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REPUBLIC OF SOUTH AFRICA

PROGRESS REPORT TO THE INDC

1970

Compiled by D. Reitmann

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1. Southern Universities Nuclear Institute, Faure, Cape Province

A considerable amount of time was spent during 1970 on the installation and improvement of the new pulsing and bunching system in the 5.5 MV accelerator. Problems with ion source behaviour and bunching of different mass particles were largely solved and a carbon foil stripper was installed in the accelerating tube. Research projects in neutron physics during the year include the following:

1.1 Level structure of ^{93}Nb and ^{115}In from (n,n'γ) studies

I.J. van Heerden and W.R. McMurray

Inelastic neutron scattering[1] and (n,n'γ) reaction studies[2] have contributed to the knowledge about excited states in ^{93}Nb. The spins of all known levels below 1.5 MeV were determined very recently by Rogers et al.[3]. These spin assignments were based on Hauser-Feshbach calculations of inelastic scattering excitation functions and γ-ray transition probabilities are in qualitative agreement with shell model calculations.

The energy levels in ^{115}In have been studied mainly through β-decay of ^{115}Cd and coulomb excitation by helium or oxygen ions.

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1) D. Reitmann et al., Nucl.Phys. 48(1963)593

2) L.E. Beghian et al., J. Phys.Soc.Jap. 24, Suppl.1(1968)190

3) V.C. Rogers et al., Nucl.Phys. A142(1970)100

In the shell model the level scheme should be given by the coupling of states available to single proton holes in the closed Z = 50 shell to vibrations in the ^{116}Sn core. In its simplest form this coupling explains the observed strong ground state transitions but it is unable to reproduce the spin sequence or branching ratios.

In the present experiment a 30 cc Ge(Li) detector was used to observe the γ-rays produced when cylindrical samples of Nb or In were bombarded with neutrons from the ^{7}Li(p,n)-reaction. Time gating was used to discriminate against background and neutron events in the detector. A typical time resolution was about 10 ns. A large number of spectra at 90^{o} were recorded for neutron energies between 0.75 and 2.7 MeV.

In the case of ^{93}Nb, the level scheme deduced from the present experiment includes levels at 29, 743.7, 808.4 (doublet), 949.6, 978.7, 1082.1, 1296.4, 1315.9, 1334.3, 1367.9, 1393.6, 1482.9, 1490.7, 1499.5, 1602.9, 1679.6, 1682.6, 1686.1, 1706.4, 1729.9, 1913.8, 1918.2 and 1940.8 keV. Up to 1296 keV this scheme is essentially the same as that found by Rogers et al. The doublet at 808 keV is based on the existence of γ-rays at 779.4 and 808.4 keV. The behaviour of their relative intensities can not be reconciled with the known spins of $\frac{9^+}{2}$ and $\frac{1^-}{2}$ for the ground- and 29 keV states if both originate from a single level at 808 keV. The excitation curves for the two γ-rays are also different and indicate that, above 1.3 MeV in neutron energy, the 779.4 keV γ-ray is being fed through cascades from higher levels.

In the energy range covered by the two experiments, present results confirm the existence of levels at 1334.3, 1482.9 and 1499.5 keV. New levels were found at 1315.9, 1367.9, 1393.6 and 1490.7 keV. Levels at 1465 and 1528 keV, based by Rogers

et al. on the existence of 656 and 720 keV γ-rays, were not observed. The 656.4 keV γ-line observed in the present experiment was attributed to a different reaction. However, a γ-ray at 653.4 keV was observed at incident neutron energies above 1700 keV. This, together with a line at 1602.9 keV with the same threshold, was attributed to the decay of a new level at 1602.9 keV.

The level scheme of ^{115}In, based on thresholds and excitation curves for observed γ-rays, contain levels at 336.6, 597.1, 828.7, 864.2, 933.6, 941.2, 1041.6, 1077.6, 1132.6, 1291.3, 1418.6, 1448.4, 1461.9, 1484.3, 1496.0, 1600.7, 1606.3, 1736.5, 1759.3, 1908.0, 1971.4, 1977.1 and 1998.0 keV. Up to 1450 keV this scheme agrees well with that derived from the decay of ^{115}Cd. New levels at 941.2 and 1041.6 keV are based on γ-transitions at 941.2 and 705.3 keV which were first observed at incident neutron energies of 1 and 1.1 MeV respectively.

It is known that angular distributions of γ-rays from levels excited by inelastic neutron scattering, provide information on the spins of the excited states, provided these spins are larger than that of the ground state. This is especially true near threshold where the population of magnetic substates is limited. Unfortunately, both ^{93}Nb and ^{115}In have ground states with spin $\frac{9}{2}$, so that γ-ray angular distributions can not provide unique spin assignments. Inelastic scattering cross sections were therefore derived from the γ-ray excitation functions and branching ratios in order to compare these with Hauser-Feshbach predictions.

1.2 Gamma transitions from excited states of ^{75}As

P.J. Celliers and W.R. McMurray

The study of the ^{75}As level scheme was motivated by the observation of resonance fluorescence from levels near 1 MeV excitation (P.J. Celliers and W.L. Mouton). The $(n,n'\gamma)$ reaction is being used to give necessary information about the level structure and branching ratios of the decay gammas. The gamma detection system incorporated a time-of-flight-gated Ge(Li) detector of 57 cc. Using ^{75}As powder in a thin walled aluminium container, $(n,n'\gamma)$ spectra have been obtained at incident neutron energies ranging from 300 to 2200 keV. Excitation curves for the observed gammas have been obtained. Measurements with an Fe sample were interpolated to enable absolute cross sections to be determined. The analysis of the data is not yet complete but the observed γ-rays fit into a level scheme with excited states at 199.5, 265.7, 280.6, 401.0, 469.0, 572.3, 617.8, 822.1, 861.1, 865.2, 887.2, 1016.0, 1064.1, 1075.2, 1129.1, 1205.0, 1301.0, 1304.8, 1310.6, 1350.8, 1371.3, 1432.1, 1607.7 and 1656.8 keV.

1.3 Neutron polarization measurements

F.D. Brooks and D.T.L. Jones

The determination of the neutron polarization in n-p scattering using the direction sensitive PSD effects observed in anthracene crystal scintillators has been continued using 22 MeV neutrons of known polarization from the $T(d,n)^3He$ reaction. These results are being analyzed.

The possibility of using n-d scattering in a deuterated anthracene crystal was also investigated as it is known that the

polarization produced in this scattering is greater than in n-p scattering. Various other possibilities for improving the quality of the results are also being looked into.

1.4 Other relevant projects

F.D. Brooks and co-workers

Projects under this heading which are still in an early stage of development include the investigation of the $^{2}H(n,2n)^{1}H$ reaction at 22 MeV by using a deuterated scintillator, a search for spontaneously fissioning isomers of ^{236}U and ^{239}U and a search for super heavy elements.

2. Nuclear Physics Research Unit, University of the Witwatersrand, Johannesburg

During 1970 the only major research facility was a 1 MV Cockcroft-Walton accelerator which produces high energy neutrons by means of the (D+T)-reaction. An order has been placed with H.V.E.C. for an EN-tandem.

2.1 Cross sections for reactions ^{28}Si + n for neutron energies between 12.8 and 16.2 MeV

D.W. Mingay, J.P.F. Sellschop and P.M. Johnson

Total cross sections for the $^{28}Si(n,\alpha)^{25}Mg$ and $^{28}Si(n,p)^{28}Al$ reactions have been measured for neutron energies between 12.8 and 16.2 MeV, for the ground and first four resolved excited states of ^{25}Mg and the unresolved pairs consisting of the ground and first excited, and second and third excited states of ^{28}Al. The neutron energy resolution was less than 30 keV.

An analysis in terms of Ericson fluctuation theory, which is also compared with Hauser-Feshbach calculated cross sections, is being completed which shows that the region studied has many broad overlapping levels with good statistical properties which leads to the extraction of an improved value for the mean compound nuclear lifetime, which is lower than the previously quoted value, as a result of the fine structure details revealed in these excitation function measurements.

3. Physics Division, Atomic Energy Board, Pelindaba, Transvaal

The program of neutron physics research was continued at the 3 MV pulsed van de Graaff as well as the 20 MW research reactor, Safari I. The CDC-1700 computer at the accelerator was used for data processing and some simple on-line data collection applications. A new thermal neutron beam tube for capture studies was installed in the reactor.

3.1 Nuclear spectroscopy from (n, γ)-reactions with slow neutrons

M.A. Meyer, C. Hofmeyr and B.C. Winkler

The original tangential thermal beam tube in Safari I was used as a neutron source and γ-rays were detected in a Ge(Li)-detector used singly or in conjunction with NaI-crystals in a pair spectrometer arrangement. The latter system produced much simpler spectra, especially at high γ-energies, but also reduced the overall detection efficiency due to the threefold coincidence requirement.

The investigation of energy levels in ^{71}Ge has been nearly completed and a number of spectra have been recorded from the (n, γ) reaction in ^{58}Ni.

3.2 Nuclear spectroscopy from (n,n'γ)-reactions

E. Barnard, N. Coetzee, J.A.M. de Villiers, D. Reitmann and P. van der Merwe

Fast neutrons from the $^{7}Li(p,n)^{7}Be$-reaction and the pulsed accelerator were used to excite levels up to about 1.5 MeV in several stable nuclei. A 40 cc Ge(Li)-detector, used in time-gated mode, was used to detect the resulting γ-rays.

The investigation of energy levels and their decay modes in ^{197}Au has been completed and the results accepted for publication in Nuclear Physics. The level schemes for ^{203}Tl and ^{205}Tl have been published[1] and a similar study on ^{127}I was accepted for publication in Zeitschrift für Physik. The results from Sb(n,n'γ) have been submitted for publication in Nuclear Physics and the experimental work on Cs, the two isotopes of Rb, Br and Ho has been completed. In most cases several new energy levels in these stable isotopes were discovered.

3.3 Fast neutron scattering

XY 36071.

E. Barnard, N. Coetzee, J.A.M. de Villiers, D. Reitmann and P. van der Merwe

The results from an investigation of inelastic neutron scattering from ^{209}Bi, combined with those on total cross sections and elastic scattering as measured by A.B. Smith of ANL, have been published[2]. A detailed study up to 1.4 MeV of total cross sections as well as elastic and inelastic neutron scattering cross sections for ^{45}Sc has been completed and the results submitted to Zeitschrift für Physik.

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1) Nucl.Phys. A157(1970)130

2) ANL-7636(1969) and Nucl.Sci. & Eng. 41(1970)63

Inelastic scattering cross sections for Ti, combined with elastic and total cross section measurements by an ANL-group, are being analysed at ANL. Measurements of inelastic scattering cross sections for ^{238}U were presented at the Helsinki conference (June 1970). The results from total, elastic and inelastic scattering cross section measurements on Cs and Rb are still being analysed. A series of high resolution measurements on the 90^{o} differential inelastic scattering cross section for the 126 keV level in Mn has been started and data have been taken in 5 keV steps from 400 to 1040 keV.