Study of ^{40}S by Gogny-TDHFB method

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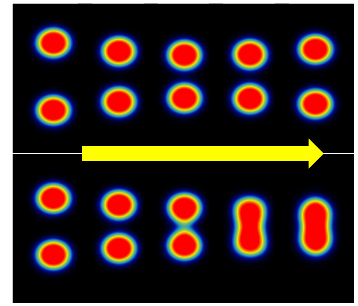
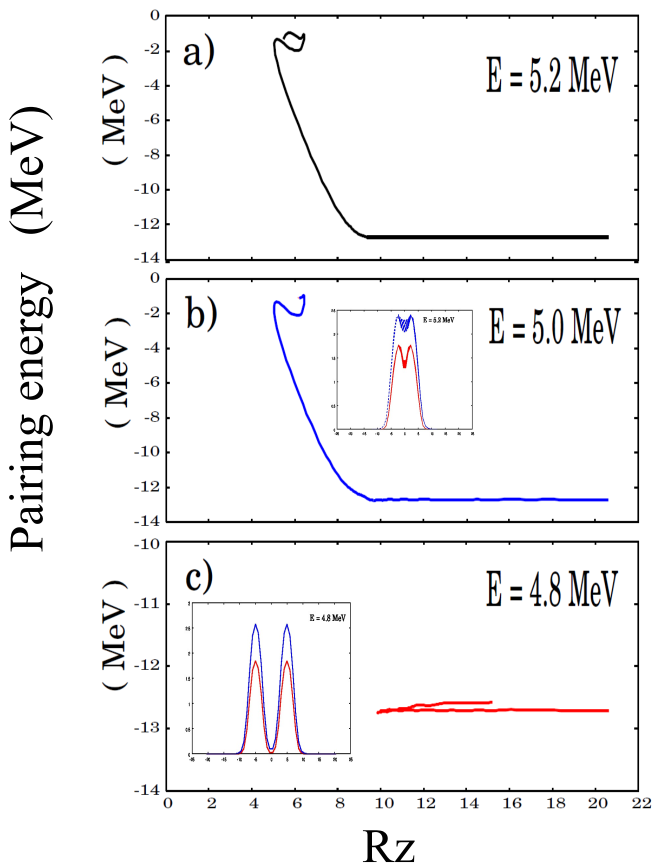
CCS, Univ. of Tsukuba

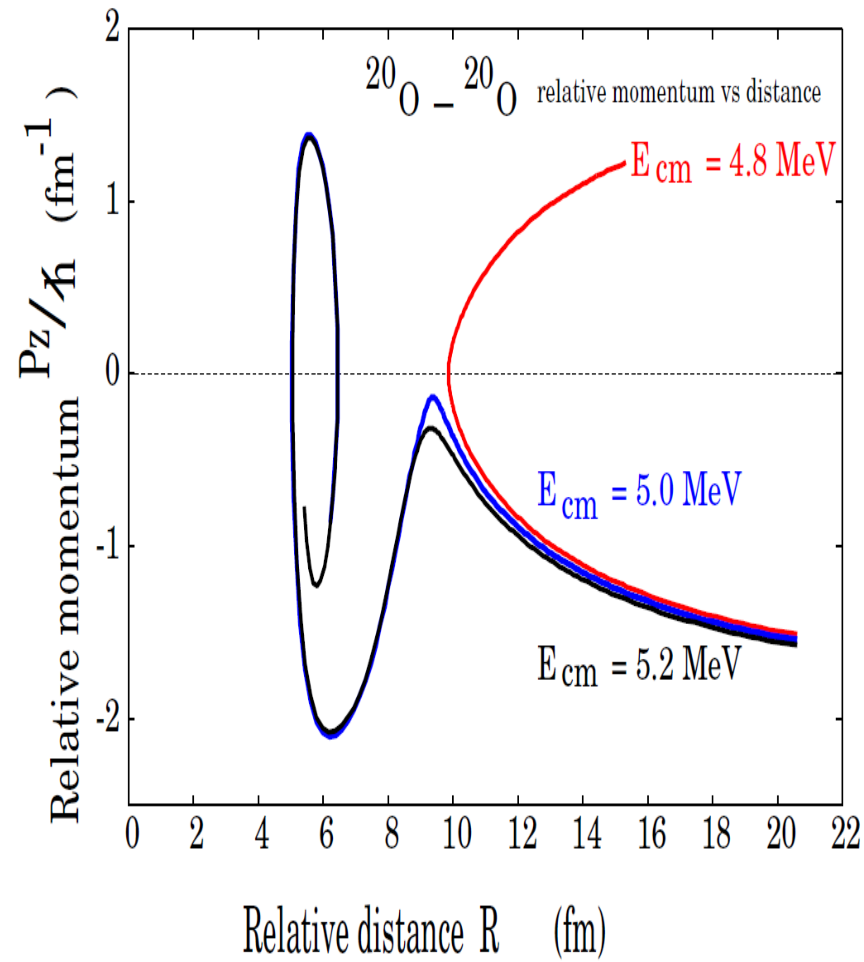
1. Motivation

$^{20}O + ^{20}O$ head-on collision
by Gogny-TDHFB



Cf. Y. H and Guillaume Scamps, Phys. Rev. C 94, 014610 (2016)





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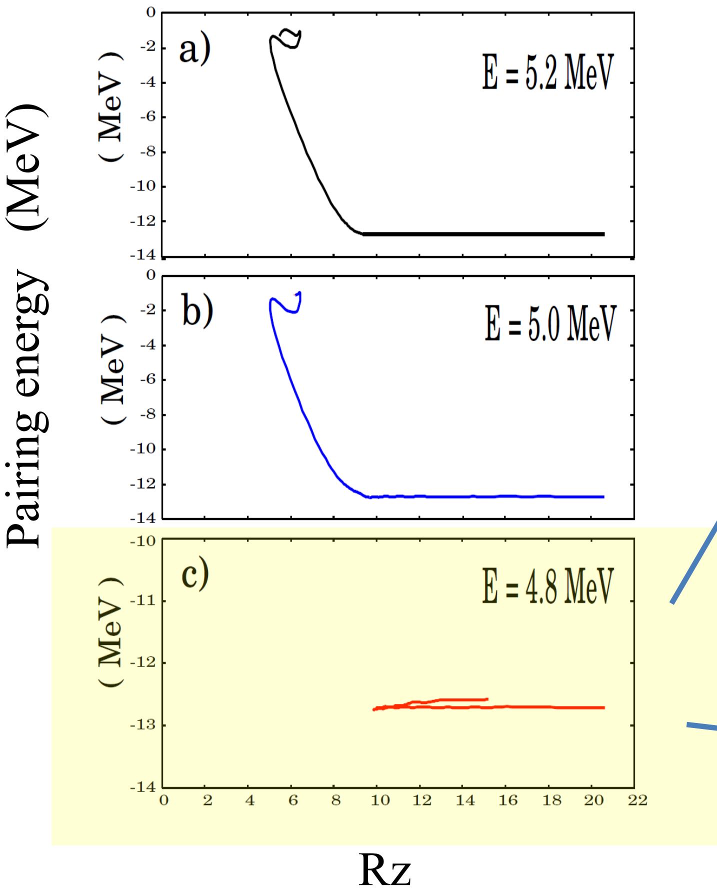
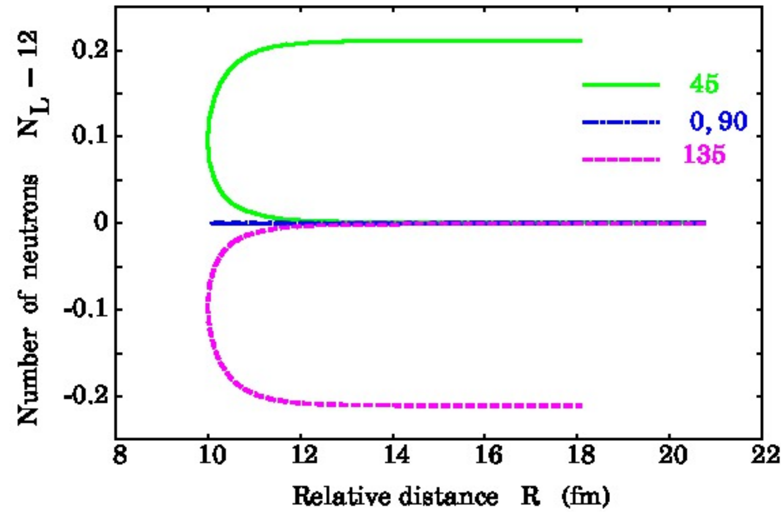
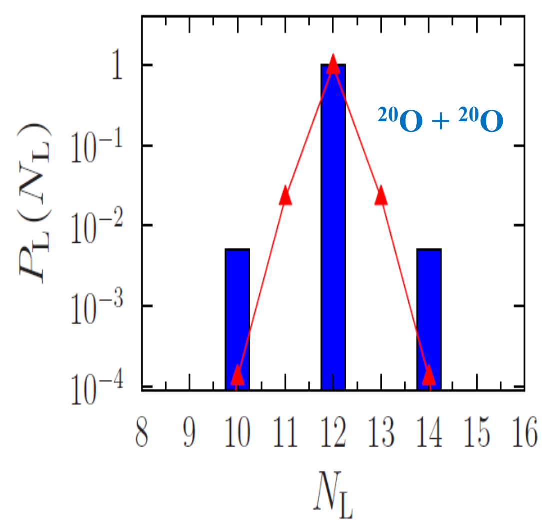
$^{20}O + ^{20}O$ head-on collision



transferred neutron number vs relative gauge angle



probability $P_L(N_L)$ of finding N_L neutrons in the left nucleus after the closest approach



G.Scamps and Y.H, PRC 96, 031602(R) (2017)

1. Motivation

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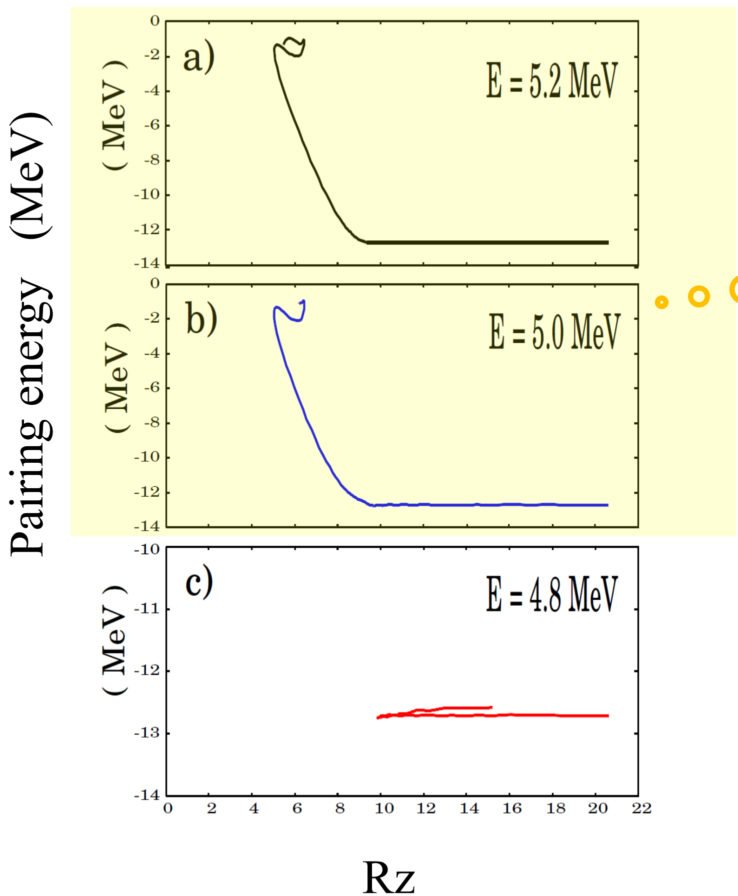

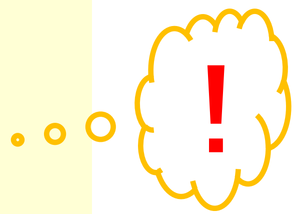

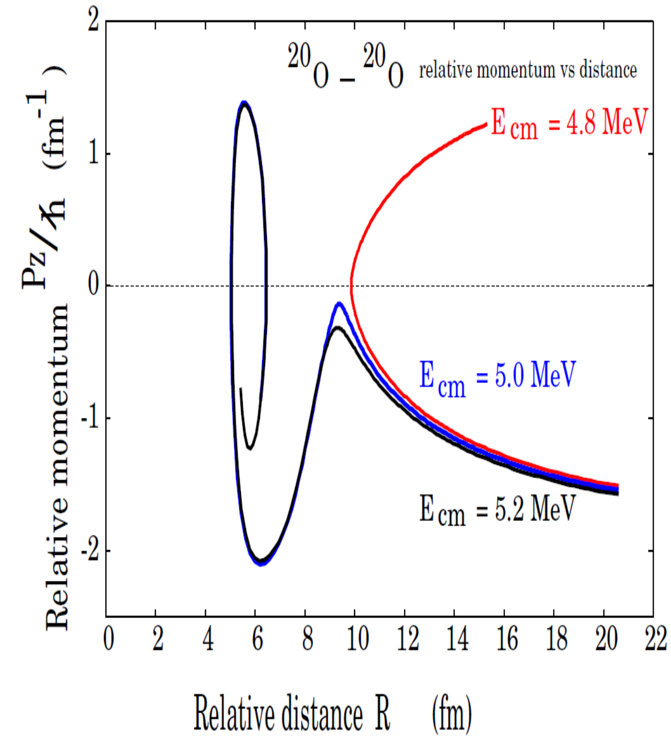

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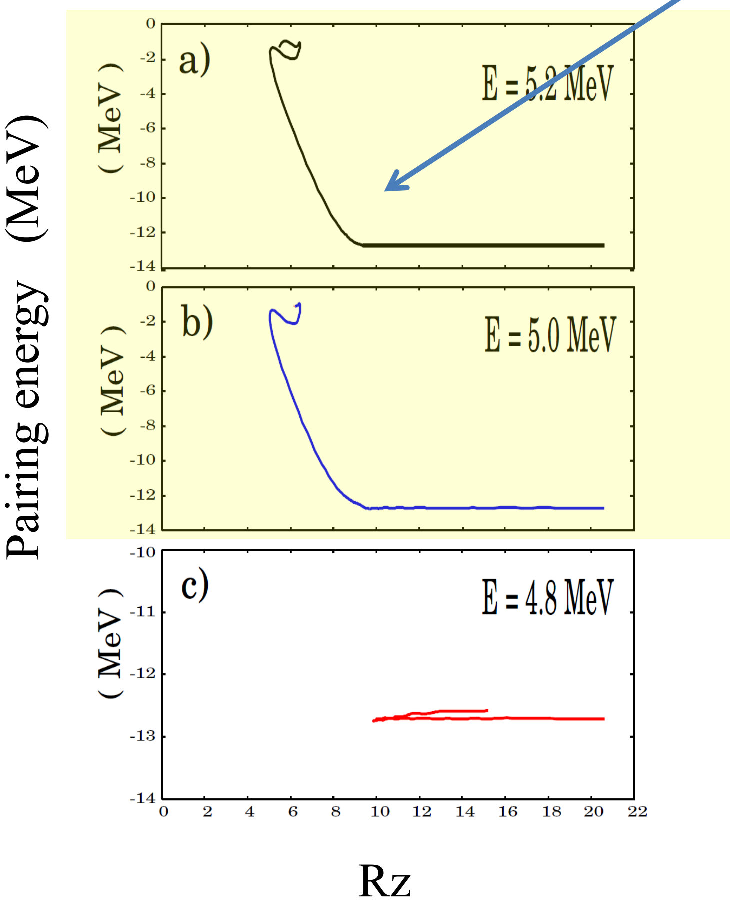
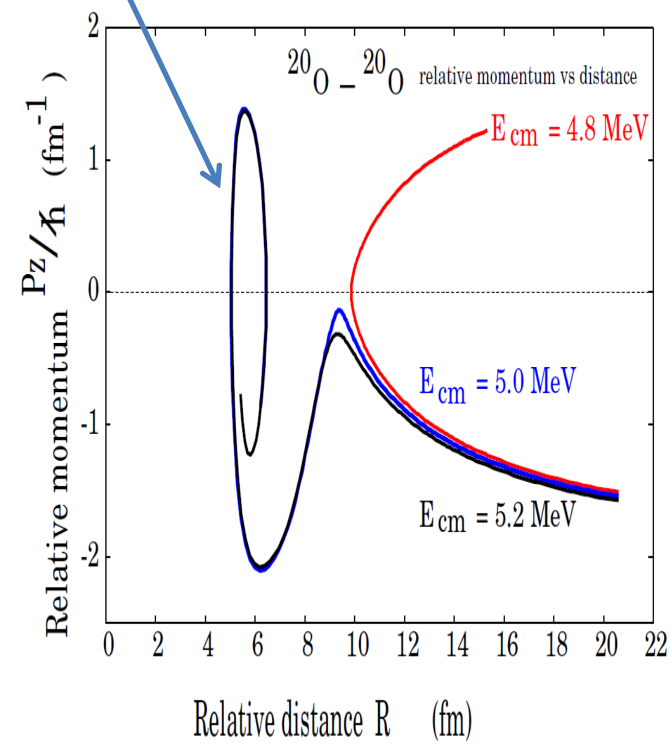
$^{20}O + ^{20}O$ head-on collision



1. smooth decrease of the pairing energy

2. damped oscillation



2． Basic equation

cf. Ring & Schuck, The Nuclear Many-Body Problems

Bogoliubov trans. :

$$\begin{cases} \beta_k^\dagger = \sum_\alpha (U_{\alpha k} C_\alpha^\dagger + V_{\alpha k} C_\alpha), \\ \beta_k = \sum_\alpha (U_{\alpha k}^* C_\alpha + V_{\alpha k}^* C_\alpha^\dagger). \end{cases}$$

$$i\hbar \frac{\partial}{\partial t} \begin{pmatrix} U(t) \\ V(t) \end{pmatrix} = \mathcal{H} \begin{pmatrix} U(t) \\ V(t) \end{pmatrix} \qquad \mathcal{H} = \begin{pmatrix} h & \Delta \\ -\Delta^* & -h^* \end{pmatrix}.$$

$$h_{\alpha\beta} = T_{\alpha\beta} + \Gamma_{\alpha\beta},$$

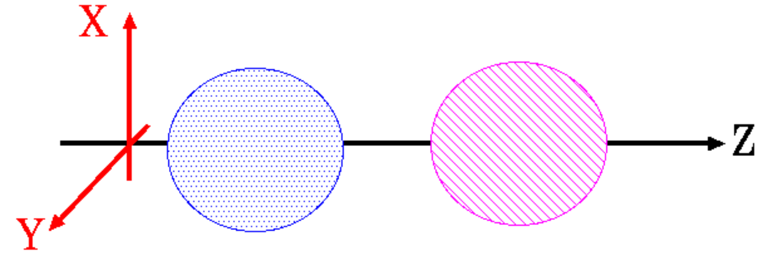
$$\Gamma_{\alpha\beta} = \sum_{\nu\delta} \mathcal{V}_{\alpha\gamma\beta\delta} \rho_{\delta\gamma}, \quad \Delta_{\alpha\beta} = \frac{1}{2} \sum \mathcal{V}_{\alpha\beta\gamma\delta} \kappa_{\gamma\delta},$$

$$\rho_{\alpha\beta} = (V^* V^T)_{\alpha\beta}, \quad \kappa_{\alpha\beta} = (V^* U^T)_{\alpha\beta}.$$

predictor-corrector method

$$\begin{pmatrix} U(t) \\ V(t) \end{pmatrix}^{(n+1)} = \exp\left(-i \frac{c\Delta t}{c\hbar} \mathcal{H}^{(n+\frac{1}{2})}\right) \begin{pmatrix} U(t) \\ V(t) \end{pmatrix}^{(n)}$$

harmonic oscillator	Lagrange mesh
x, y	z



$$\{\phi_{n_x}(x), \phi_{n_y}(y), \phi_{n_z}(z)\} \Longrightarrow \{\phi_{n_x}(x), \phi_{n_y}(y), \underline{f_{n_z}(z)}\}$$

harmonic oscillator

Lagrange mesh

$$f_l(z) = \frac{1}{N}\frac{\sin\left(\pi\left(z - z_l\right)/h\right)}{\sin\left(\pi\left(z - z_l\right)/L\right)}$$

$$L = Nh$$

$$f_k(z_{k'}) = \delta_{kk'}$$

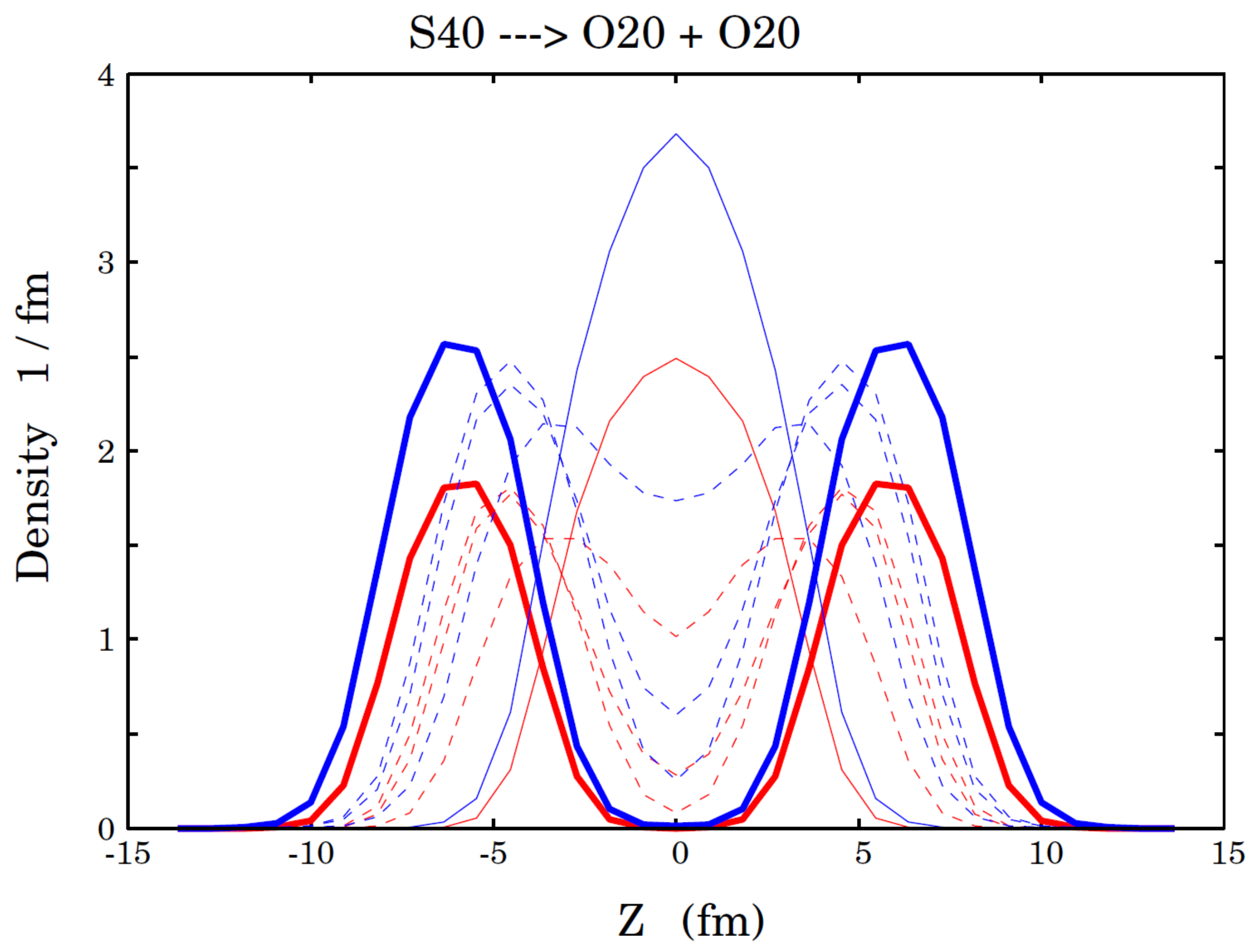
$$\int_{-L/2}^{L/2} f_l(z) f_{l'}(z) dz = h\,\delta_{ll'}$$

$$\int_{-L/2}^{L/2} f_l(z) W(z) f_{l'}(z) dz = h\,W(z_l)\,\delta_{ll'}$$

D. Baye and P. Heenen,
J. Phys. A 19, 2041 (1986).

HFB calculations with constraint term $\propto |z|$

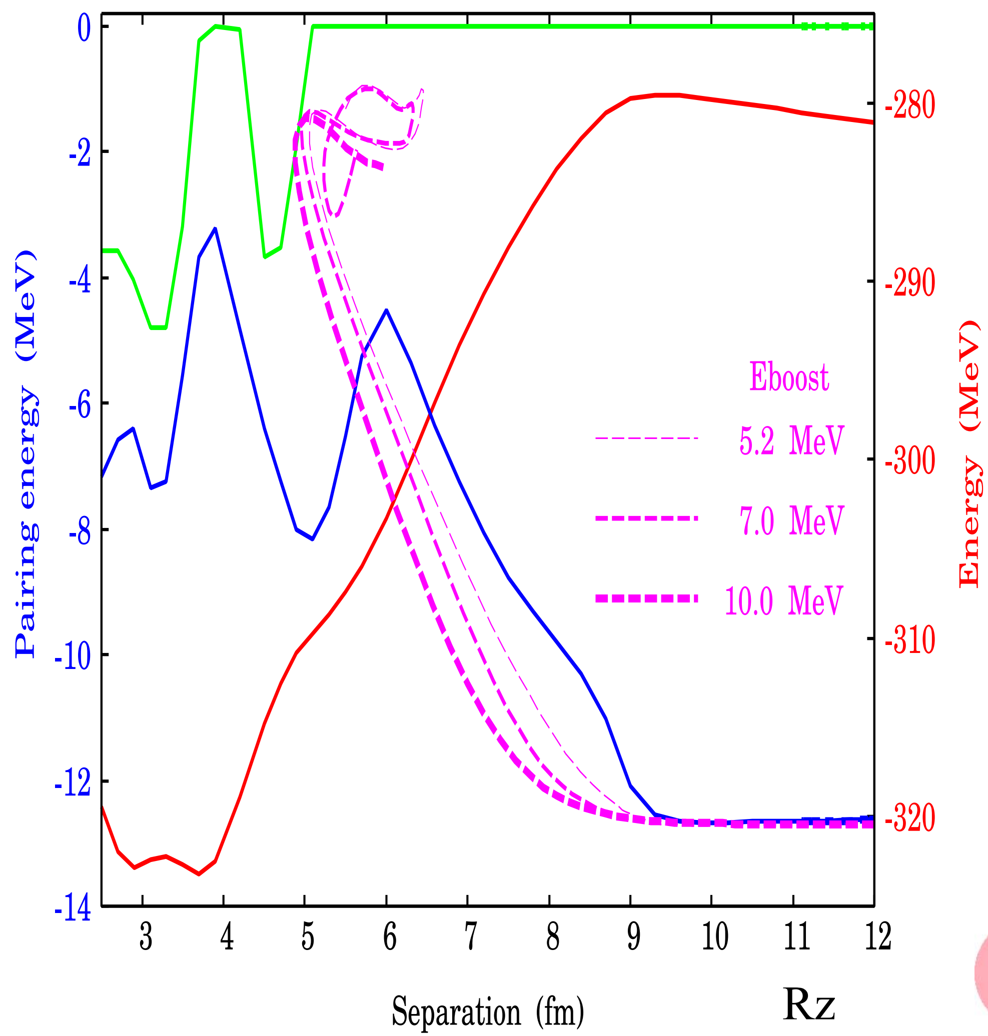
- harmonic oscillator shell Nsh= **5**
- number of mesh points (z axis): **31**
- $\varDelta$x = **0.91** fm

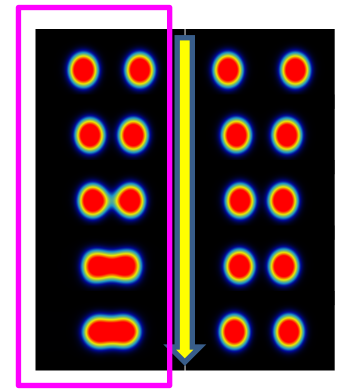


3-1. Pairing energy vs Rz

$^{20}O + ^{20}O$ head-on collision

smooth change of pairing energy with respect to separation Rz

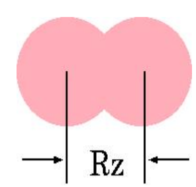




proton pairing energy (CHFB)

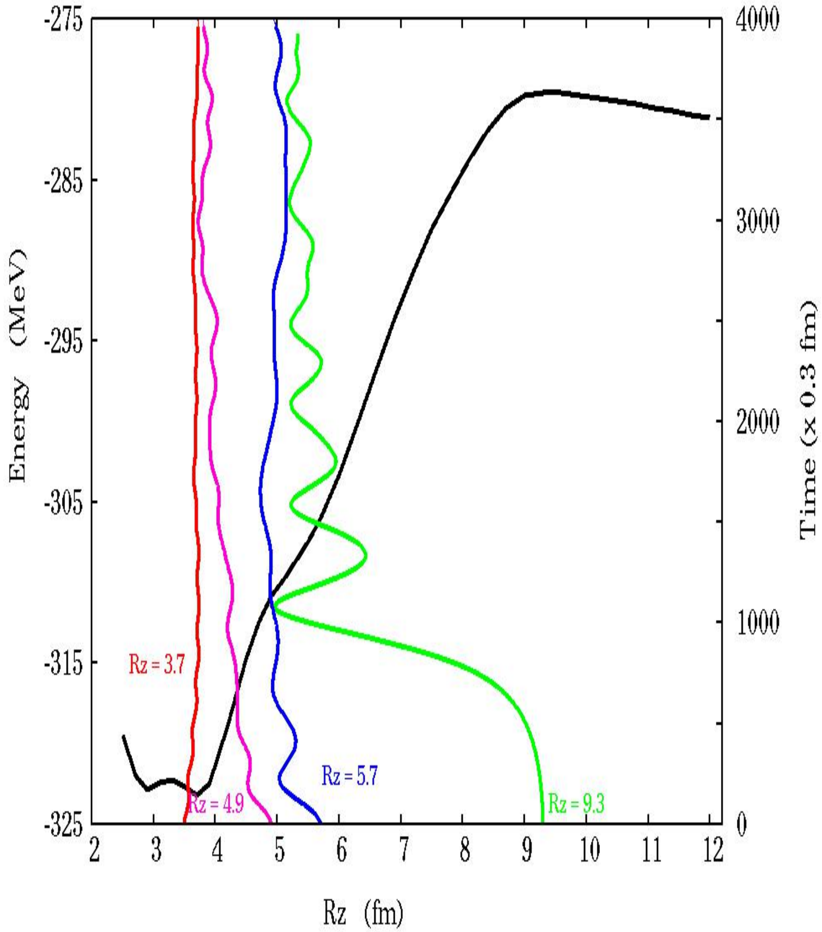
neutron pairing energy (CHFB)

total energy (CHFB)

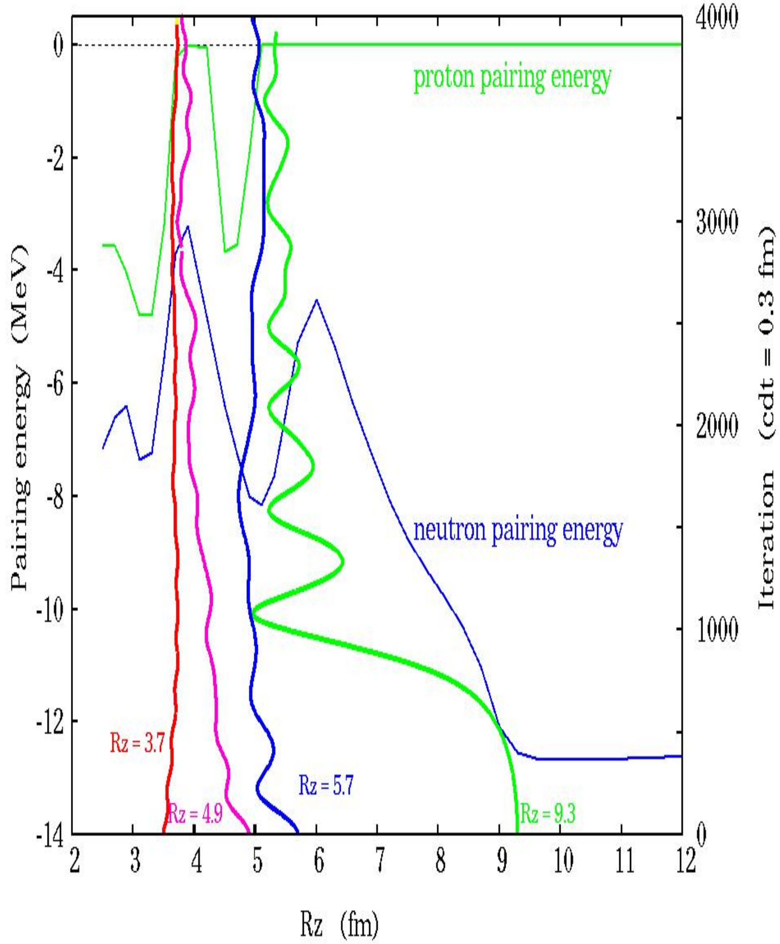


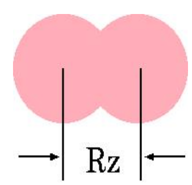
3-2. TDHFB trajectories, total energy and pairing energies

Total energy



Pairing energy





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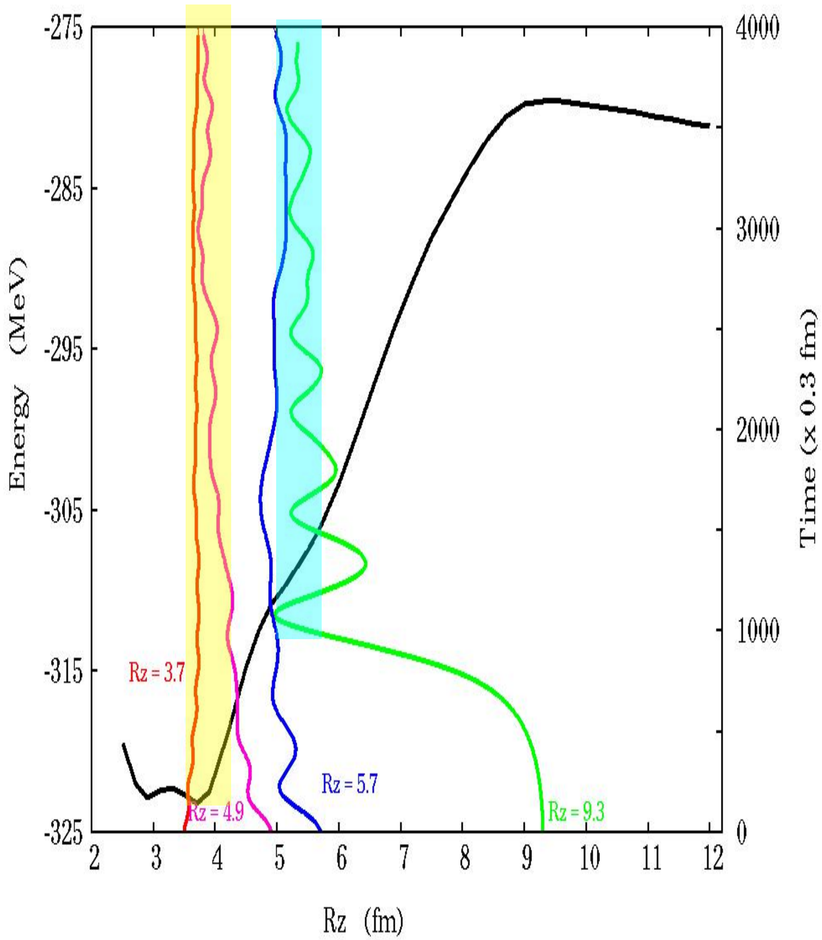
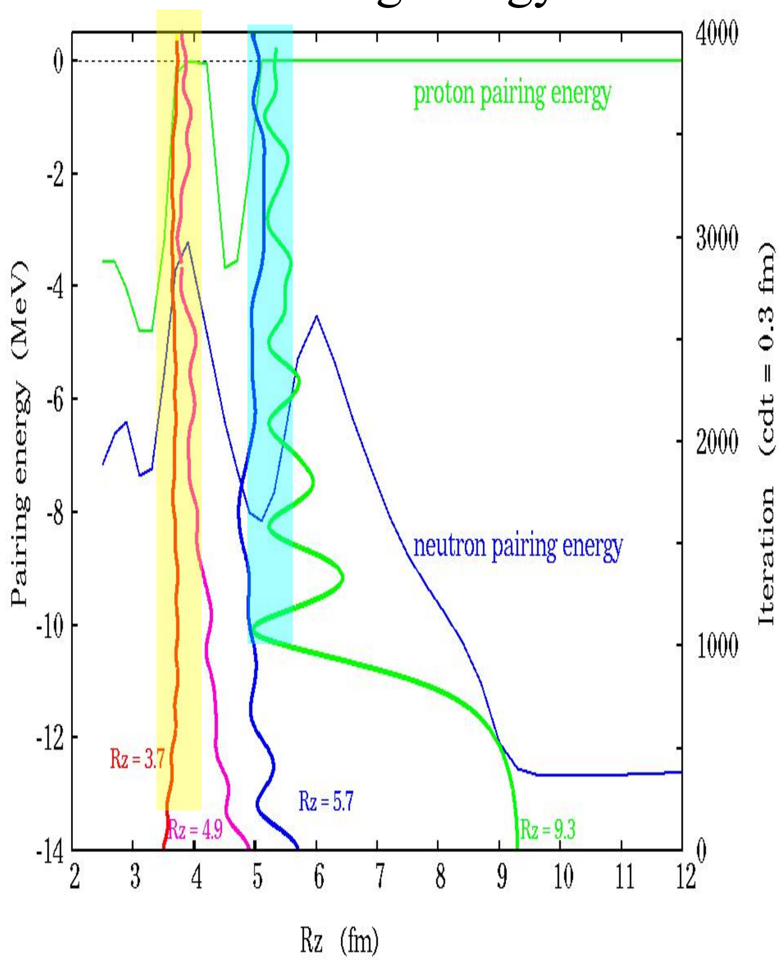
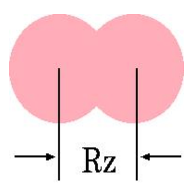


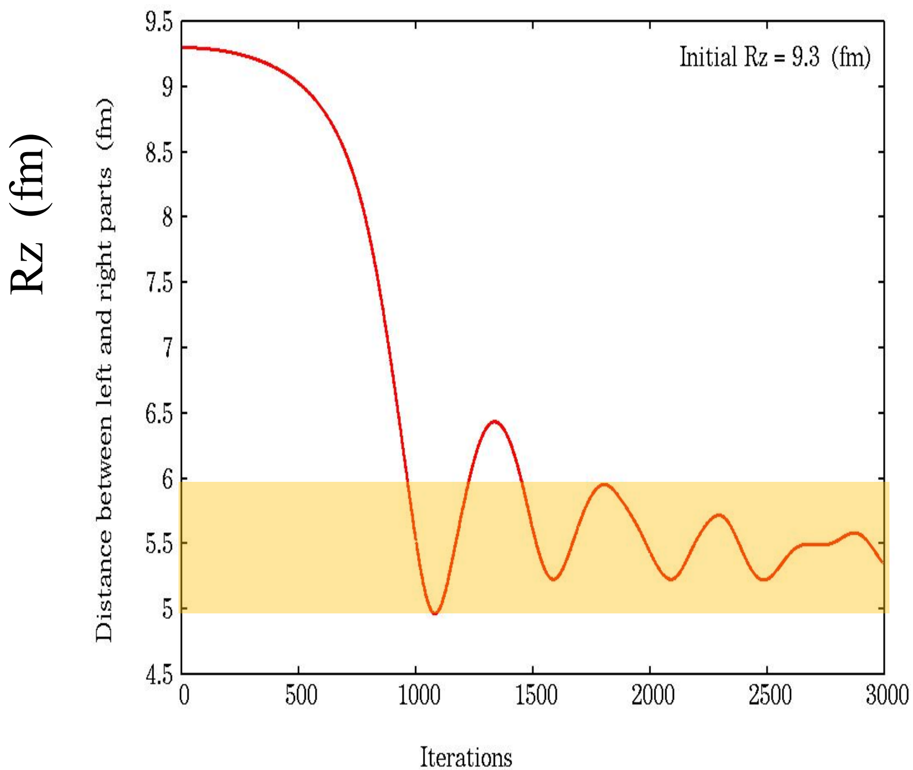
Pairing energy

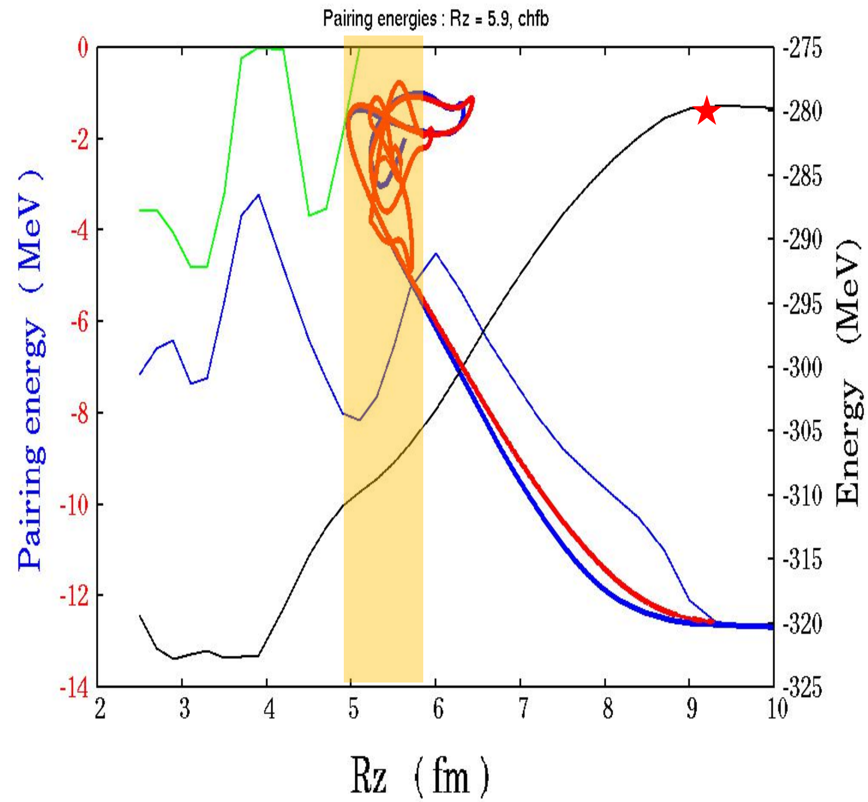




☆ TDHFB trajectory (initial Rz = 9.3 fm)

pairing energy
(TDHFB from
Rz = 9.3 fm)

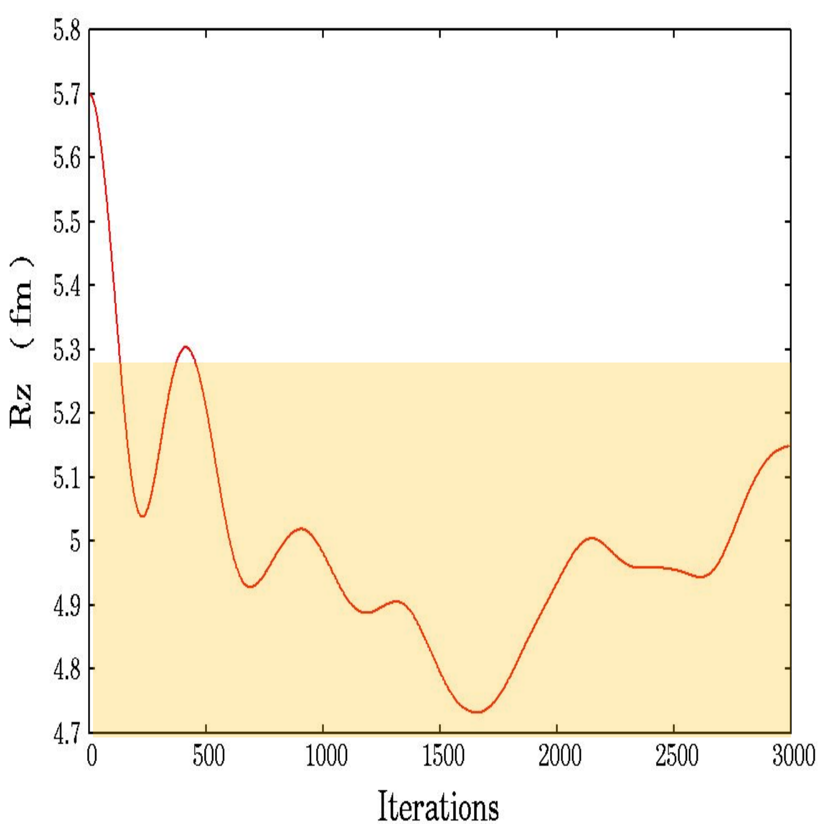


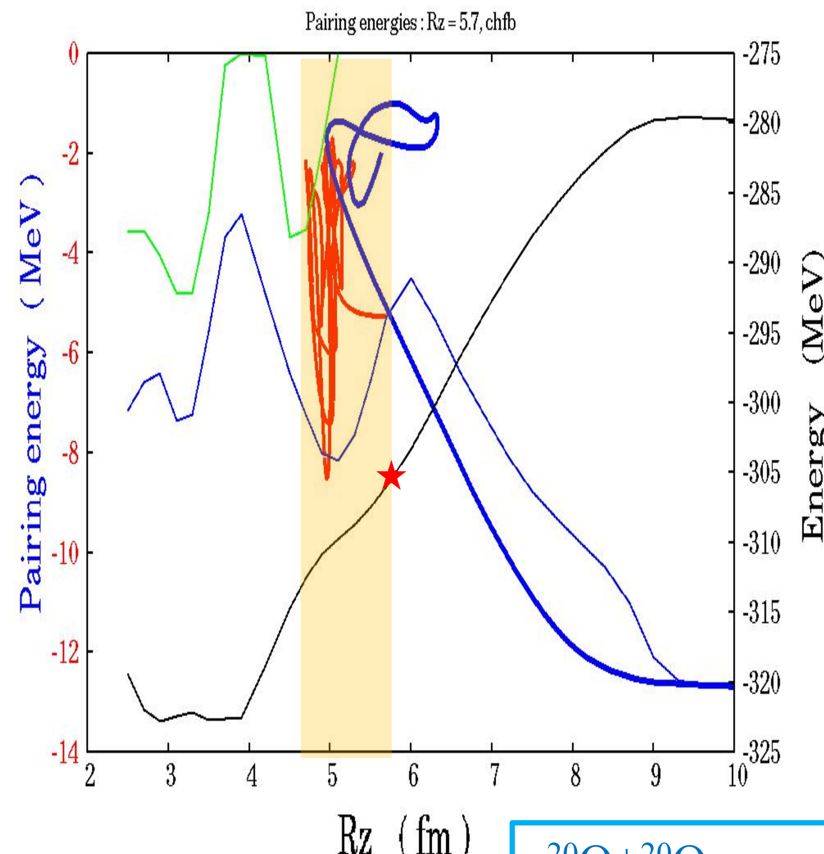


$^{20}O+^{20}O$
Eboost = 7.0 MeV

☆ TDHFB trajectory (initial Rz = 5.7 fm)

pairing energy
(TDHFB from
Rz = 5.7 fm)

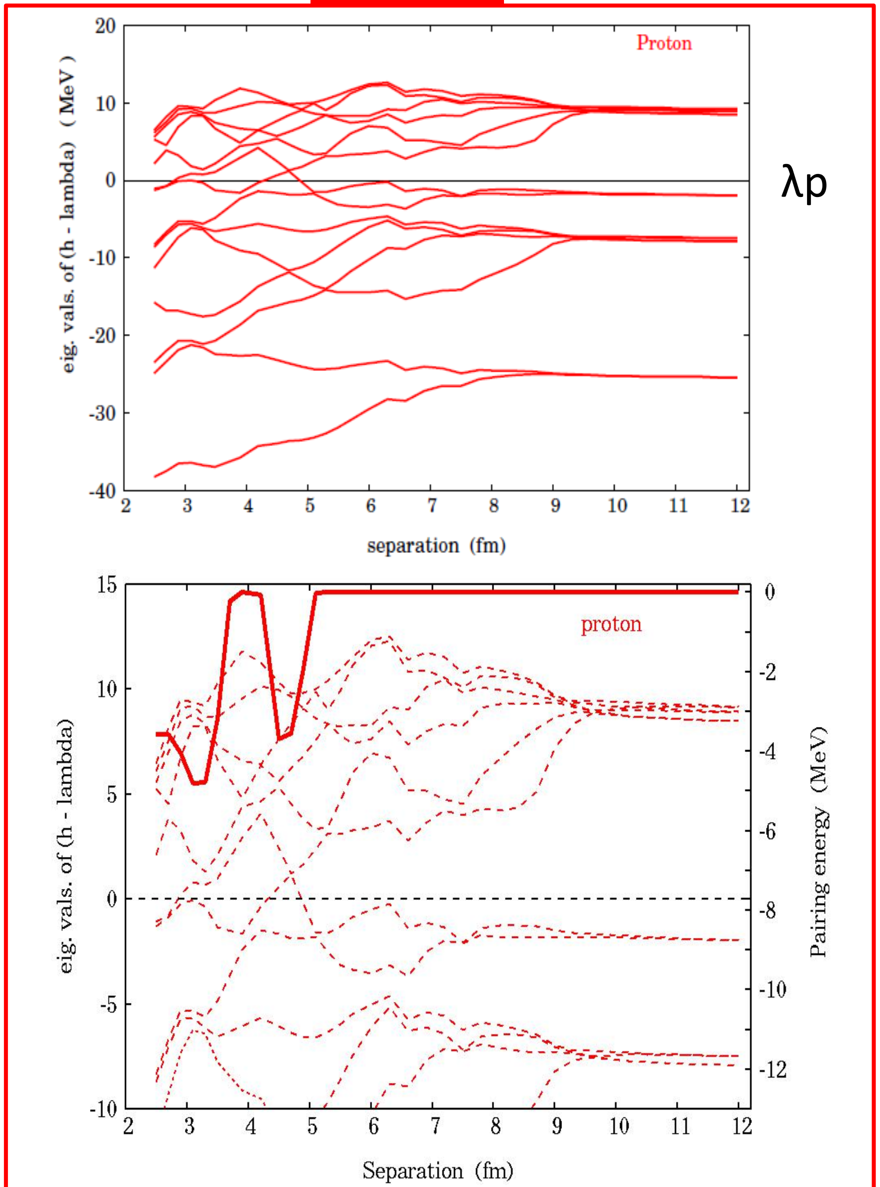




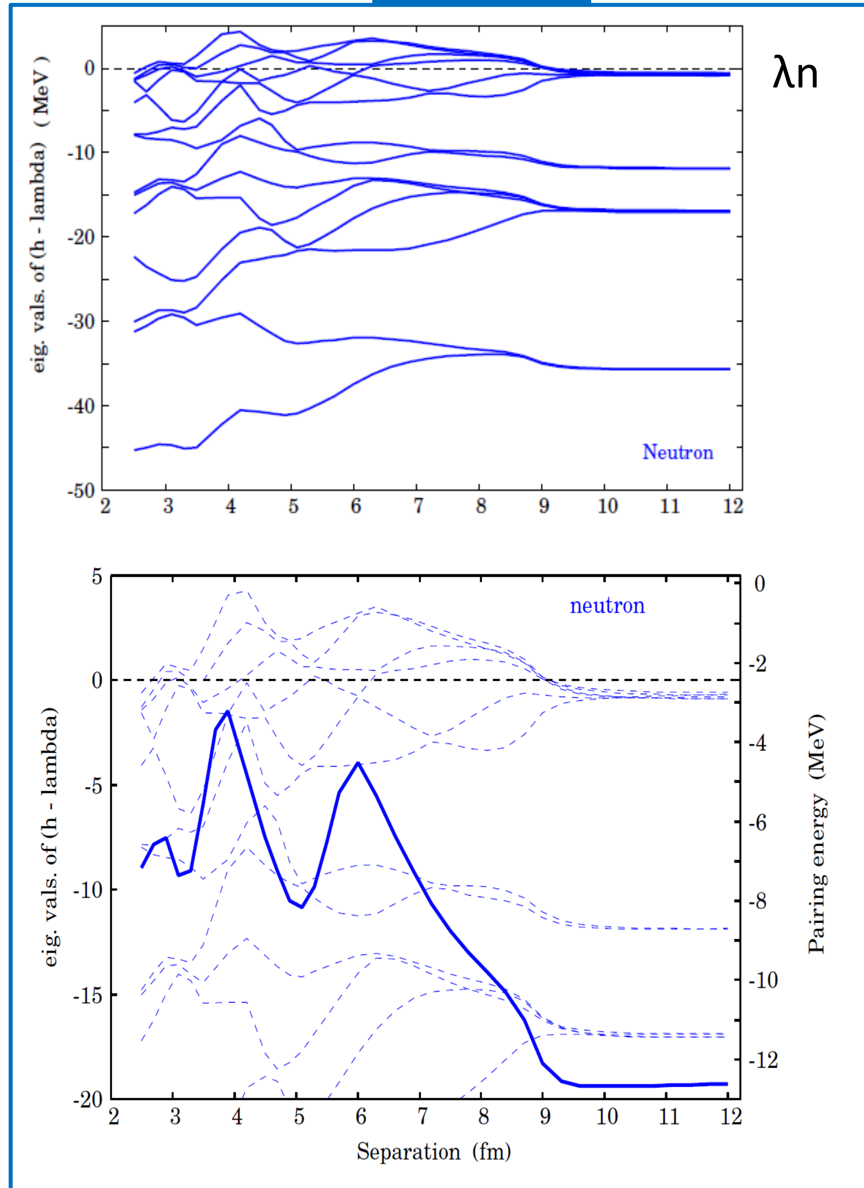
$^{20}O+^{20}O$
Eboost = 7.0 MeV

3-3. TDHFB trajectories and single-particle energies

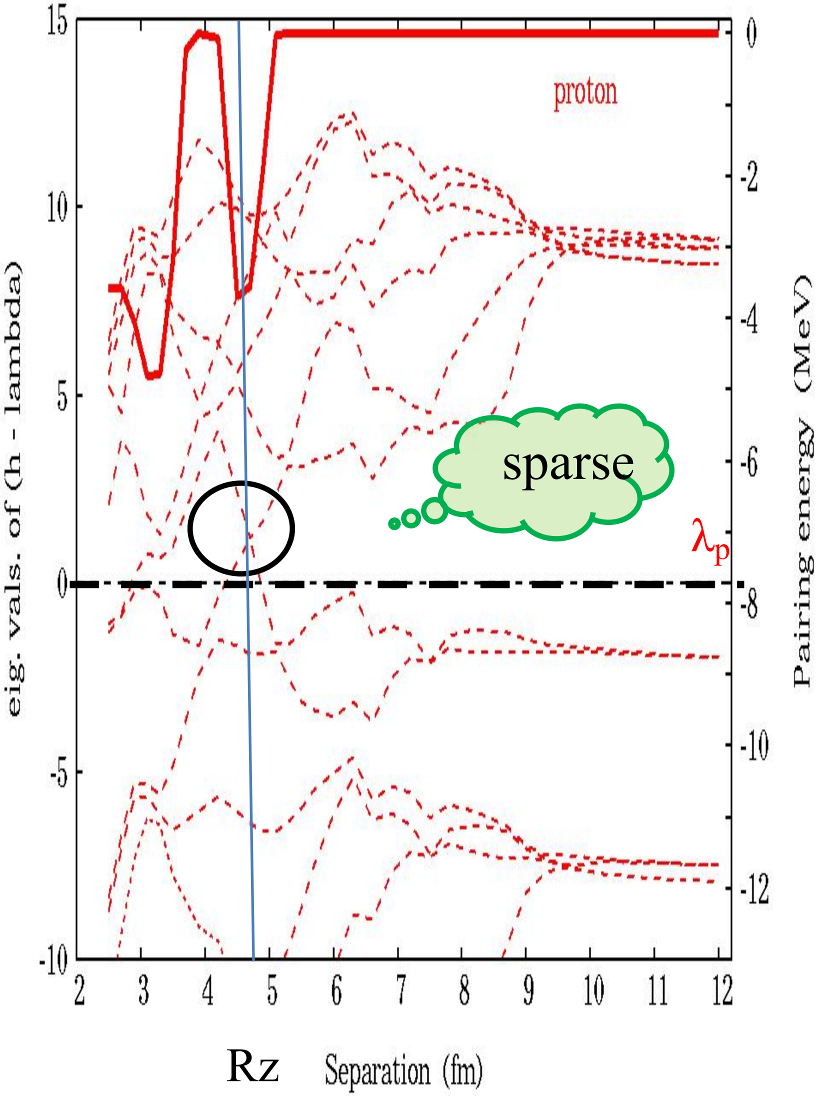
protons

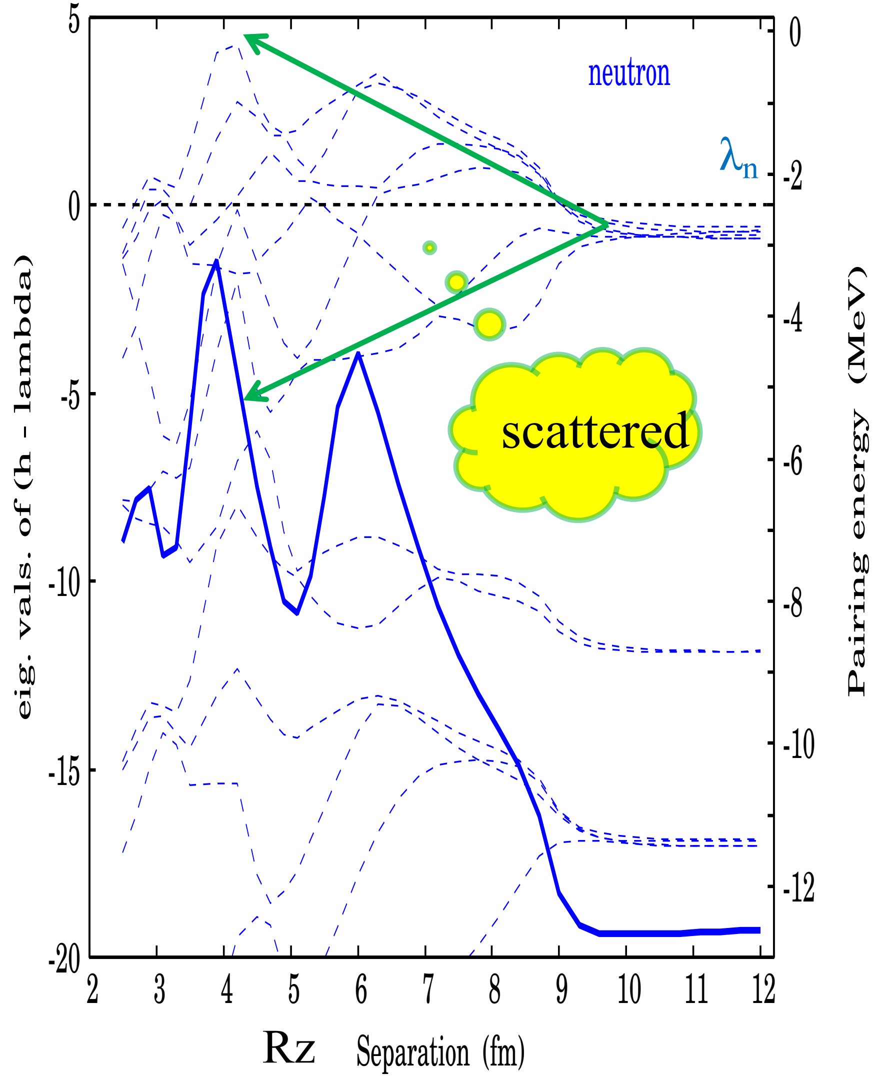


neutrons

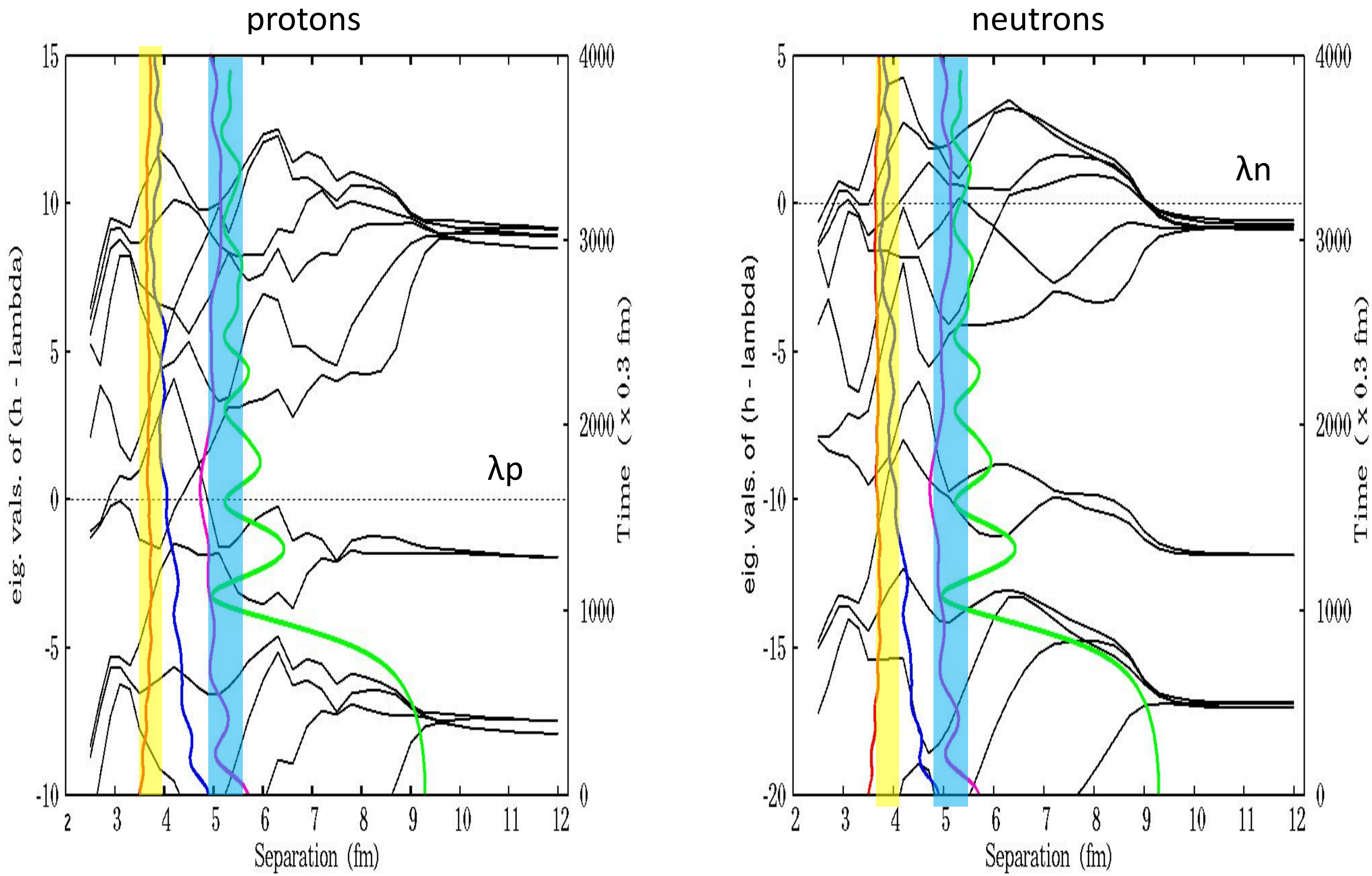


magnifications



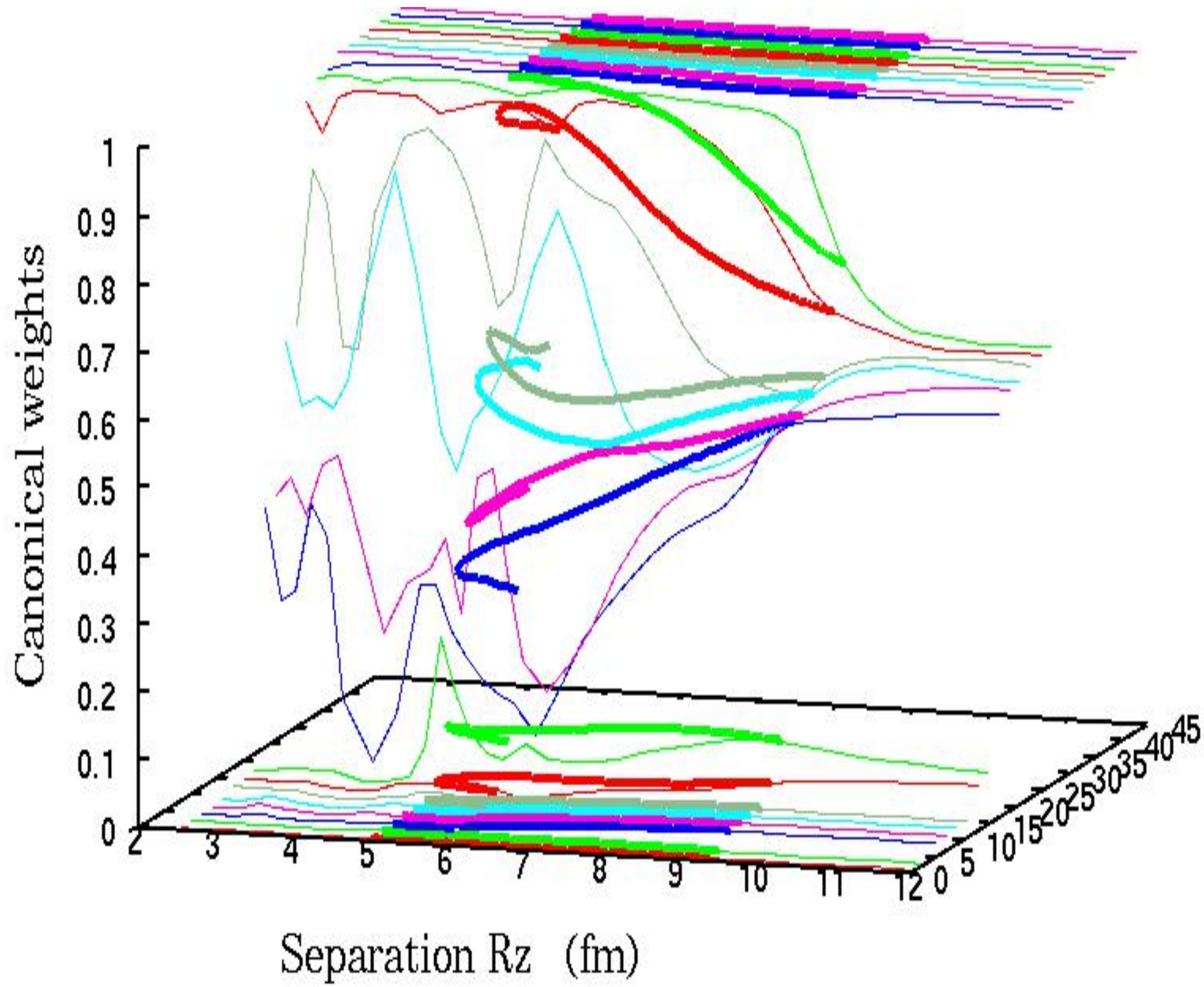


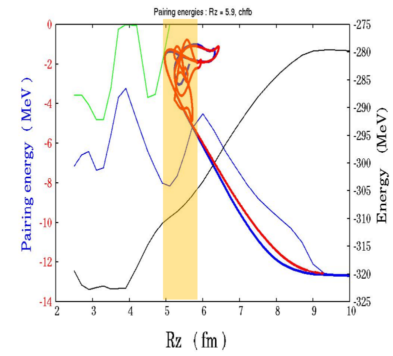
typical trajectories

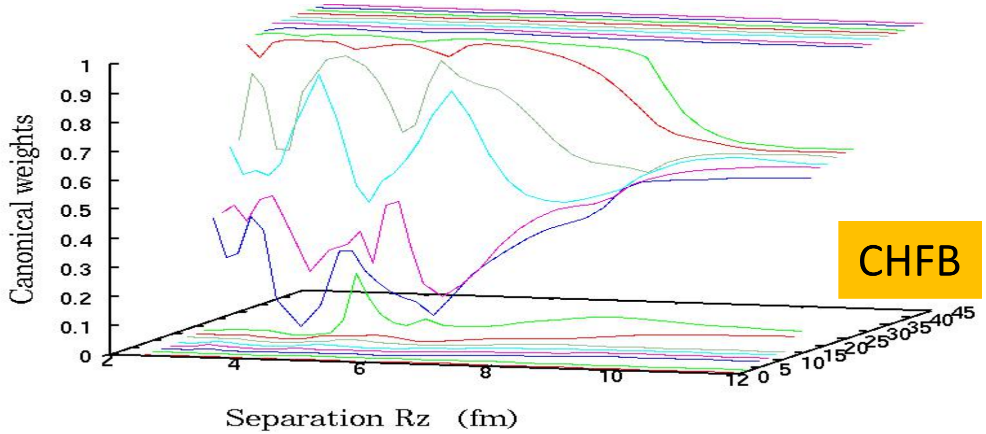


2.4 Comparison of canonical weights between CHFB and TDHFB

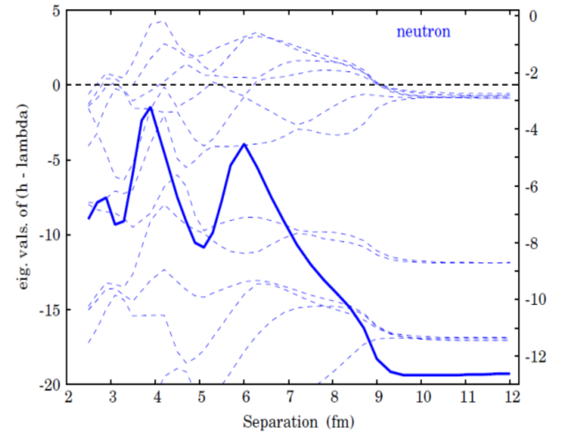
TDHFB
(Rz (0) = 9.3 fm)

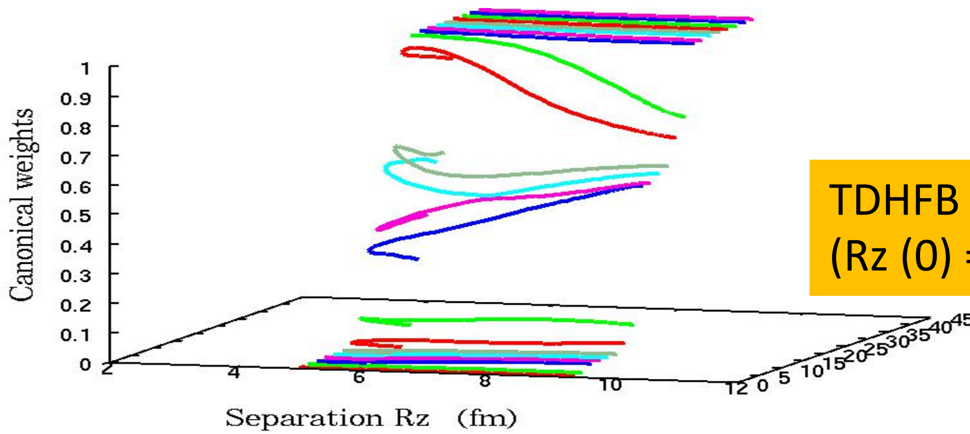




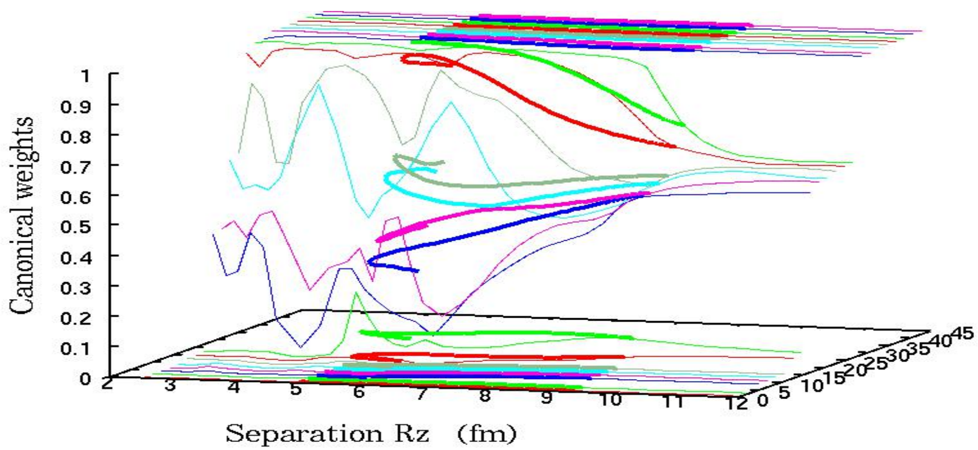


CHFB

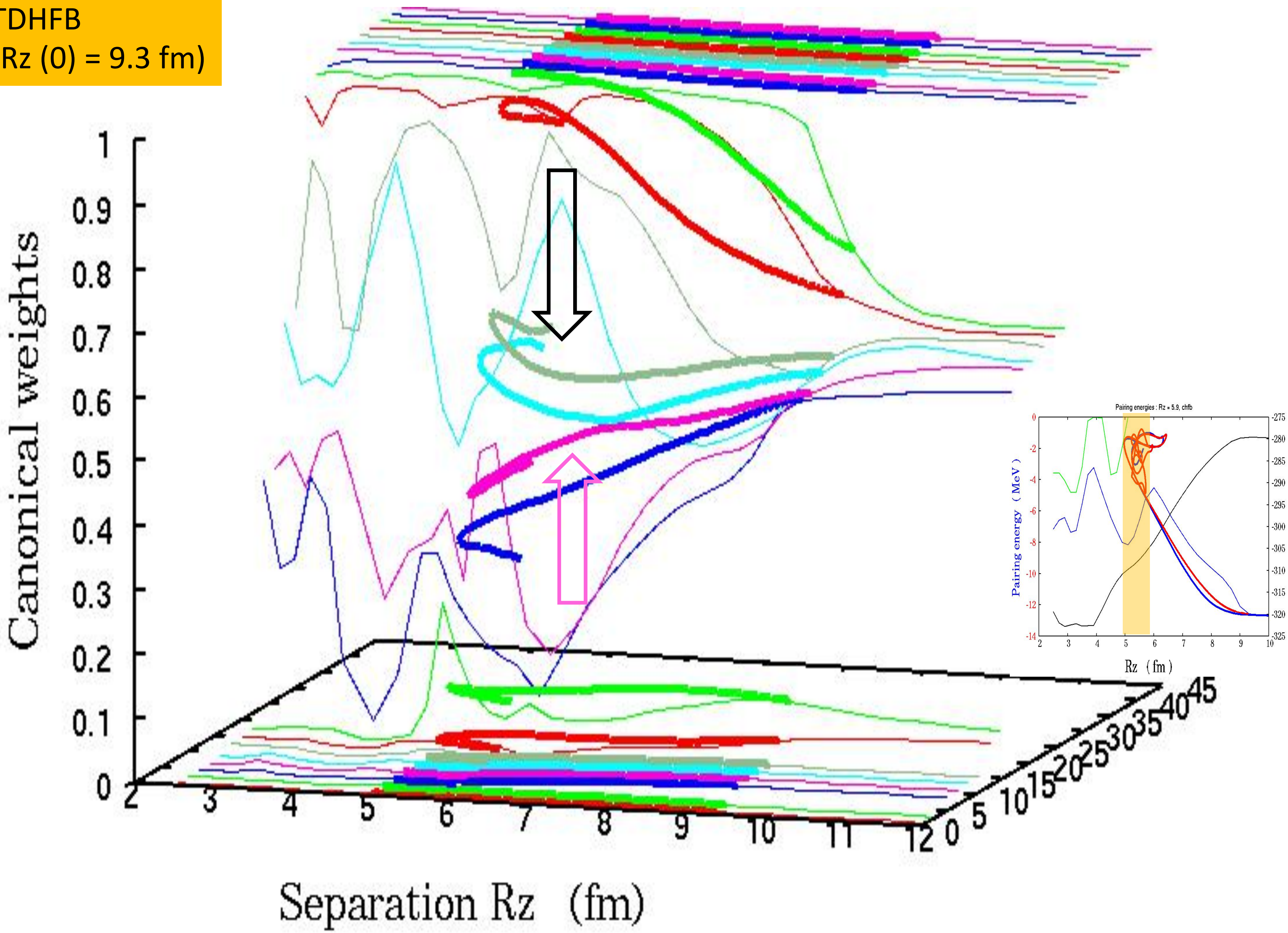




TDHFB
(Rz (0) = 9.3 fm)



TDHFB
(Rz (0) = 9.3 fm)



4. Summary

1. smooth change of pairing energy
   <==> change of distribution
   of the neutron single-particle energies
   and smooth change of occupation weights

2. damped oscillations
   <==> (comparatively) large change of distributions
   of neutron occupation weights
   near chemical potential energy

3. More quantitative method of analysis?

Thanks for listening!