μs isomers of ^{158,160}Nd[†]

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The doubly mid-shell nuclei of the mass number $A\sim160$ region are well known for undergoing a rapid increase in the deformation of their ground states when going from the neutron number N=88 to 90[1)]. From $N = 92$ onwards their quadrupole deformation is close to saturation and these nuclei possess well-deformed prolate ground-state rotational bands. Several of the $N = 98$ and 100 isotopes here are known to possess 2-qp isomeric states,[2–4)], one may therefore expect similar long-lived states to exist in ^{158,160}Nd, whose level schemes are unknown. The presence of isomeric states offers the opportunity to study the structure of nuclei via the use of delayed γ-ray spectroscopy of in-flight, mass-separated beams of fission fragments. The observation of K-isomers allows the position of single-particle Nilsson states to be mapped in regions dominated by collective structures, which is useful for testing the predictions of mean-field models. In the present work we have studied excited states in the nuclei ^{158,160}Nd via delayed γ-ray spectroscopy.

In-flight fission of a 345-MeV/nucleon ^{238}U beam was performed at RIBF. Ions including ^{158,160}Nd were selected using the BigRIPS spectrometer and implanted in the WAS3ABi stopper[5)], or a copper plate, situated at the F11 focal plane. The WAS3ABi stopper allowed detected β decays to be correlated with identified and implanted ions, whereas the use of a passive stopper allowed a higher ion implantation rate for isomer studies. The EURICA Ge array[5)] was used to detect any γ rays emitted following ion implantation at the BigRIPS focal plane. Use of ion–γ and ion–$\gamma-\gamma$ coincidences has allowed the first level schemes to be established for the nuclei ^{158,160}Nd. More details on the experiment can be found in Ref.[6)].

Delayed γ rays with energies of 151.7, 233.4 and 1197.1 keV were found to be in coincidence with ^{158}Nd ions. A delayed cascade proceeding by transitions with energies of 65.2, 149.9 and 892.8 keV was assigned to ^{160}Nd nuclei. The level schemes of ^{158,160}Nd constructed in the present work are shown in Fig. 1. The order of the decays was assigned from the level systematics in the neighboring nuclei Nd[2)]. The spins and parities of the isomers were assigned from their decay patterns and half-lives, as explained in Ref.[6)].

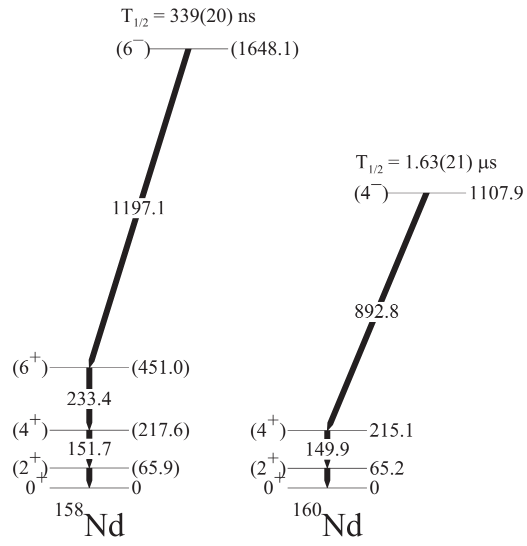

Fig. 1. Level schemes of ^{158,160}Nd obtained in the present work.

The configurations of the isomeric states of ^{158,160}Nd have been assigned with the aid of blocked-BCS (BBCS) calculations. These have allowed a $\nu5/2[523]\otimes\nu7/2[633]$ configuration to be assigned to the (6^-) isomer of ^{158}Nd and a $\nu1/2[521]\otimes\nu7/2[633]$ one to the (4^-) isomer of ^{160}Nd, the same as found in the stable ^{170}Yb[4)]. It is worth noting that one experimental decay scheme is incompatible with the results of projected shell-model[7)] and Hartree-Fock calculations[8)].

A peak appears in the r-process abundances around mass 160 and its origin remains unclear. Measurements of β-decay half-lives performed within the EURICA campaign at RIBF have shown variations in these values in the same region, which have a nuclear structure origin[9)]. Identification of further Nilsson states and analysis of the β-decay data gathered in the our experiment will help resolve these anomalies.

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References
1) R. Casten *et al.*, Phys. Rev. C **33**, 1819 (1986).
2) G. Simpson *et al.*, Phys. Rev. C **80**, 024304 (2009).
3) Z. Patel *et al.*, Phys. Lett. **B 753**, 182 (2016).
4) P. Walker *et al.*, Nucl. Phys. **A 365**, 61 (1981).
5) P.A. Söderström *et al.* Nucl. Instrum. Meth. Phys. Res. **B 317**, 649 (2013).
6) E. Ideguchi *et al.*, Phys. Rev. C. **94**, 064322 (2016).
7) Y.-C. Yang *et al.*, J. Phys. G **37**, 085110 (2010).
8) S.K. Ghouri *et al.*, Int. Mod. J. Phys. **21**, 1250070 (2012).
9) J. Wu *et al.*, Phys. Rev. Lett. **118**, 072701 (2017).