APH N.S., Heavy Ion Physics 18/2–4 (2003) 155–156

HEAVY ION PHYSICS
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Breakup and Electromagnetic Response of Light Weakly-Bound Dicluster Systems

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Received 10 January 2003

Abstract. This study is focused on the breakup and electromagnetic response of light weakly-bound dicluster nuclei. The cluster picture in the case of ^{7}Li is shown to be a very good approximation and in this framework we calculate nuclear structure observables. We solve the Schrödinger equation for the relative motion both for discrete and continuum states and this automatically takes the role of resonances into proper account. A concentration of strength in the low energy continuum, solely due to the weakly-bound nature of the bound states is seen and explained as a favorable matching between the wavelengths of the initial and final states. Finally, preliminary results on form factors are briefly outlined and their microscopic derivation as well as utilization in reaction studies are discussed.

Keywords: nuclear clusters, breakup
PACS: 21.60.Gx, 25.60.Gc

1. Discussion of Model

We adhere to the description of ^{7}Li as a dicluster system formed by an α plus a t. It was shown by many authors [1] that this way of treating the system gives a good description of the properties of the nucleus under study. We solved the Schrödinger equation for the relative motion of the two clusters (considered as frozen spherical distributions of charge and mass). Both Coulomb and nuclear interactions have been included, the former being corrected at small distances for the finite extension of the charge distributions, the latter having a common Woods–Saxon shape whose depth has been adjusted in each case to give the correct energy for both bound and resonant states in the continuum. This provides both resonant and non-resonant strengths. The wavefunctions that we have found differ slightly from the ones obtained within the RGM method, having, however, very similar spatial extensions. The calculated charge and matter radii, electric and matter quadrupole intrinsic moments are found to be in good agreement with the experimental data.

1219-7580/03/ $ 20.00

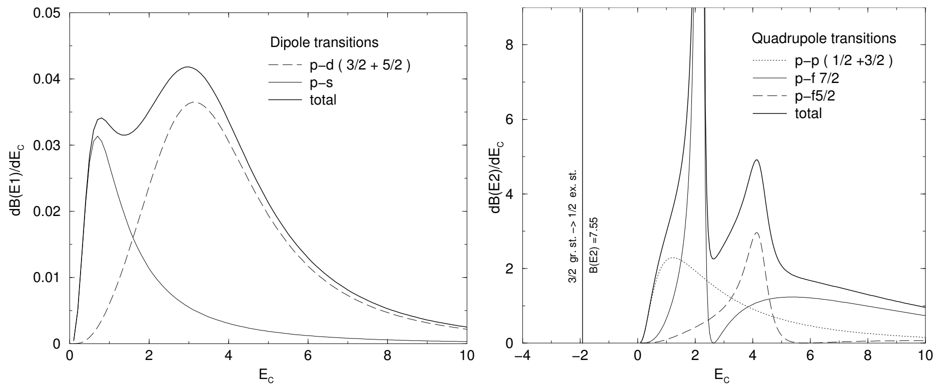

Fig. 1. Electric dipole and quadrupole response (differential reduced transition probability with respect to energy in the continuum). Energies are in MeV, the zero being the threshold for breakup, while the vertical scale is in $e^2\mathrm{fm}^{2L}$/MeV.

2. Results

We calculated the transition from the $3/2^-$ ground state to the $1/2^-$ excited bound state obtaining $B(\mathrm{E2}) = 7.55\ e^2\mathrm{fm}^4$ and $B(\mathrm{M1}) = 2.45\ \mu^2$, both very close to the measured values [2, 3]. The results for dipole and quadrupole transitions to the continuum are displayed in Fig. 1. In addition to the resonant quadrupole strength associated with the f-states, a concentration of strength at low energy is clearly seen. It has the same nature as in [4, 5] where it is explained as due to a favorable matching between the wavelengths of the initial weakly-bound wavefunction and of the final one in the continuum.

Concerning reaction studies the microscopic derivation of form factors has been done with a twofold aim: to elucidate the dependence on the distance of two interacting ions and on the energy in the continuum, and to set the relevance of the nuclear breakup that is found to be dominant still at 14 fm (about the double of the sum of radii in a reaction with a heavy target). The study of such reactions is currently under investigation.

Acknowledgements

I am particularly indebted to Andrea Vitturi for sharing his ideas with me, intuitions and computer codes and for the patience which he had constantly shown towards me. This work and the participation in the Symposium have been both supported by INFN and Dip. di Fisica di Padova.

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