EXPERIMENTAL APPROACHES TO DOUBLE SHELL-CLOSURES FAR FROM STABILITY

M. Lewitowicz, GANIL BP 5027, 14021 Caen, France

Invited talk presented at the Conference ENAM 95, Arles, France, June 19-23, 1995

Production and Identification of μs-Isomers in Fragmentation-like Reactions of a ^{112}Sn Beam

R. Grzywacz[a,b], R. Anne[b], G. Auger[b], D. Bazin[b], C. Borcea, V. Borrel[d], J.M. Corre[b], T. Dörfler, A. Fomichov[f], M. Gaelens[g], D. Guillemaud-Mueller[d], R. Hue[b], M. Huyse[g], Z. Janas[h], H. Keller[h], M. Lewitowicz[b], S. Lukyanov[f,b], A.C. Mueller[d], A. Ostrowski[b], Yu. Penionzhkevich[f], M.Pfützner[a], F. Pougheon[d], K. Rykaczewski[a,b],M. Robinson[b], M.G. Saint-Laurent[b], K. Schmidt[h], W.-D. Schmidt-Ott[c], O. Sorlin[d], J. Szerypo[g], O. Tarasov [f,b], J. Wauters[g] J. Żylicz[a]

Contribution to the Conference ENAM 95, Arles, France, June 19-23, 1995

GANIL P 95 20

Production and Identification of μs-Isomers in Fragmentation-like Reactions of a ^{112}Sn Beam

R. Grzywacz[a,b], R. Anne[b], G. Auger[b], D. Bazin[b], C. Borcea[c], V. Borrel[d], J.M. Corre[b], T. Dörfler[e], A. Fomichov[f], M. Gaelens[g], D. Guillemaud-Mueller[d], R. Hue[b], M. Huyse[g], Z. Janas[h], H. Keller[h], M. Lewitowicz[b], S. Lukyanov[f,b], A.C. Mueller[d], A. Ostrowski[b], Yu. Penionzhkevich[f], M.Pfützner[a], F. Pougheon[d], K. Rykaczewski[a,b],M. Robinson[b], M.G. Saint-Laurent[b], K. Schmidt[h], W.-D. Schmidt-Ott[e], O. Sorlin[d], J. Szerypo[g], O. Tarasov [f,b], J. Wauters[g], J. Żylicz[a]

[a]*IFD, Warsaw University, Poland*; [b]*GANIL, Caen, France*; [c]*IAP, Bucharest, Roumania*; [d]*IPN, Orsay , France*; [e]*University of Göttingen, Germany*; [f]*FLNR, JINR Dubna, Russia*; [g]*IKS KU Leuven, Belgium*; [h]*GSI Darmstadt, Germany*;

Fragmentation-like reactions with heavy projectiles at intermediate energies are characterized by a wide distribution of the products in mass A and atomic number Z, (see e.g. [1]). In the studies performed at projectile–fragment separators, complete identification of produced nuclei is based usually on the known magnetic rigidities used to transmit the ions from the target to the final focus together with the measurements of energy-loss, total kinetic energy and time-of-fligth [2]. A novel method for an unambiguous Z and A assignment to the fragmentation products has been developed. This identification is based on the detection of γ-radiation following the decay of short-lived ($T_{1/2}$ about 0.1 to 100μs) known isomeric states in time correlation with the respective heavy-ion implantation signals. Such a correlation method is characterized by a high sensitivity due to the strong suppression of γ-radiation background. Therefore it can also be applied to study the decay properties of isomers in nuclei very far from beta-stability usually produced at low rates.

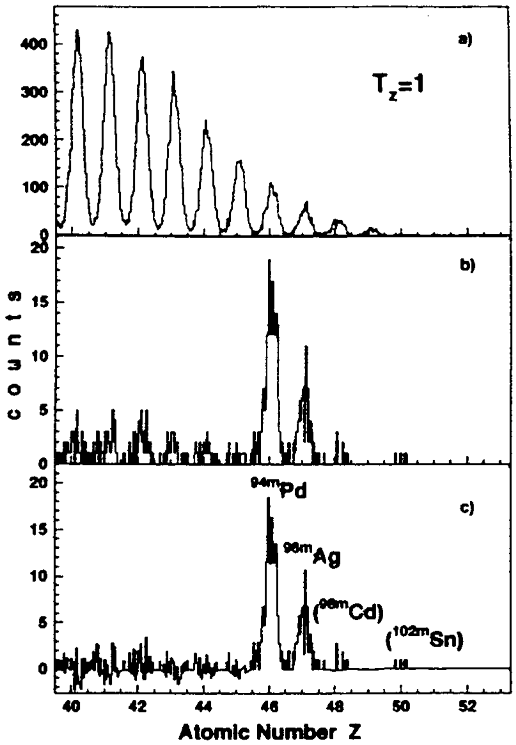
In the cases where isomeric state decays via highly converted electromagnetic transition, fully stripped fragments can be transported over a long path length with relatively small intensity losses. This is due to the blocking of the main conversion-electron decay channel and the resulting increase of the ionic half-life, compared to the one of a neutral atom [3,4].

In experiments with ^{112}Sn beam (58 A·MeV, 63 A·MeV) at LISE3 spectrometer at GANIL forty known isomers has been detected among 400 examined products. They were found in a (Z,A) range from ^{18}F to ^{105}Cd; excitation energies varied from 87 keV (^{63m}Ni) to 6.5 MeV (^{54m}Fe), spin values were from 1^+ (^{22m}Na) to $21/2^+$ (^{91m}Zr,^{93m}Ru,^{105m}Cd), and the halflives (given for the isomer in the neutral atom) ranged from 57 ns (^{66m}Ga) to 71 μs (^{94m}Ru).

Intensities of the isomeric beams (from 10^{-3} to 10 pps) were deduced from the characteristic γ-radiation, and compared to the total number of observed ions to obtain the isomeric to ground-state production ratios (from 3 to 90 percent).

Evidence for a new isomeric state in ^{66}As was obtained [4]. The γ-decay properties of this isomer were studied subsequently at GANIL in a similar experiment using a ^{78}Kr beam and high resolution γ detectors [5].

A recent experiment performed with a hybrid Ge-BGO setup resulted in the detection of two additional isomers: ^{96m}Ag and ^{94m}Pd. The existence of the isomeric states in those nuclei



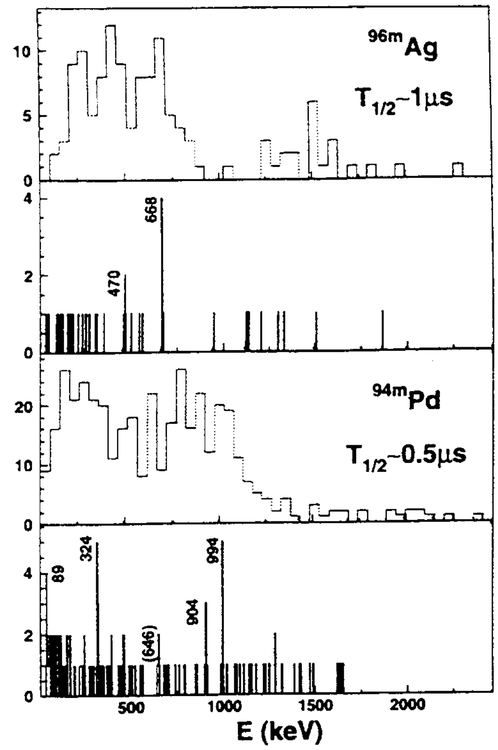


Fig. 1. Identification plots with the evidence for isomers ^{94m}Pd and ^{96m}Ag, the projection chosen for $T_z=1$ implanted isotopes, selections for a) all implanted ions b) in coincidence with γ-radiation c) same as b) but with random background subtracted. Few correlated counts for ^{98}Cd and ^{102}Sn can be also tentatively assigned to the isomeric decay.

Fig. 2. Gamma radiation observed in correlation with ^{96}Ag and ^{94}Pd in BGO and germanium detectors

is signaled by the high ratio of heavy-ion coincident γ transition detected in BGO detector (fig.1c) and is confirmed by weak gamma lines measured by the Ge detector placed behind the implantation telescope (fig.2). Based on γ-correlated events in BGO one may determine the half-life of $\approx 1\mu s$ for ^{96m}Ag and ≈ 0.5 μs for ^{94m}Pd. Recently, ^{96m}Pd was also found in the in-beam type experiment [6] and interpreted as a 14^+ state. Few γ-correlated counts for ^{98}Cd and ^{102}Sn may be a signature of theoretically predicted metastable 8^+ and 6^+ states.

The method described here is well suited for scanning large parts of the nuclear chart for isomers in the $0.1\mu s$ to $100\mu s$ half-life region. Such an experiment can be performed with only one $B\rho$ setting of a projectile-fragment separator equipped with a sensitive γ detection set-up at the final focus. The measurement of isomeric-decay is thus possible for nuclei very far from beta-stability.

This work has been partially supported by CNRS under PICS No 258 and by the KBN within the project 2 P302 14806. One of us (RG) would like to thank the Foundation for Polish Science for financial support.

1) M. Lewitowicz *et al.*, Phys. Lett. B**332** (1994) 20
2) D. Bazin *et al.*, Nucl. Phys. A**515** (1990) 349
3) W. Phillips *et al.*, Phys. Rev. Lett. **62** (1989) 1025
4) R. Grzywacz *et al.*, Phys. Lett. B in print
5) B. Blank *et al.* Nouvelles du GANIL **54** (1995) 3
6) M. Górska *et al.* to be published