Ground state properties of exotic nuclei in deformed medium mass region

Manju[1],* Jagjit Singh[2], Shubhchintak[3], and R. Chatterjee[1]
[1]*Department of Physics, Indian Institute of Technology Roorkee, Uttarakhand- 247667, India*
[2]*Nuclear Reaction Data Centre, Faculty of Science, Hokkaido University, Sapporo 060-0810, Japan and*
[3]*Department of Physics and Astronomy, Texas A&M University-Commerce, Commerce, Texas 75429, USA*

Introduction

With the development of technology it is now possible to study nuclei far from the β-stable region. In this region, one can encounter weakly bound nuclei having very low separation energies (of order of $\approx$ 1MeV or less [1]). One also sees an interesting phenomenon - that of neutron halo formation, in this region [1]. The formation of these haloes takes place due to the tunneling of weakly bound nucleon through the potential well. Electromagnetic dissociation is one of the most widely used methods to study these exotic systems. Electromagnetic dissociation of halo nuclei provides invaluable information about their structure and multipole responses. The dissociation cross section is related to the electromagnetic strength $B(E\lambda)$ and this strength has information about the structure of the projectile ground state [2]. The previous studies [3, 4] also show that the Coulomb breakup cross sections are dominated by electric dipole *B(E1)* strengths. Earlier [3, 4] one has studied the scaling phenomenon in these halo nuclei lying in the low mass region. In Ref. [3] authors shows the peak position of the relative energy spectra can be simply used to estimate the one neutron separation energy of the projectile.
So far lots of work have been done with the nuclei lying in low mass region. It would therefore be interesting to extend this to understand the behavior of nuclei lying in the medium mass region. In this contribution we propose to study simple scaling properties in the breakup of exotic medium mass deformed nuclei like ^{31}Ne and ^{37}Mg.

*Electronic address: `manju.dph2014@iitr.ac.in`

Formalism

We consider the Schrödinger equation which contains the deformed Woods-Saxon potential. The coupled channel equation with the radial wave function for the deformed potential can be written as,

$$\left(\frac{d^2}{dr^2} - \frac{\ell(\ell+1)}{r^2} + \frac{2\mu}{\hbar^2}[\varepsilon_m - V_{ws}(r)]\right)u_{\ell jm} = \frac{2\mu}{\hbar^2}\sum_{\ell' j'}\langle \mathbf{Y}_{\ell jm}|V_{cc}|\mathbf{Y}_{\ell' j' m}\rangle u_{\ell' j' m}, \quad (1)$$

where, V_{ws} represents the spherical part of the Woods-Saxon potential and spin-orbit strength and V_{cc} shows the deformed part of the Woods-Saxon potential which contains coupling terms. In Eq. (1) we have included only the lowest order deformation (quadrupole deformation, β_2) in the Woods-Saxon potential.
On solving, Eq. (1) gives us the deformed bound wave function, $\phi_b(= u_{\ell jm})$. With this wave function we can calculate the electric dipole strength.
The dipole strength distribution for transition from bound state $\phi_b(r)$ with separation energy S_n to a continuum state $\phi_c(E_c,\mathrm{r})$ with continuum energy E_c is given by,

$$\frac{dB(E1)}{dE} = (3/4\pi)(Z_{eff}e)^2\langle \ell 010|\ell' 0\rangle^2 \times \left|\int \mathrm{d}r\ \phi_b(r)\ \phi_c(E_c,r)r^3\right|^2, \quad (2)$$

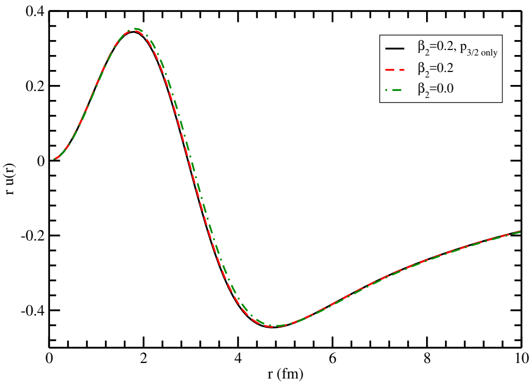

FIG. 1: Wave function for different deformations (β_2) for ^{31}Ne.

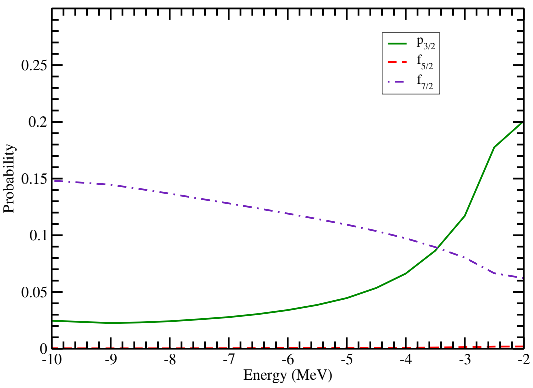

FIG. 2: Probabilities of $p_{3/2}$, $f_{5/2}$ and $f_{7/2}$ as a function of energy.

where, Z_{eff} is the effective charge [4].
We shall use Eq. (2) to study various scaling relations in the breakup of medium mass exotic nuclei. Initial efforts in this direction can be found in Refs.[3, 4]

Results and discussion

As a preliminary case, we have calculated the deformed wave function for ^{31}Ne. Fig. 1, shows the deformed wave function of ^{31}Ne at $\beta_2 = 0.0$ and 0.2. Separation energy S_n, for $2p_{3/2}$ state is taken to be -0.29 MeV. The solid line corresponds to the case when $\beta_2 = 0.2$, and in this case only $\ell = 1$ and $j = 3/2$ component is included. The dashed line represents the wave function for $\beta_2 = 0.2$, where all the components corresponding to $\ell = 1, 3$ and 5 with all the allowed j values included. The dotted-dashed line with $\beta_2 = 0.0$ shows the wave function at zero deformation.
Fig. 2 shows the plot of probability with energy for different configurations $p_{3/2}$, $f_{5/2}$, $f_{7/2}$ keeping all the parameters fixed. We have made a preliminary comparison of our result with one of Ref. [5] results which confirms the validity of our deformed wave function.
We will present the dipole moment, size of the nucleus and other ground state properties of deformed nuclei ^{37}Mg and ^{31}Ne.
Furthermore with this deformed wave function we will calculate the electric dipole strength distribution for deformed nuclei ^{37}Mg and ^{31}Ne.
This will allow us to investigate the two-dimensional scaling phenomenon with two parameters: quadrupole deformation and separation energy.

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