Benchmark calculation of inclusive responses in the four-body nuclear system

S. Quaglioni[1], I. Stetcu[1], S. Bacca[2], N. Barnea[3], B.R. Barrett[1], Petr Navrátil[4], Calvin W. Johnson[5], Winfried Leidemann[6], and Giuseppina Orlandini[6]

[1] *Department of Physics, University of Arizona, P.O. Box 210081, Tucson, Arizona 85721, (sofia@physics.arizona.edu).*
[2] *Gesellschaft für Schwerionenforschung, Planckstr. 1, 64291 Darmstadt, Germany.*
[3] *Racah Institute of Physics, Hebrew University, 91904, Jerusalem, Israel.*
[4] *Lawrence Livermore National Laboratory, Livermore, P.O. Box 808, California 94551.*
[5] *Physics Department, San Diego State University, 5500 Campanile Drive, San Diego, California 92182-1233.*
[6] *Dipartimento di Fisica, Università di Trento and INFN (Gruppo Collegato di Trento), via Sommarive 14, I-38050 Povo, Italy.*

New approaches will allow in the near future a more consistent treatment of both structure and reactions within an *ab initio* framework. In this context, the application of the Lorentz integral transform (LIT) method [1] for the description of electromagnetic processes will be described. This technique allows one to rigorously evaluate reaction observables, reducing the continuum problem to a bound−state problem. Therefore, a fully microscopic treatment of the dynamics in both the initial and final states can be reached through the use of bound−state techniques. The recent results of a benchmark calculation for the ^{4}He response functions to two external excitations, different in isospin nature and range, by means of the LIT method, within both the no−core shell model (NCSM) [2] and the effective interaction hyperspherical harmonic (EIHH) [3] expansion techniques will be presented. The aim of this study has been to investigate the reliability of the NCSM approach to the description of inclusive response functions via the LIT method. For the NN interaction, we have used the Minnesota potential model [4]. The obtained EIHH and NCSM ^{4}He response functions for the isovector dipole and isoscalar quadrupole transitions, respectively, will be given. We will also show that the NSCM can be successfully applied to the solutions of the bound−state equations required by the LIT method. However, due to differencies in the asymptotics of the wave functions and in the strength distribution in the continuum achieved with the harmonic oscillator (HO) and hyperspherical harmonic expansions, the practical implementation of the method, especially concerning the problems of convergence, might lead to difficulties. In particular, to ensure a small numerical uncertainty in the response function, obtained by numerical inversion [5], one has to achieve a very good accuracy in the calculation of the LIT. Consequently, it is necessary to find a range of HO frequencies $\hbar\Omega$, for which both the ground and the excited states of the system present good convergence properties. The actual choice of $\hbar\Omega$ depends on both the nucleus under consideration and the range of the transition operator. For ^{4}He we find that frequencies in the range $12\ \mathrm{Mev} \leq \hbar\Omega \leq 28\ \mathrm{MeV}$ have the required characteristics for both the isovector dipole and isoscalar quadrupole excitations.

S.Q., I.S., and B.R.B acknowledge partial support by NFS grants PHY0070858 and PHY0244389. The work was performed in part under the auspices of the U. S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W−7405−Eng−48. P.N. received support from LDRD contract 04−ERD−058. W.L. and G.O. acknowledge support by the grant COFIN03 of the Italian Ministry of University and Research. N.B. acknowledges support by the Israel Science Foundation (Grant No. 202/02). C.W.J. acknowledges USDOE grant No.DE−FG02−03ER41272.

[1] V.D. Efros, W. Leidemann, and G. Orlandini, Phys. Lett. **B338**, 130 (1994);
[2] P. Navrátil and B.R. Barrett, Phys. Rev. **C54**, 2986 (1996); Phys. Rev. **C57**, 562 (1998);
[3] N. Barnea, W. Leidemann, and G. Orlandini, Phys. Rev. **C61**, 054001 (2000); Phys. Rev. **C67**, 054003 (2003);
[4] D.R. Thomson, M. LeMere, and Y.C. Tang, Nucl. Phys. **A286**, 53 (1977);
[5] V.D. Efros, W. Leidemann, and G. Orlandini, Few. Body. Syst. **26**, 251 (1999); D. Andreasi, W. Leidemann, C. Reiß, and M. Schwamb, Eur. Phys. J **A24**, 361 (2005).