Halflives of Neutron Deficient Nuclei below ^{100}Sn ◇

E. Wefers, T. Faestermann, R. Schneider, A. Stolz, K. Sümmerer [a], J. Friese, H. Geissel [a], M. Hellström [b], P. Kienle, H.-J. Körner, M. Münch, G. Münzenberg [a], P. Thirolf, and H. Weick [a]
[a] GSI Darmstadt [b] University of Lund, Sweden

Neutron deficient nuclei near ^{100}Sn have been produced at the GSI, Darmstadt, by fragmentation of a 1 A·GeV ^{112}Sn beam in a beryllium target, separated in the FRS and identified with a new detector system [1]. The unambiguously identified ions were stopped in a highly segmented silicon detector stack [2]. We determined the halflives for each implanted isotope by using a maximum likelihood method [3].

Fig. 1 shows the measured isotopic yields for fragments from Strontium to Indium. The cross sections extracted from these yields are in good agreement with empirical predictions (EPAX [4]). The spectra show the previously unobserved $T_z = -1$ nuclei ^{76}Y (2 events) and ^{78}Zr (one event). Due to the excellent resolution of our identification detectors we can assign a 3σ confidence level to these observations. In addition fig. 1 demonstrates the absence of the $N = Z - 1$ nuclei ^{81}Nb, ^{85}Tc and ^{89}Rh, which are probably unstable against proton emission.

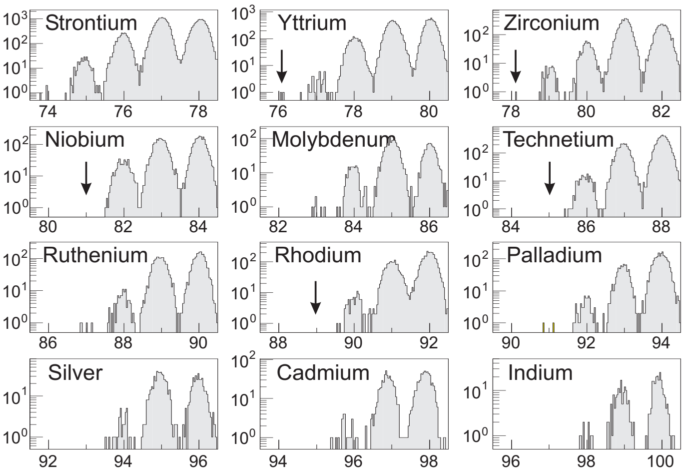

Fig. 1: Mass spectra of the observed ions between Sr and In. The arrows indicate the identification of ^{76}Y and ^{78}Zr and the absence of ^{81}Nb, ^{85}Tc and ^{89}Rh.

The identification of ^{76}Y and ^{77}Y coincides with recent predictions for the proton dripline [5], whereas ^{81}Nb and ^{85}Tc are not predicted to be dominantly proton emitters in that work using a relativistic Hartree-Bogoliubov model.

For the identified nuclides as well as for the unobserved ones we determined limits for their halflives resulting from their flight time through the FRS (table 1). Note that the failure to observe ^{89}Rh could also be due to the small cross section expected (50 pb) just at our detection limit. In order to improve our knowledge on the proton dripline we implanted the $N = Z - 1$ nuclei ^{75}Sr, ^{77}Y, ^{79}Zr and ^{83}Mo into the Si detector stack. The measured halflives, which are as short as expected for β-decays between mirror nuclei, are also listed in table 1. For ^{77}Y we collected 12 nuclei which decay all via β-decay, therefore a possible proton emission can only be a small branch.

	$T_{1/2}$		$T_{1/2}$		$T_{1/2}$
^{75}Sr	80^{+400}_{-40} ms	^{76}Y	> 170 ns	^{77}Y	57^{+22}_{-12} ms
^{78}Zr	> 170 ns	^{79}Zr	80^{+400}_{-40} ms	^{81}Nb	< 44 ns
^{83}Mo	6^{+30}_{-3} ms	^{85}Tc	< 110 ns		

Table 1: Halflives of $N < Z$ nuclei. For details see text.

An important nuclear physics input quantity for network calculations modelling the astrophysical rp-process are the halflives of the so-called waiting point nuclei. We measured the halflives of all these nuclei from ^{80}Zr up to ^{92,93}Pd. In addition we were able to determine halflives of several unknown Indium, Rhodium and Technetium isotopes near the $N = Z$-line without an extra magnetic setting of the FRS. These results are listed in table 2.

	$T_{1/2}$ [s]		$T_{1/2}$ [s]		$T_{1/2}$ [s]
^{80}Zr	$5.3^{+1.1}_{-0.9}$	^{84}Mo	$3.7^{+1.0}_{-0.8}$	^{87}Tc	2.18 ± 0.16
^{88}Ru	$1.2^{+0.3}_{-0.2}$	^{89}Ru	1.45 ± 0.13	^{91}Rh	1.74 ± 0.14
^{92}Rh	5.6 ± 0.5	^{93}Rh	13.9 ± 1.6	^{92}Pd	$1.0^{+0.3}_{-0.2}$
^{93}Pd	1.0 ± 0.2	^{99}In	$3.0^{+0.8}_{-0.7}$		

Table 2: Halflives of nuclei near the $N = Z$ line.

In an earlier report of preliminary results [6], an erroneous value for the ^{93}Pd and ^{92,93}Rh halflife was given because some daughter decays were included and the background suppression was insufficient in the first analysis.

To investigate superallowed Fermi-β-decays we studied the six heaviest candidates of $N = Z$ odd-odd nuclei between ^{78}Y and ^{98}In. For the first time we observed fast transitions, compatible with superallowed Fermi transitions for ^{90}Rh, ^{94}Ag and ^{98}In. Beside these fast transition of the mother nuclei, we observe a long living isomeric state in some cases. The measured halflives of the short and long living states of the $N = Z$ odd-odd nuclei can be found in table 3.

	$T_{1/2}$[ms]	$T^{\mathrm{iso}}_{1/2}$[s]		$T_{1/2}$[ms]	$T^{\mathrm{iso}}_{1/2}$[s]
^{78}Y	55^{+9}_{-6}	$5.7^{+0.7}_{-0.6}$	^{82}Nb	48^{+8}_{-6}	
^{86}Tc	59^{+8}_{-7}		^{90}Rh	12^{+9}_{-4}	$1.0^{+0.3}_{-0.2}$
^{94}Ag	26^{+26}_{-9}	$0.45^{+0.20}_{-0.13}$	^{98}In	32^{+32}_{-11}	$1.2^{+1.2}_{-0.4}$

Table 3: Halflives of $N = Z$ odd-odd nuclei.

References

[1] A. Stolz *et al.*, GSI Scientific Report 1998, p.174
[2] E. Wefers *et al.*, GSI Scientific Report 1998, p.173
[3] A. Stolz, Ph.D. thesis, TU München, 2001
[4] K. Sümmerer and B. Blank, Phys. Rev. **C61** (2000) 034607-1
[5] G.A. Lalazissis *et al.*, Nucl. Phys. **A679** (2001) 481
[6] E. Wefers *et al.*, AIP Conference Proc. **495** (1999) 375

◇ This work was supported by BMBF (06TM872 TPI) and SFB 375