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Proton-neutron interaction at N ≅ Z. First observation of the T_z=1 nucleus $^{94}_{46}Pd_{48}$ in-beam.

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Neutron deficient nuclei close to N≅Z are expected to exhibit a new kind of pairing based on the T=0, I=1,I_{max} configurations , which in the ($p_{1/2}$,$g_{9/2}$) shell model space below ^{100}Sn is governed by the $g^2_{9/2}$ proton (π)- neutron (ν) interaction. The empirical interaction deduced for this model space [1], which has been shown in numerous cases [2,3] to describe experimental levels and electromagnetic transitions very well, exhibits indeed strongly bound $g^2_{9/2}$, T=0, I=1^+,9^+ two-body matrix elements (tbme) besides the "normal pairing" T=1, I=0^+ tbme. In the experimentally barely studied far from stability upper $\pi g_{9/2}$ shell due to the hole-hole character of the πν interaction spin gap isomers are expected [4].

We have therefore designed an experiment to study exclusively the γ-decay of isomers in a recoil catcher device placed inside the OSIRIS γ-ray spectrometer. Filter detectors for neutrons (6 segments) and charged particles (4 segments) were used to identify residues from the reaction ^{58}Ni + ^{40}Ca at 225 MeV energy of the Ni beam from VICKSI. Details on the geometry and the sensitivity of the setup are given in refs. [5,6]. In Fig. 1 a sequence of six γ-rays is shown, which are in mutual coincidence, and in delayed coincidence with protons and neutrons, with a half life of $t_{1/2}$=0.8 (2) μs (insert Fig. 1). From the proton and neutron multiplicities, as deduced from intensity ratios $I_{2p\gamma\gamma}/I_{p\gamma\gamma}$ and $I_{pn\gamma\gamma}/I_{p\gamma\gamma}$ shown in Fig. 2, the γ-cascade can be assigned to the (2p2n) exit channel from the compound nucleus ^{98}Cd* and hence to ^{94}Pd. The population cross section was estimated to be σ = 0.2 mb corresponding to 0.06 % of the total residue cross section.

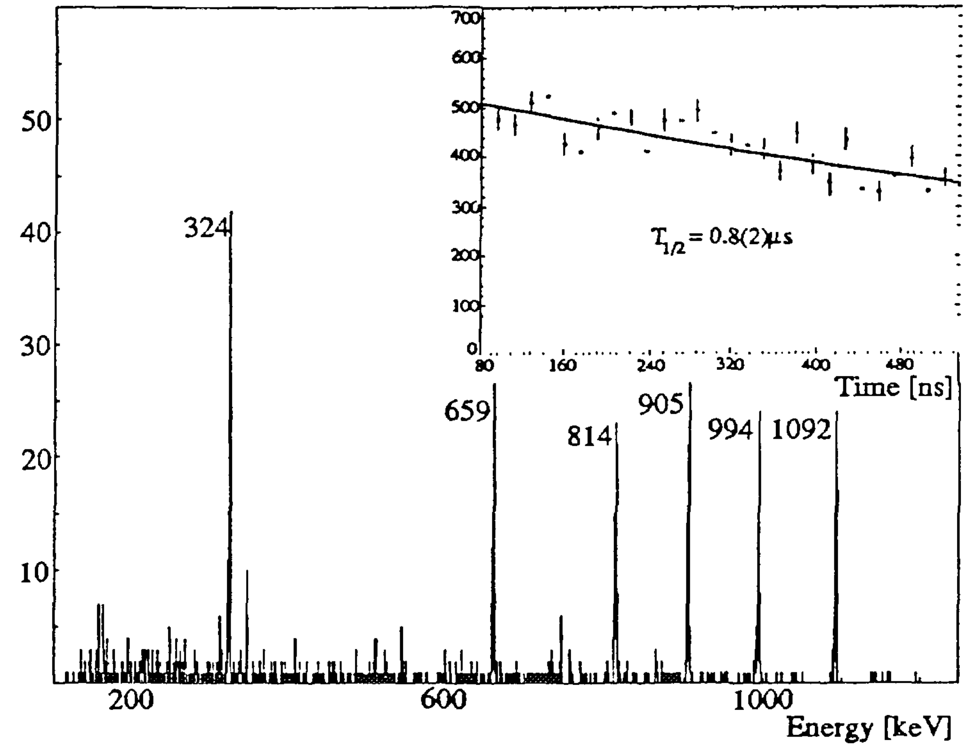

Fig.1: Delayed (20-570 ns) sum of gates $n\gamma\gamma$ coincidence spectrum and decay of the $I^{\pi}=(14^{+})$ isomer in ^{94}Pd.

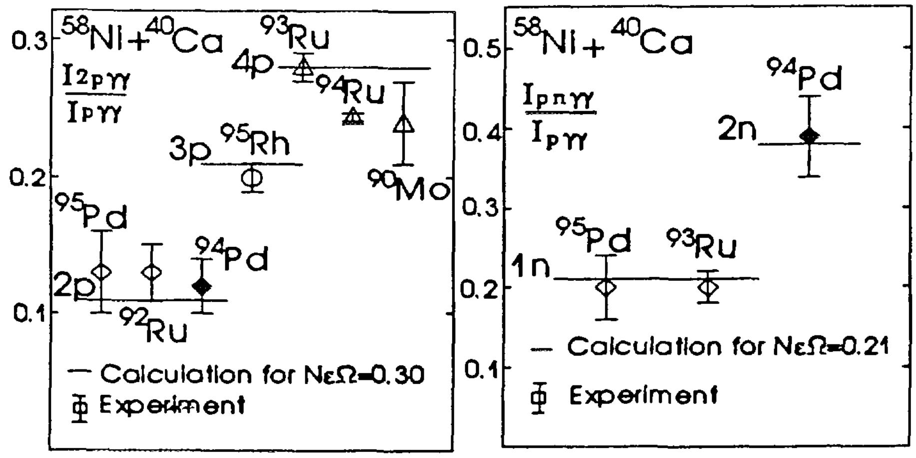

Fig.2:Intensity ratios $I_{2p\gamma\gamma}/I_{p\gamma\gamma}$ and $I_{pn\gamma\gamma}/I_{p\gamma\gamma}$ for residues from ^{58}Ni+^{40}Ca → ^{98}Cd* The array efficiencies NεΩ are taken from experiment.

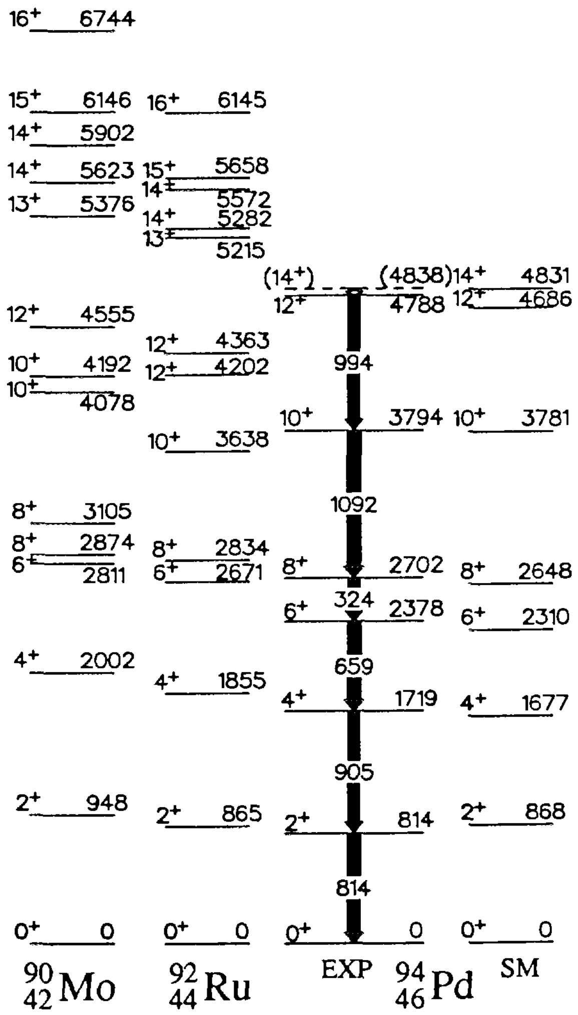

Fig.3: Experimental level scheme of ^{94}Pd in comparison to N=48 isotones and shell model predictions. The insert shows the N=48 yrast lines

^{94}Pd, which was not studied before, is the heaviest $T_z = 1$ nucleus identified in-beam. From the half life, nγγ coincidence spectra and the systematics of N=48 isotones the level scheme shown in Fig. 3 is deduced. As the measured isomeric half life is incompatible with the γ-ray energies observed in ^{94}Pd, when compared to typical E1 and E2 transition strengths in this region, an unobserved E2 transition with $\Delta \leq 90$ keV has to be invoked, as odd parity states are not expected to be yrast at this excitation energy. In Fig. 3 the results of shell model calculations in the ($p_{1/2}$, $g_{9/2}$) model space are shown, which were obtained with an empirical interaction [1]. The excellent agreement encouraged us to use the theoretical $B(E2;14^+ \rightarrow 12^+) = 4.9$ W.u. to deduce the above mentioned limit for $\Delta \leq 90$ keV as compared to the shell model value of 145 keV. From the difference an improved value for the πν $g_{9/2}^2$ $I^\pi=9^+$ tbme of -2.0 MeV in comparison to the previous empirical -1.75 (7) MeV [1] can be inferred. This also improves the agreement for the $I^\pi = 21/2^+$ spin gap isomer in ^{95}Pd [4]. On the other hand variation of the $I^\pi = 1^+$, T=0 tbme was found to have no influence on the position of the ^{94,95}Pd isomers. The yrast lines for the isotones ^{92}Ru, ^{94}Pd and ^{96}Cd (insert Fig. 3) show the development of a $\Delta I = 4$ spin gap isomer in ^{96}Cd and an increasing 8^+-6^+ transition energy causing the disappearance of the $I^\pi = 8^+$ isomer ($t_{1/2} \leq$ 5 ns in ^{94}Pd as deduced from the present experiment). Where experimentally accessible, all these features are nicely reproduced by the shell model, which proves the adequacy of the model space and the residual πν interaction.

References

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