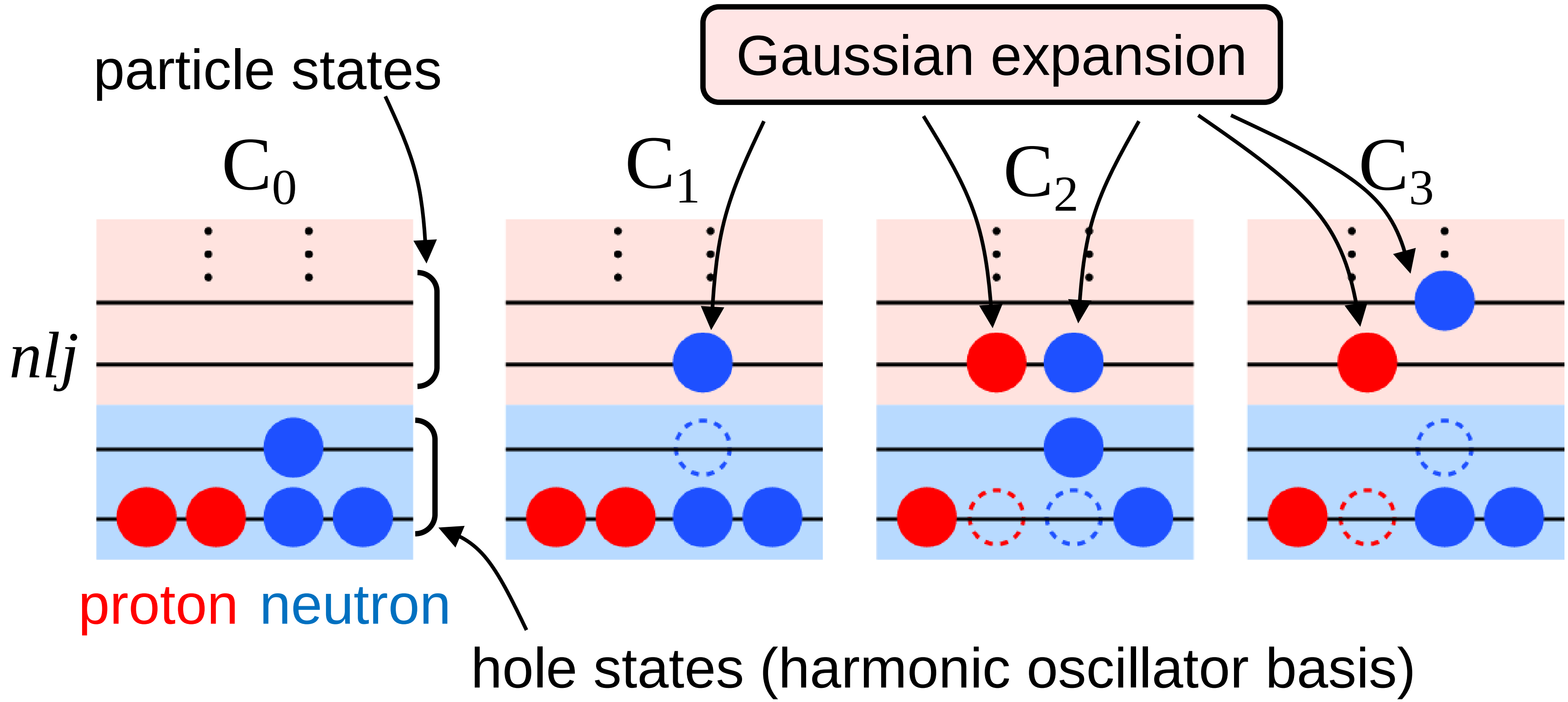
- Argonne Group
  - Green' function Monte Carlo
    C.Pieper, R.B.Wiringa,
    Annu.Rev.Nucl.Part.Sci.51 (2001)
- Brueckner Theory
  - H. Bando, S. Nagata, Y. Yamamoto
    PTP44 (1970) 646
  - Brueckner AMD
    T. Togashi, K. Kato, PTP117 (2007) 189
  - Extended BHF Theory
    Y. Ogawa, H. Toki, Ann. Phys.326(2011)2039.
- FMD+UCOM (central+tensor)
  - Neff, Feldmeier, NPA 713 (2004) 311.
- Charge & Parity Projection
  - HF by S. Sugimoto, K. Ikeda, H.Toki, NPA789 (2007) 155.
  - AMD by Dote et al. PTP115 (2006) 1069.



α-α structure

Tensor-optimized shell model (TOSM)

TM, Sugimoto, Kato, Toki, Ikeda PTP117(2007)257

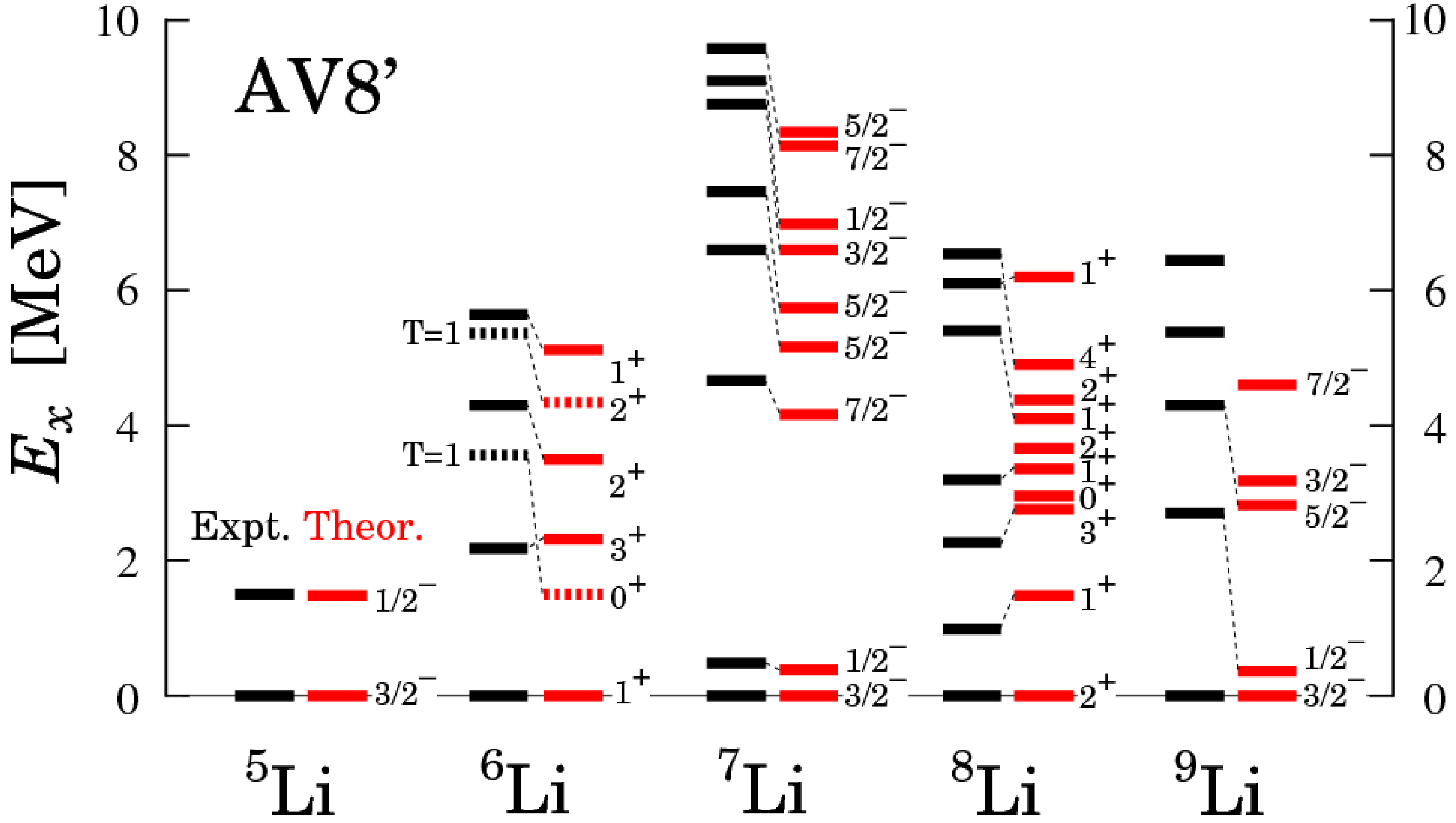


- Describe **spatially compact particle states** to gain the tensor contribution, as seen in deuteron

$^{5\text{-}9}$Li with TOSM+UCOM

- Excitation energies in MeV

TM, A. Umeya, H. Toki, K. Ikeda
PRC86(2012) 024318



- Excitation energy spectra are reproduced well

Formulation of Tensor-AMD

$$\left|\Phi_{\text{T-AMD}}\right\rangle = C_0\left|\Phi_{\text{AMD}}\right\rangle + \sum_{i<j}^{A}\sum_{S,T} F_{ij}^{ST}(\vec{r}_{ij})\left|\Phi'_{\text{AMD}}\right\rangle$$

$$F^{ST}(\vec{r}) = r^2 S_{12}\sum_{n} C_n^{ST}\exp(-\rho_n^{ST} r^2)$$

- Variational parameters
  - ν, $\mathbf{Z}_i$ (i=1, ..., A) , spin-direction (up/down)
  - C_0 , ${C^{ST}}_n$, ${\rho^{ST}}_n$ (Gaussian expansion)
  - Tensor-type correlation for **relative motion**
  - Decided by using cooling equation +parity projection.

S. Nagata, T. Sasakawa, T. Sawada, R. Tamagaki, PTP22,274 (1959).

Tensor matrix elements

$$\left|\Phi_{\mathrm{AMD}}\right\rangle = \frac{1}{\sqrt{A!}} \det\left\{\varphi_1, \ldots, \varphi_A\right\}$$

$$\left|\varphi\right\rangle = |\mathbf{Z}\rangle \left|\chi^{\sigma\tau}\right\rangle$$

$$\langle \mathbf{r} | \mathbf{Z} \rangle \propto \exp\left[-\nu\left(\mathbf{r} - \frac{\mathbf{Z}}{\sqrt{\nu}}\right)^2\right]$$

Matrix elements

$$\left\langle \varphi_i \varphi_j \ldots \left| \hat{O} \right| \varphi_{i'} \varphi_{j'} \ldots \right\rangle_{\mathrm{A}}$$

Corr. func.(bra)

Hamiltonian

$$\hat{O} = S_{12} \cdot S_{12} \cdot S_{12}$$

Corr. func.(ket)

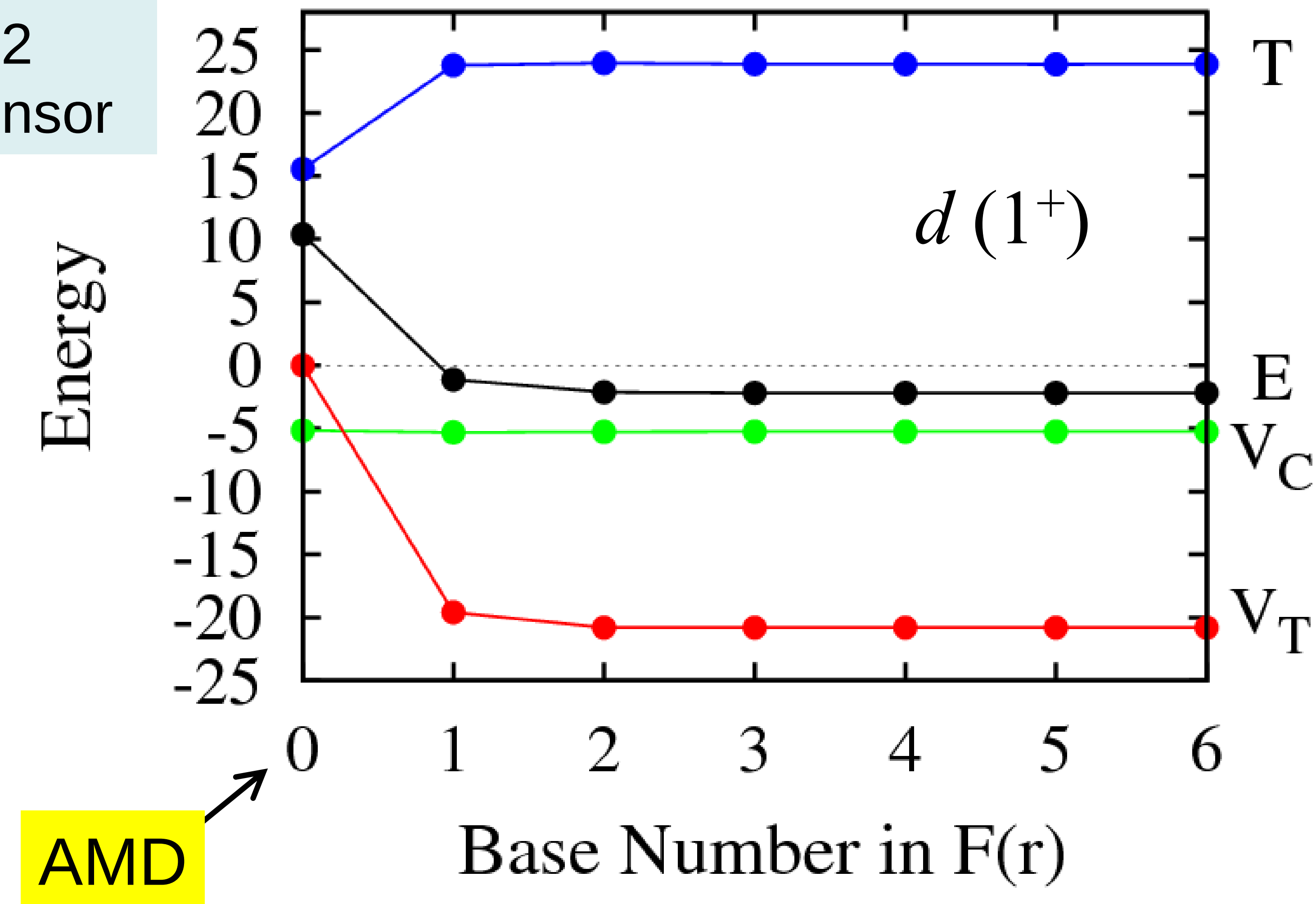
- 6-body matrix elements within 2-body Hamiltonian.
- At most, 4-body matrix elements to be evaluated.
  - 6-body ME : {2-body ME} × {2-body ME} × {2-body ME}
  - 5-body ME : {3-body ME} × {2-body ME}

TOSM vs. Tensor-AMD

	TOSM	Tensor-AMD
Correlation	1p1h, 2p2h (single particle)	Tensor-type (relative motion)
CM excitation	Lawson method	Nothing
Hole states	Fix as harmonic oscillator basis	Can optimize in each basis
Short-range repulsion in V_{NN}	central-UCOM	central-UCOM

Deuteron in Tensor-AMD

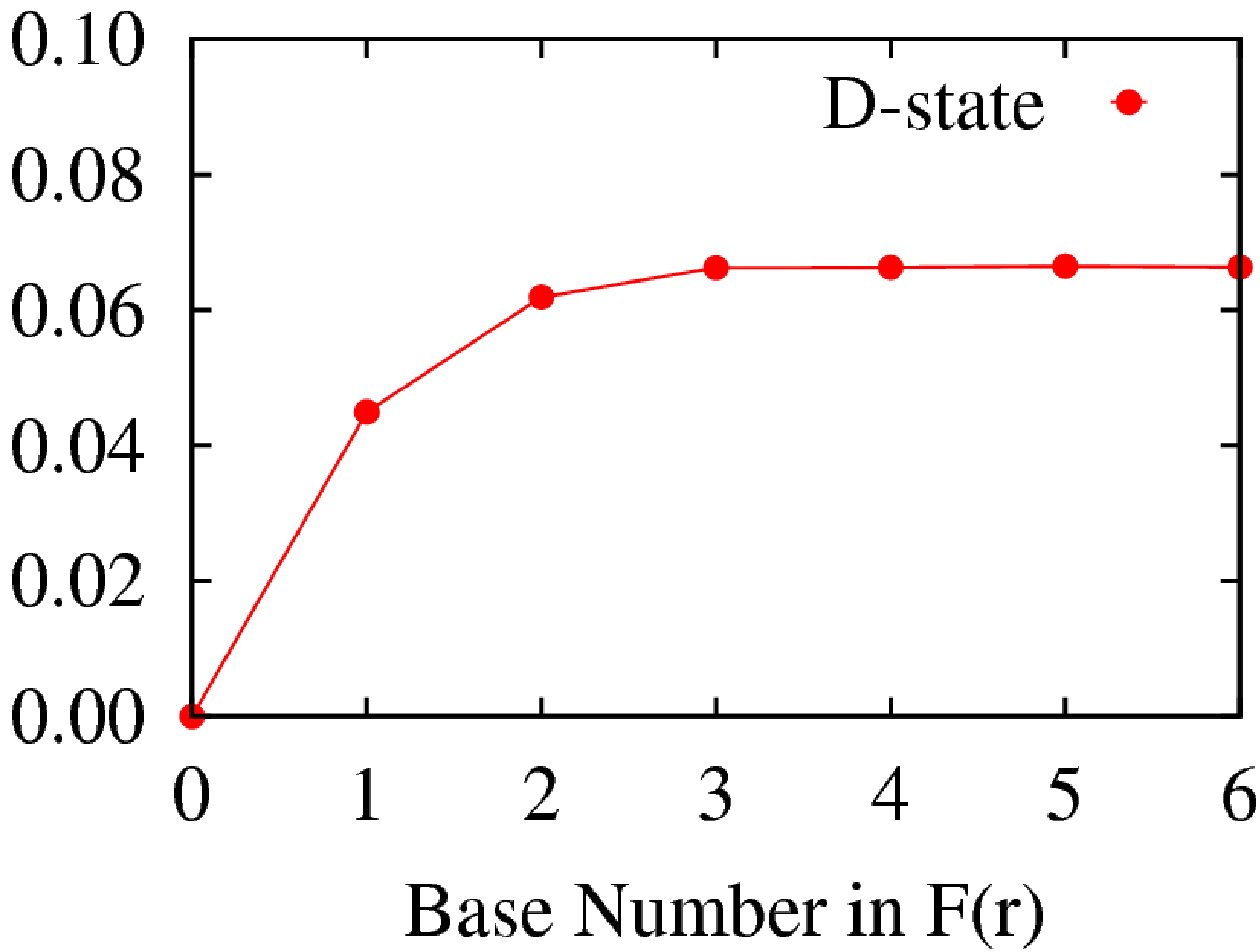
- Volkov No.2
- Furutani tensor



- Good convergence

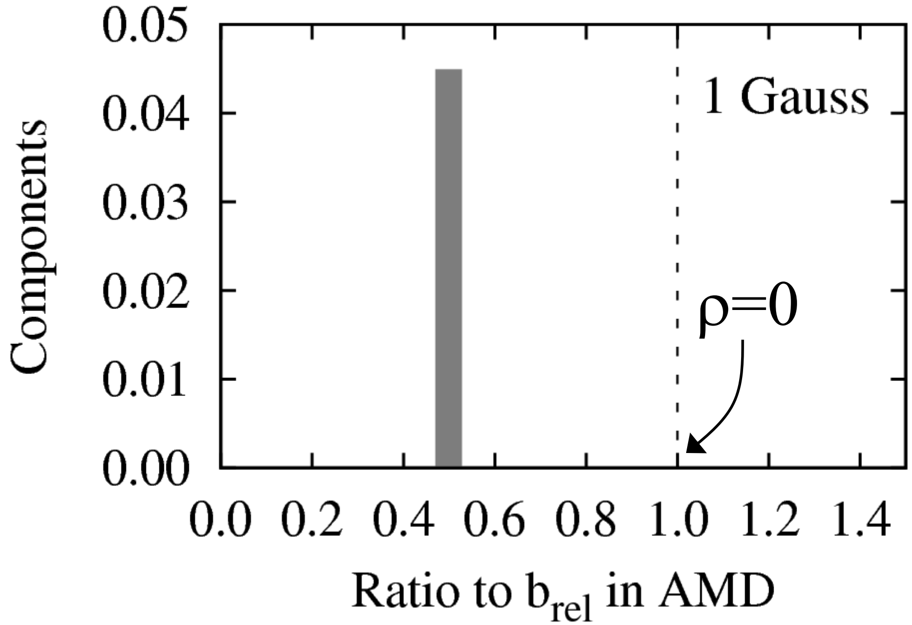
$$F(\boldsymbol{r}) = r^2 S_{12}\, \Sigma_n\, C_n \exp(-\rho_n r^2)$$

D-state probability



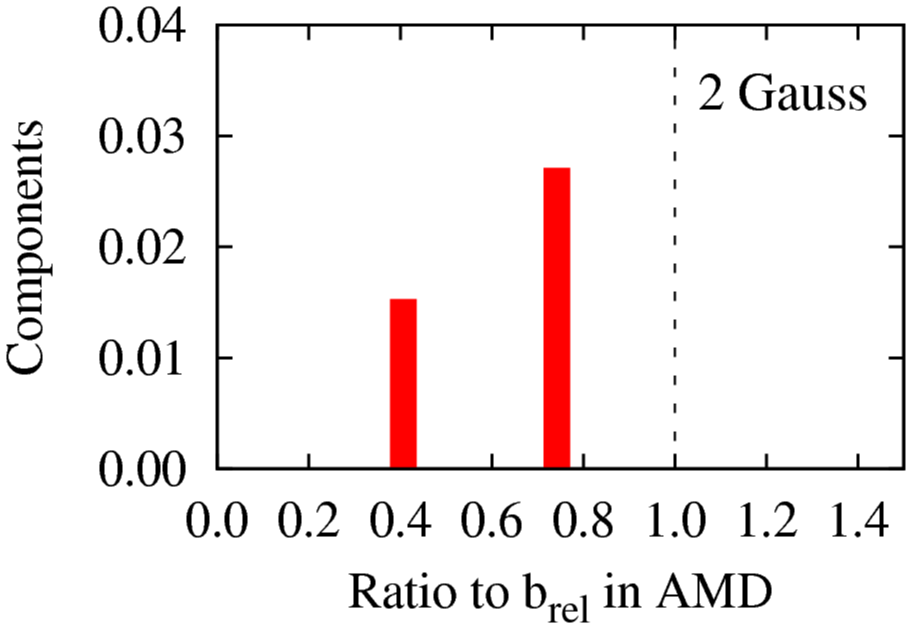
- Good convergence $F(\boldsymbol{r}) = r^2 S_{12} \Sigma_n C_n \exp(-\rho_n r^2)$

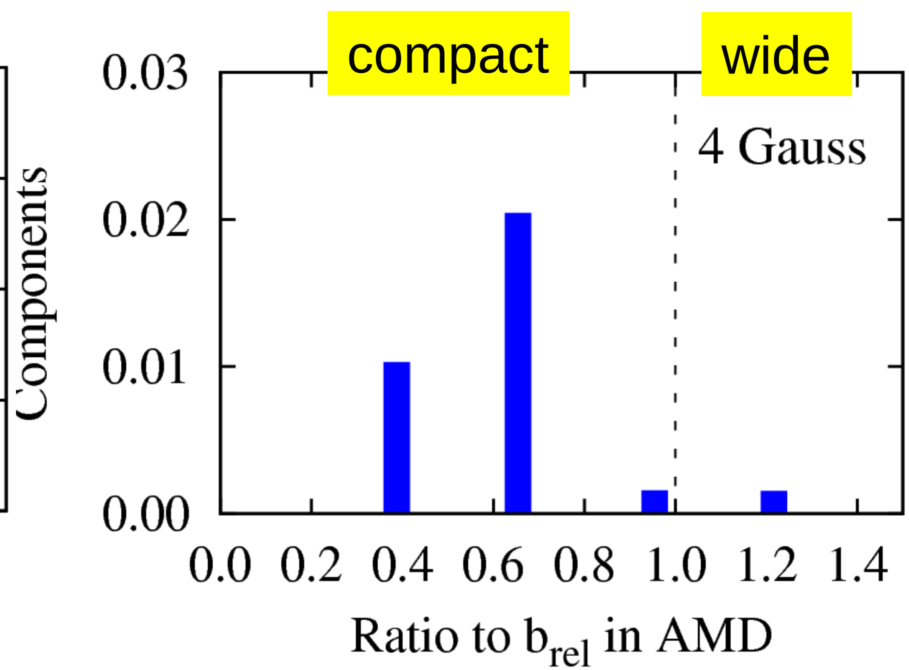
Gaussian expansion in $F(\boldsymbol{r})$



$$F(\boldsymbol{r}) = r^2 S_{12} \, \Sigma_n \, C_n \exp(-\rho_n r^2)$$

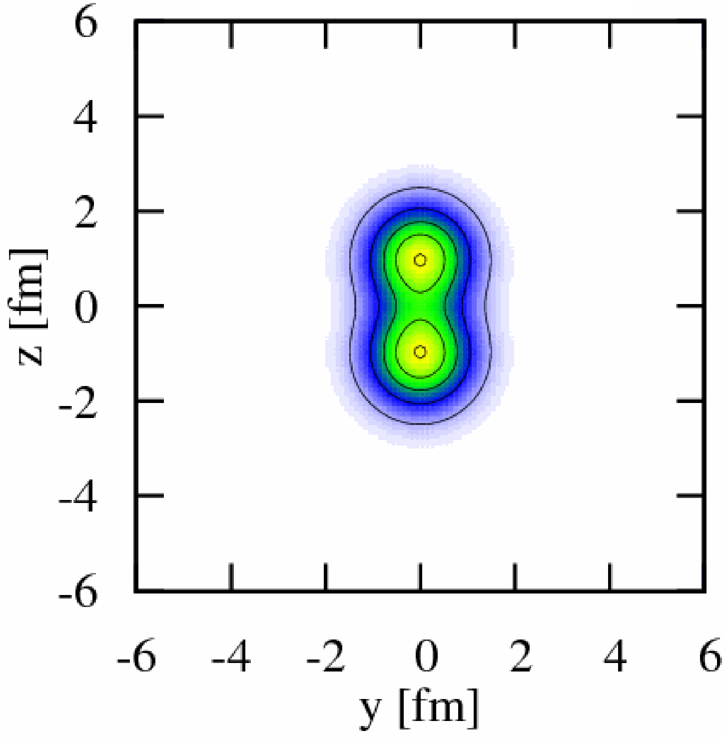
- Ratio to the Gaussian length (fm) of AMD basis
- Compact component is dominant in relative *D*-state



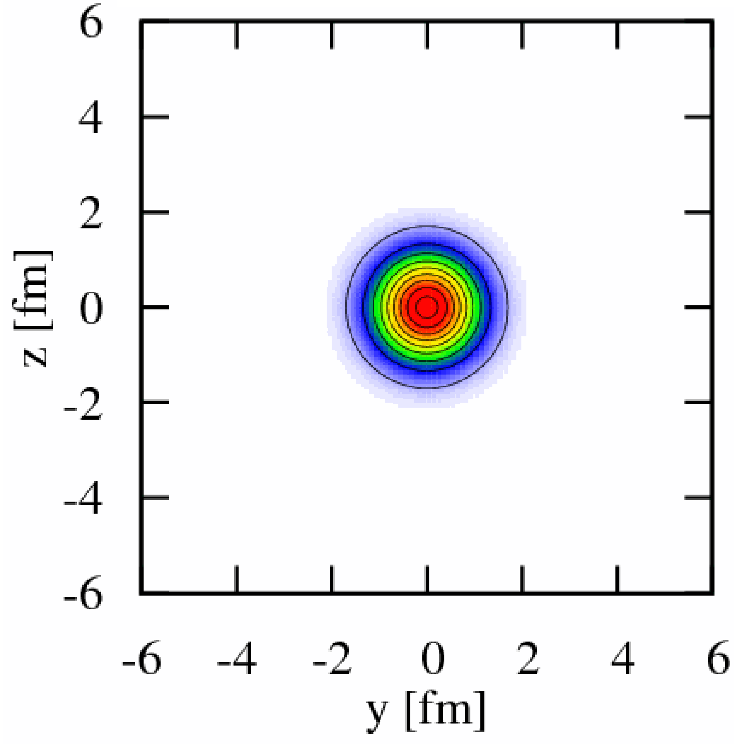


Intrinsic density of deuteron

AMD



AMD part
in Tensor-AMD



$\langle V_T \rangle = -0.63$ MeV

Describe *S*-wave part in deuteron

Summary

- **Formulation of Tensor-AMD**.
  – Nagata's method
  – Comparison with TOSM
- Deuteron results
  – Converge with Gaussian expansion of tensor-correlation function
  – Spatially compact component is dominant in **relative *D*-state**