Study of Ground-state configuration of neutron-rich Aluminium isotopes through Electromagnetic excitation

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Introduction

The region of the nuclear chart around neutron magic number, $N{\sim}20$ and proton number (Z), $10 \leq Z \leq 12$ is known as the *"Island of Inversion"*. The valance neutron(s) of these nuclei, even in their ground state, are most likely occupying the upper *pf* orbitals which are normally lying above *sd* orbitals, N∼20 shell closure. Nuclei like ^{34,35}Al are lying at the boundary of this *"Island of Inversion"*. Little experimental information about their ground state configuration are available in literature [1]. Gamma-ray spectroscopy after Coulomb breakup is a direct probe for studying ground state configuration of loosely bound nuclei [2]. Recently, an experiment (S306) has been performed [3] at GSI, Darmstadt using LAND-FRS setup to explore the neutron-rich exotic nuclei in and around N∼20 *"Island of Inversion"*. In this article, we shall report the preliminary results about the predominant ground state configuration of ^{34,35}Al.

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Experiment and method of analysis

Short-lived radioactive nuclei were produced by the fragmentation of pulsed ^{40}Ar beam (at 531 MeV/u) on ^{8}Be (8gm/cm^2) production target at fragment separator (FRS). Secondary beam from FRS, containing ^{34,35}Al bombarded on various reaction targets at Cave C. The reaction target was surrounded by the exclusive LAND-ALADIN setup for kinematically complete measurement. Coulomb dissociation of the projectile was studied using ^{208}Pb target (2 gm/cm^2). The nuclear contribution in the above reaction was estimated using ^{6}C target (935 mg/cm^2). Data analysis is being performed using CERN-ROOT platform and *land02* framework with modification from SINP group. The incoming beam was identified uniquely by energy loss and ToF measurements before the reaction target along with the known magnetic rigidities of FRS(Fig. 1). Neutrons and

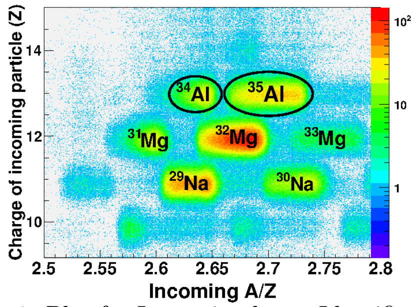

FIG. 1: Plot for In-coming beam Identification.

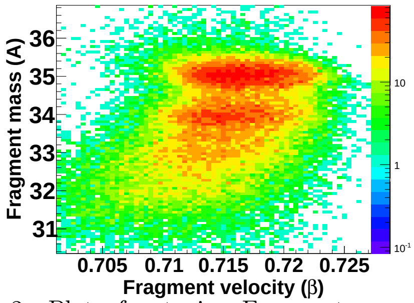

FIG. 2: Plot of outgoing Fragment mass of Al isotopes Vs fragment velocity.

γ-rays from the de-exciting projectile or projectile like fragments were detected by the LAND and the 4π-Crystal Ball spectrometer, respectively. Reaction fragments were tracked via the Silicon Strip Trackers and GFI detectors placed before and after the magnetic spectrometer (ALADIN), respectively. Finally, mass of the outgoing fragments were identified by reconstructing the magnetic rigidities inside ALADIN and velocity measurements of the reaction fragments (Fig. 2). All the γ-rays detected by the 4-π crystal ball detector in the laboratory frame were subjected to Doppler correction resulting in the reconstructed energy in the rest frame. ^{33}Al reaction fragments were obtained after Coulomb break-up of ^{34}Al. Fig. 3 shows the Doppler corrected γ-sum spectrum of ^{33}Al obtained in coincidence with the fragment and the one neutron. These observed γ-lines are in agreement with the characteristic γ-rays of ^{33}Al reported in Ref. [4]. By measuring the four-momenta of all the decay products, the excitation energy E^* of the nucleus prior to decay can be reconstructed on an event-by-event basis by analysing the invariant mass.

Results and Discussion

The ground state configuration of ^{34}Al (N=21) isotope is more complicated as it is evident from gamma-ray spectra of ^{33}Al obtained after Coulomb breakup of ^{34}Al. On the other hand no γ-rays have been observed corresponding to ^{34}Al after Coulomb breakup of ^{35}Al. Preliminary invariant mass analysis of ^{35}Al (N=22) and comparison with direct breakup model calculation shows the dominance of *p-wave* in the single particle wave function of the valance neutron.

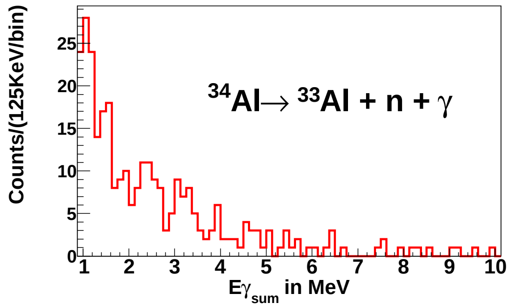

FIG. 3: Doppler corrected γ-sum spectra of ^{33}Al obtained after Coulomb breakup of ^{34}Al in ^{208}Pb target.

TABLE I: Preliminary ground state configuration of ^{35} Al.

Nuclei	Ground state configuration from this experiment
^{35}Al	^{34}Al(gr.) $\otimes$ ν p$_{3/2}$

However, using similar technique it has been observed that the valence neutron of the ground state of neutron-rich Na isotopes (N=18,19) occupy $s_{1/2}$ orbital [5].

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