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In-beam gamma-ray spectroscopy of ^{254}No

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Abstract. The recoil-tagging technique has been employed to perform an in-beam gamma-ray spectroscopic study of the transfermium nucleus ^{254}No. The experiment was carried out at the Department of Physics of the University of Jyväskylä and utilised the JUROGAM array of germanium detectors coupled to the gas-filled recoil separator RITU. The ground-state rotational band was extended and evidence for non-yrast states was observed for the first time.

PACS. 21.10.-k Properties of nuclei; nuclear energy levels – 23.20.-g Electromagnetic transitions – 29.30.-h Spectrometers and spectroscopic techniques

1 Introduction

Knowledge of the structure of very heavy elements is essential for the testing and development of mean-field theories describing the properties of the heaviest nuclei. Important input comes from the study of transfermium nuclei, the heaviest systems for which high-spin data is experimentally accessible. An important isotope in this region is ^{254}No, the ground-state band of which has been studied previously [1].

Recent developments in spectrometer and data acquisition techniques at the Accelerator Laboratory of the University of Jyväskylä (JYFL) have made the study of these transfermium nuclei possible. A new in-beam gamma-ray spectroscopic study of ^{254}No has been performed in an attempt to improve upon previously obtained results.

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2 Experimental details

The fusion-evaporation reaction $^{208}\mathrm{Pb}(^{48}\mathrm{Ca}, 2\mathrm{n})^{254}\mathrm{No}$ was employed. Prompt gamma-rays were detected at the target position with the JUROGAM Ge-array consisting of 43 Compton-suppressed HPGe-detectors.

To select the gamma-rays of interest from the high fission background the recoil-tagging technique was employed [2,3]. Fusion-evaporation residues were separated from primary beam and fission products with the gas-filled recoil separator RITU [4]. They were implanted into the DSSDs ($2 \times 60 \times 40$ strips) of the GREAT detector system [5] which has a MWPC placed upstream allowing discrimination between recoils and decay products. Selecting those gamma-rays detected at the target position in coincidence with an implanted recoil led to effective suppression of the fission background. The detector signals were handled by the new TDR (Total Data Readout) data-acquisition system [6]. This is a triggerless system, providing a time-ordered stream of data timestamped with a precision of 10 ns. Event-building is done in software and for both online and offline analysis the software-package Grain [7] was used.

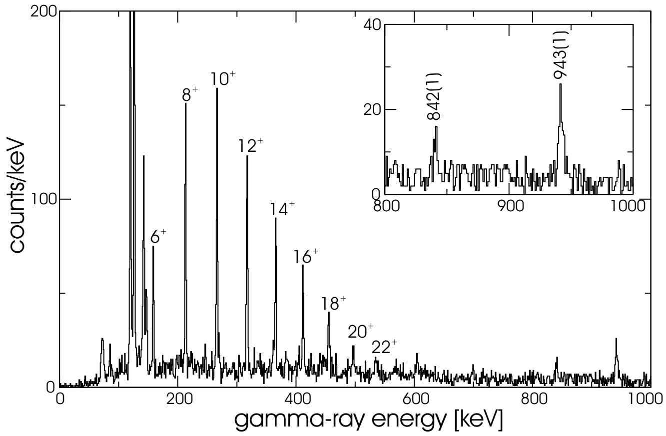

Fig. 1. Recoil-gated gamma-ray spectrum of ^{254}No with the rotational ground-state band transitions labeled with spin assignments. The inset shows an enlarged part of the spectrum with the two prominent non-yrast high-energy lines.

Table 1. Energies and intensities of ground-state band transitions.

Transition	Energy (keV)	Transition	Energy (keV)
$2^+ \to 0^+$	44(1)	$14^+ \to 12^+$	366.6(2)
$4^+ \to 2^+$	102(1)	$16^+ \to 14^+$	412.7(2)
$6^+ \to 4^+$	159.5(2)	$18^+ \to 16^+$	456.0(3)
$8^+ \to 6^+$	214.1(1)	$20^+ \to 18^+$	498(1)
$10^+ \to 8^+$	267.3(1)	$22^+ \to 20^+$	536(1)
$12^+ \to 10^+$	318.1(2)		

3 Results and discussion

A recoil-gated gamma-ray spectrum is shown in fig. 1. The absence of competing evaporation channels together with the selective recoil-tagging technique allowed the γ-rays of interest to be unambiguously assigned to ^{254}No.

The members of the ground-state rotational band are clearly visible and marked with spin assignments. Studying $\gamma\gamma$-coincidences and assuming $E2$-multipolarity, the band previously established [1] could be confirmed up to spin 20 and extended up to spin 22. Energies of the ground-state band transitions are listed in table 1. The lowest two transitions were not observed, which was attributed to strong internal conversion, but can be extrapolated from a Harris fit to the band. The energy of the 4^+ to 2^+ transition (101(1) keV) was recently confirmed in a conversion electron spectroscopy measurement [8].

The dynamical moment of inertia for the ground-state band is plotted in fig. 2 and compared with neighbouring nuclei. In contrast to ^{252}No, the $\mathcal{J}$ (2) behaviour of ^{254}No is very smooth and no upbend is observed.

Between the main peaks non-yrast transitions are visible but the lack of statistics prevented placement into the level scheme. More prominent signs of non-yrast structure can be seen at higher energy (see fig. 1 and inset therein) where two relatively intense peaks are observed at 842(1) keV and 943(1) keV. The energy difference of these prominent high-energy lines matches the 4^+ to 2^+ ground-state band transition energy of 101(1) keV. We therefore tentatively place a high-lying low-spin state as in fig. 3, decaying into the ground-state band via the two high-energy transitions mentioned above. This assumption is supported by the absence of clear coincidences with ground-state band transitions. The feeding of this level is assumed to go via highly converted transitions.

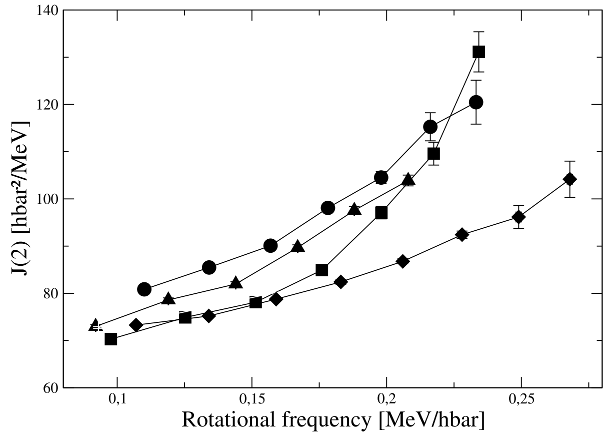

Fig. 2. Dynamical moment of inertia of the transfermium nuclei ^{254}No (diamonds), ^{250}Fm (triangles), ^{252}No (squares) and ^{251}Md (circles).

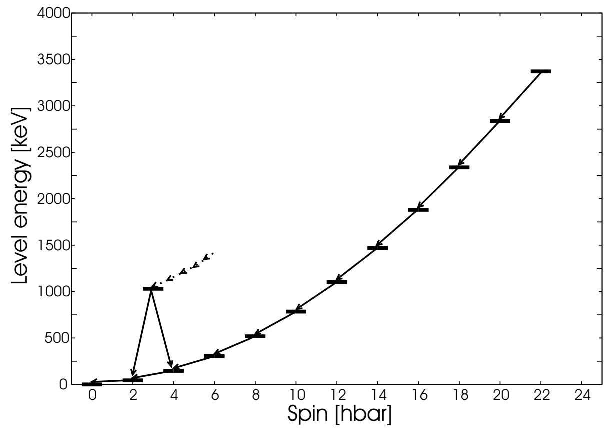

Fig. 3. Yrast plot of ground-state band with suggested positioning of high-energy lines. The assumed feeding pattern of the high-lying low-spin state is shown in dashed lines.

Similar high-lying low-spin states can be found in neighbouring nuclei. In particular, a level at similar excitation energy (906 keV) is found in the isotone ^{250}Cf [9] where it is a 3^- state and a member of a $K = 2$ octupole vibrational band. The absence of evidence in the ^{254}No spectrum of other states belonging to the octupole vibrational band cannot, however, be explained at present. In particular the $2^- \to 2^+$ transition is expected to be intense but cannot be distinguished in the spectra of ^{254}No. The interpretation of the possible high-lying low-spin state in ^{254}No therefore remains an open question.

With the setup used, previous results have been confirmed and some new transitions added. To significantly improve the knowledge of ^{254}No, a combination of in-beam conversion electron and gamma-ray spectroscopy is required.

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