Structure of neutron-rich N=126 closed shell nuclei

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Abstract.

A series of experiments devoted to the study of the neutron-rich $N \sim 126$ region have been performed at GSI, Darmstadt, within the Rare Isotopes Investigations at GSI (RISING) project. The highlights of the experimental results from these highly successful experiments include the first observation of excited states in three neutron-rich $N=126$ closed shell nuclei: (i) In $^{205}\text{Au}_{79}$ the conversion electron decay of the $\pi h_{11/2}^{-1}$ seconds lived isomeric state into the $\pi d_{3/2}^{-1}$ ground-state has been observed. In addition the yrast structure has been established up to spin-parity $(19/2^+)$ via the observation of the decay of an isomeric state with configuration $\pi(h_{11/2}^{-1})_{10}(s_{1/2}^{-1})$; (ii) In $^{204}\text{Pt}_{78}$, the yrast sequence has been observed following the internal decay of $I^\pi=(5^-)$, (7^-) and (10^+) isomeric states; (iii) In $^{203}\text{Ir}_{77}$ excited states have been observed following the decay of an isomeric state with structure 'similar' to that in its ^{205}Au isotope. Shell model calculations have been performed in order to get a deeper understanding of the structure of these $N=126$ nuclei. It was found that in order to get a good description for all available information on the $N=126$ isotones below lead, both on excitation energies and transition strengths, small modifications of the standard two-body matrix elements were required.

INTRODUCTION

Studies of the structure of single magic nuclei are of fundamental importance in our understanding of nuclear structure since they allow direct tests of the purity of shell model wave functions. Information on the single-particle energies and two-body residual interactions can be derived from the experimental observables such as energies of the excited states and transition probabilities.

The doubly magic ^{208}Pb nucleus, with 82 protons and 126 neutrons, provides the heaviest classic shell model core. Experimental information on the neutron-rich, $N = 126$ nuclei is very scarce. Prior to our investigations, information has been obtained on excited states for only two isotones with $Z < 82$: ^{207}Tl [1] and ^{206}Hg [2]. In the case of ^{205}Au only the ground state was known [3].

¹ for the RISING collaboration

FIGURE 1. Identification plot showing the H-like nuclei arriving to the final focal plane of the fragment separator. This setting was optimised for the transmission of fully-stripped ^{199}Os ions.

FIGURE 2. Experimental and calculated partial level schemes of the $N = 126$ ^{204}Pt [7] and ^{206}Hg [2] nuclei. Arrow widths denote relative intensities of parallel decay branches. The dominant state configurations are indicated. (a) and (d) are calculations using the Rydsrtöm matrix elements, while (b) and (c) are with the modified ones, as described in the text.

EXPERIMENTAL TECHNIQUE

A number of experiments were performed with the aim to study the structure of $N=126$ nuclei. The nuclei of interest were populated via relativistic energy projectile fragmentation of a ^{208}Pb beam. The SIS-18 accelerator at GSI provided the primary beams at $E/A = 1$ GeV. The nuclei of interest were selected and identified in flight by the FRagment Separator (FRS) [4]. The identified ions were implanted in a stopper, positioned at

FIGURE 3. Experimental (middle) and calculated level schemes of ^{205}Au . Calculations using the Rydsröm matrix elements are shown on the left, while calculations with the modified TBMEs are on the right hand side.

FIGURE 4. Same as figure 3, but for ^{203}Ir . The experimental level scheme is preliminary.

the final focal plane of the FRS. Both passive and active stopper were used. A passive stopper was employed in internal isomeric decay studies. A passive, Silicon based stopper [5] was used in the case of charged-particle decays (in our case: conversion electron decay). The stopper was surrounded by the RISING array in the “Stopped Beam” config-

uration [6]. For details on the experimental setup, identification procedure and analysis see [7, 8, 9, 10].

RESULTS

An identification plot showing the H-like nuclei arriving to final focal plane of the fragment separator is shown in figure 1.

Isomeric decays were observed in three N=126 nuclei: ^{205}Au [8, 9, 10], ^{204}Pt [7], ^{203}Ir [8]. The nature of the isomeric states are explained in the abstract.

In order to obtain a quantitative understanding of the underlying single-particle structure of the excited states of the observed N=126 nuclei, shell-model calculations have been performed employing the OXBASH code [11]. The standard interaction two-body matrix elements (TBMEs) were used as taken from ref. [12]. The proton-hole energies were taken from the experimental level scheme of ^{207}Tl [1].

In order to get a good description for ^{204}Pt and ^{206}Hg , both on excitation energies and transition strengths, small modifications of the standard TBMEs were required [7]. Calculations with these modified matrix elements were also performed.

The experimental level schemes are compared with those from the shell-model calculations in figures 2-4.

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