MICROSCOPIC CALCULATION OF THE TOTAL PHOTOABSORPTION CROSS SECTION OF $A = 6$ NUCLEI

In collaboration with:
Nir Barnea, Mario A. Marchisio,
Winfried Leidemann, Giuseppina Orlandini

OUTLINE OF THE TALK:

* Inclusive processes: LIT method

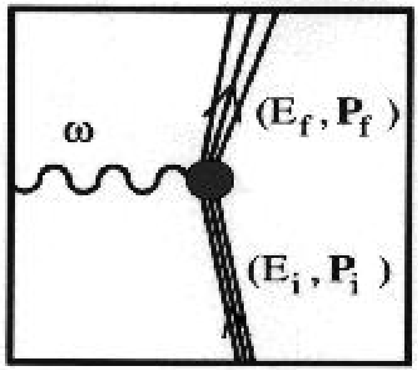
* EIHH approach

* Lanczos algorithm

* Results

* Conclusions and future perspectives

INCLUSIVE PHOTODISINTEGRATION
OF A NUCLEUS



Cross section $\sigma(\omega) = \frac{4\pi^2\alpha}{2J_i+1}\,\omega F(\omega)$

$$F(\omega) = \int d\Psi_f \left| \left\langle \Psi_f \right| \mathbf{E1} \left| \Psi_0 \right\rangle \right|^2 \delta(E_f - E_0 - \omega)$$

A new AB INITIO calculation for the 6−body problem is allowed via the use of:

LIT Lorentz Integral Transform Method

P.L. ***B 338*** *(1994) V.D.Efros, W.Leidemann, G.Orlandini*

EIHH Effective Interaction with HH Formalism

P.R. ***C 61*** *(2000) N.Barnea, W.Leidemann, G.Orlandini*

LORENTZ INTEGRAL TRANSFORM METHOD FOR INCLUSIVE PROCESSES

It enables to consider the full final state interaction of the system exactly.

1. Apply an integral transform on $F(\omega)$ with a lorentzian shape kernel $K(\omega)$

$$
\begin{aligned}
L(\sigma) &= \int d\omega K(\omega) F(\omega) \\
&= \int d\omega \frac{F(\omega)}{(\omega - \sigma_R)^2 + \sigma_I^2} = \left\langle \widetilde{\Psi} \middle| \widetilde{\Psi} \right\rangle
\end{aligned}
$$

$$
\sigma = -\sigma_R + i\sigma_I
$$

2. The problem is reduced to the solution of a Schrödinger-like equation

$$
(H - E_0 - \sigma_R + i\sigma_I)\left|\widetilde{\Psi}\right\rangle = \widehat{O}\,|\Psi_0\rangle
$$

which can be found with bound state techniques.

3. Inversion of the transform

$$
L(\sigma) \longrightarrow F(\omega) \longrightarrow \sigma(\omega)
$$

EFFECTIVE INTERACTION THEORY

Problem: Solve $\widehat{H}\,|\Psi\rangle = E\,|\Psi\rangle$ for an A-body system with $\widehat{H} = \widehat{T} + \widehat{V}$ expanding $|\Psi\rangle$ on a finite set P of basis functions $|\Phi_i\rangle$.

Purpose: Define an effective interaction that, acting in a truncated model space reproduces the true energy spectrum.

LEE-SUZUKI APPROACH

1. Similarity transformation $X = e^{\omega}$

$$\widetilde{H} = X^{-1}\widehat{H}X = \widehat{P}\widetilde{H}\widehat{P} + \widehat{P}\widetilde{H}\widehat{Q} + \widehat{Q}\widetilde{H}\widehat{P} + \widehat{Q}\widetilde{H}\widehat{Q}$$

2. Decoupling condition

$$\widehat{Q}\widetilde{H}\widehat{P} = \widehat{Q}\left(X^{-1}\widehat{H}X\right)\widehat{P} = 0$$

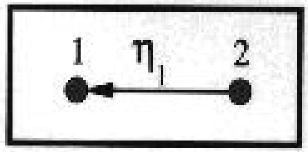
3. Effective interaction

$$\widehat{H}_{eff} = \widehat{P}\widetilde{H}\widehat{P} = \widehat{P}\left(X^{-1}\widehat{H}X\right)\widehat{P}$$

HYPERSPHERICAL FORMALISM

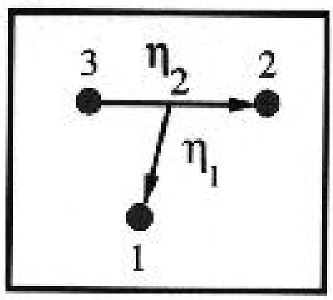
It is used for the expansion of an A body internal wave function.

A=2



$$\eta_1 \to \rho_1, \theta_1, \phi_1$$
$$\Delta_{(1)} = \Delta_{\rho_1} - \frac{1}{\rho_1^2}\hat{\ell}_1^2$$

A=3



$$\eta_1 = \rho_1 = \rho_2 \cos\varphi_2$$
$$\eta_2 = \rho_2 \sin\varphi_2 \eta_1$$
$$\eta_1, \eta_2 \to \rho_2, \underbrace{\varphi_2, \theta_1, \phi_1, \theta_2, \phi_2}_{\hat{\Omega}_2}$$
$$\Delta_{(2)} = \Delta_{\rho_2} - \frac{1}{\rho_2^2}\hat{K}_2^2$$

In General

$$\eta_1, \eta_2, \cdots, \eta_{A-1} \to \rho, \hat{\Omega}$$
$$H = \Delta_\rho^2 - \frac{\hat{K}^2}{\rho^2} + \sum_{i<j}^{A} \hat{V}_{ij}\left(\rho, \hat{\Omega}\right)$$

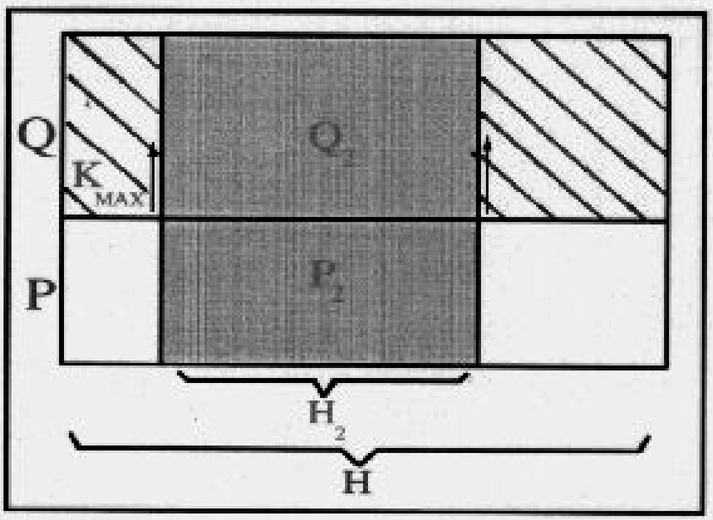
The HH are eigenfunctions of the hyperspherical angular momentum $\hat{K}^2$.

EIHH METHOD

$$H = \Delta_\rho^2 - \frac{\hat{K}^2}{\rho^2} + V_{12}\left(\rho, \hat{\Omega}\right) + \cdots + V_{AA-1}\left(\rho, \hat{\Omega}\right)$$

$$H^{(2)}(\rho) = \Delta_\rho^2 - \frac{\hat{K}^2}{\rho^2} + V_{AA-1}\left(\rho, \hat{\Omega}\right)$$

$$H^{(2)}(\rho) \xrightarrow{L.S.} H_{eff}^{(2)}(\rho) \longrightarrow V_{eff}^{(2)}(\rho) = H_{eff}^{(2)}(\rho) - \frac{\hat{K}^2}{\rho^2}$$



In the limit of $K_{MAX} \to \infty$ one has $V_{eff}^{(2)} \to V$ $\Rightarrow$ the solution is exact when convergence is reached

ADVANTAGES OF EIHH

- ρ is a collective coordinate

- $\hat{K}^2$ depends on the angular momenta of the residual $A-2$ system

$\Rightarrow$medium correction $\Rightarrow$faster convergence.

POTENTIAL

In the two-body hyperspherical Hamiltonian

$$V_{AA-1}\left(\rho, \hat{\Omega}\right)$$

we use a semirealistic potential:

- Minnesota

- Malfliet Tjon

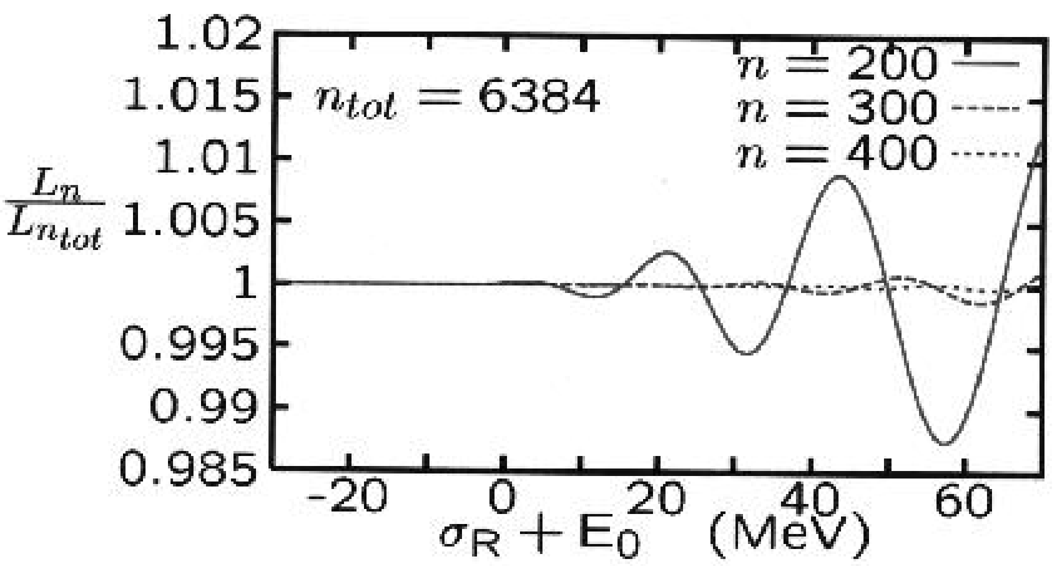
CALCULATION OF THE LIT WITH THE LANCZOS ALGORITHM

Recursive definition of the Lanczos vectors

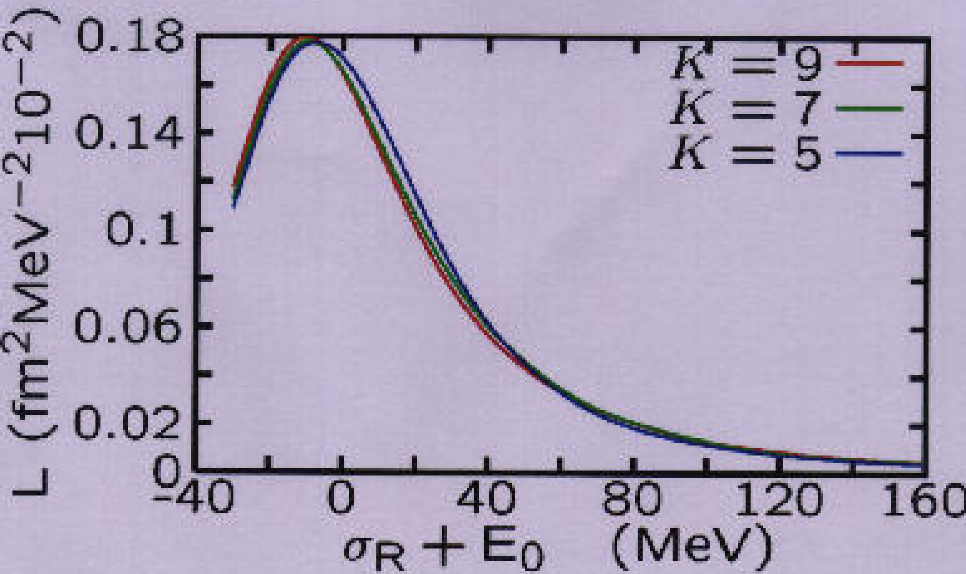
$$b_{n+1} \left|\phi_{n+1}\right\rangle = \widehat{H} \left|\phi_n\right\rangle - a_n \left|\phi_n\right\rangle - b_n \left|\phi_{n-1}\right\rangle$$

The Lorentz integral transform can be written as a function of the Lanczos' coefficients

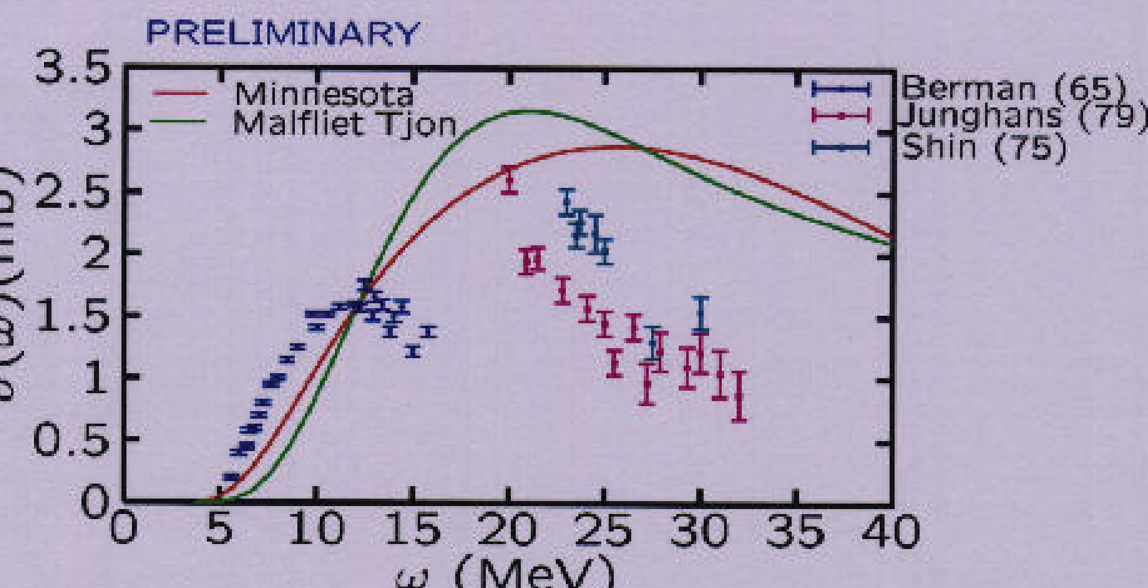
$$L(\sigma) = \frac{1}{\sigma_I} Im \frac{\langle\psi_0| \widehat{D}_z^\dagger \widehat{D}_z |\psi_0\rangle}{(z - a_0) - \frac{b_1^2}{(z-a_1) - \frac{b_2^2}{(z-a_2) - b_3^2 \cdots}}}$$



LIT RESULTS FOR ^6Li

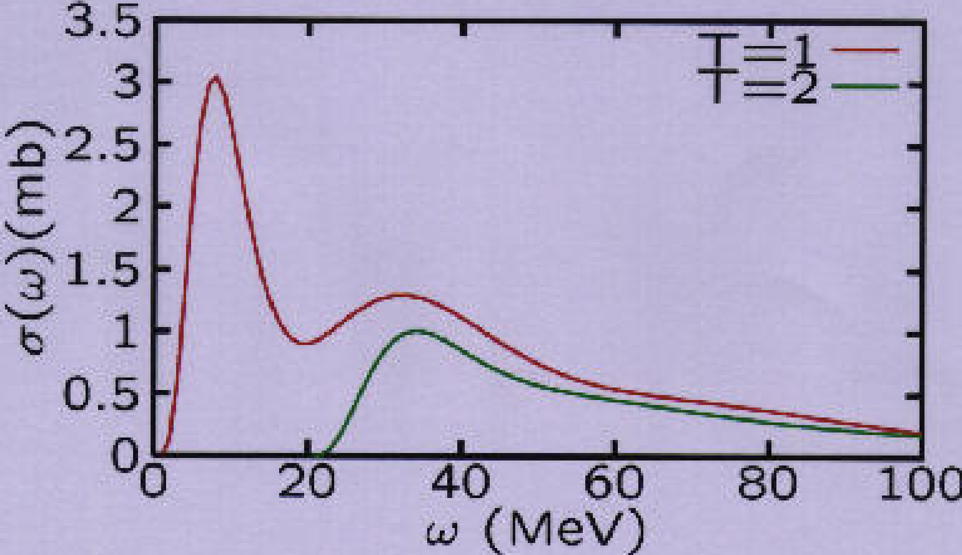


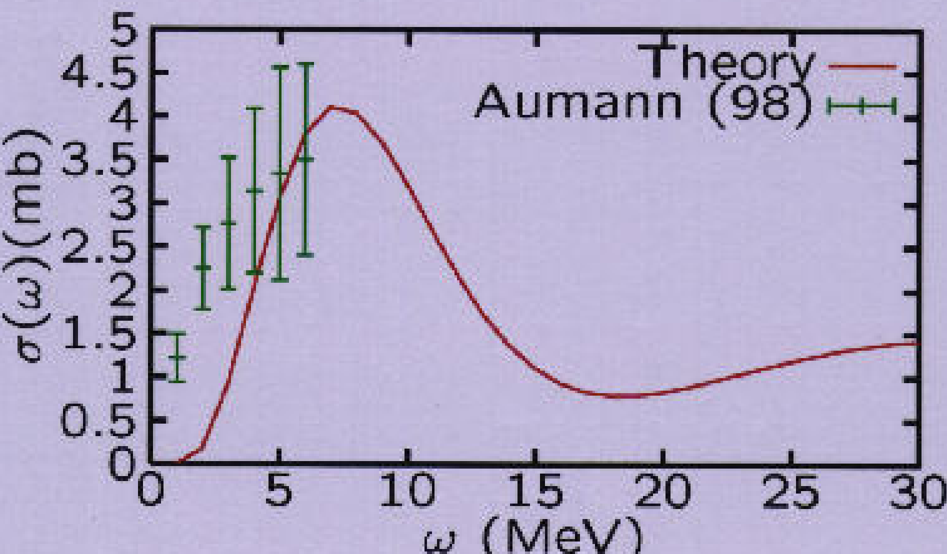
CROSS SECTION FOR ^6Li



CROSS SECTION FOR ^6He

Minnesota





CONCLUSIONS

- We are presenting the first microscopic calculation of inelastic reactions of $A = 6$ nuclei with the full final state interaction

- The LIT and EIHH are two very powerful techniques for an AB INITIO calculation with $A > 4$

FUTURE PERSPECTIVES

- The convergence has to be improved (parallelization of the code)

- Use of more realistic potentials

- Applications with virtual photons

- Study of even larger systems

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