Electromagnetic Processes in Proton-rich Systems: an Analytical Approach

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The field of interest for nuclear astrophysicists and halo physicists converge at several locations along the proton dripline. Stellar evolution involves sequences of direct and resonant capture reactions. Usually, the direct, radiative capture reactions of astrophysical interest involve systems where the binding energy of the captured proton is small. The structure of these loosely bound systems is interesting in itself but it would also be very appealing to be able to give estimates for the rates of these reactions.

To this aim, we propose a model wave function for loosely bound two–body systems having the correct large–, as well as, small–distance asymptotic behavior. Coulomb scattering waves are used for the final state. We are, using this model, able to calculate several transition matrix elements analytically, and thus, investigate how the strength function, and other observables, are influenced by the structure of the ground state. In the first stage of this work we have studied the electromagnetic dissociation reaction. Using the method of virtual quanta [1], this process can be considered as photodissociation which is related to the radiative capture reaction via detailed balance.

The prime case of loosely bound proton systems is the ^{8}B nucleus and this will be our first example. Studies of the ^{8}B electromagnetic dissociation process are important both in connection with the boron solar neutrino problem [2] and when estimating the spectroscopic factors of the ^{8}B ground state [3]. We start testing our model by comparing with numerical results obtained using the three–body wave function of L. Grigorenko *et al.* [4]. Our investigations then show that, for energies above ∼0.5 MeV, the E1 transition matrix element is almost insensitive to the Whittaker tail of the wave function, and thus almost independent of the binding energy. We therefore conclude that the spectroscopic factor of the excited–core configuration is only weakly reflected in the E1 strength function at energies above 0.5 MeV. We have also investigated the influence of the nuclear radius, for which we have found a strong sensitivity both in the strength function and in the total cross section.

References

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