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INDC INTERNATIONAL NUCLEAR DATA COMMITTEE

PROGRESS REPORT FROM SOUTH AFRICA

TO THE INDC

1968

compiled by D. Reitmann

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REPUBLIC OF SOUTH AFRICA

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1. SOUTHERN UNIVERSITIES NUCLEAR INSTITUTE, FAURE, CAPE PROVINCE

The Institute, which is a joint venture between the Universities of Cape Town and Stellenbosch, makes use of a pulsed 5.5 Mev van de Graaff accelerator as major facility. Relevant topics of research include the following:

1.1 NEUTRON SCATTERING REACTIONS

1.1.1 THE LEVEL STRUCTURE OF ^{139}La AND ^{141}Pr

publ

J.G. Malan, W.R. McMurray, P. van der Merwe, I.J. van Heerden (SUNI)
C.A. Engelbrecht (AEB)

Using time-of-flight techniques, the isotones ^{139}La and ^{141}Pr were studied by means of elastic and inelastic neutron scattering in the energy range 230-2580 keV. The energies of more than 20 levels in ^{139}La and of more than 15 levels in ^{141}Pr were determined. Contrary to results from coulomb excitation experiments, no evidence was found for levels between 200 and 1100 keV in either nucleus. Excitation functions and angular distributions for scattering to a number of levels in both nuclei were measured. Optical model parameters were determined from fits to elastic scattering angular distributions and to the excitation functions for scattering to the first excited states. A Hauser-Feshbach analysis of the inelastic data yielded probable spin values for some higher levels. For other 'levels' the calculations indicated unresolved structure. These results have been published (Nucl. Phys. A124 (1969) 111).

It was suspected that unresolved level structure would explain the large discrepancies found between the measured and calculated excitation functions for some of the 'levels'. It was therefore decided to use the high resolution of a Ge(Li) detector to observe the gamma decays following inelastic neutron scattering. A series of γ-ray spectra were obtained from ^{139}La and ^{141}Pr for incident neutron energies between 500 and 2300 keV.

These were assigned to transitions from levels up to an excitation of 1835 keV in ^{139}La and 1844 keV in ^{141}Pr, most of these levels previously being observed in the (n,n') measurements. Some weakly excited new levels were also observed. These results have been published (Nucl. Phys. A124 (1969) 433).

Using the (^{3}He,d) reaction on ^{138}Ba, B.H. Wildenthal et al.[1] assigned $J\pi$ values of $1/2^+$ and $11/2^-$ to their 1.21 and 1.42 Mev energy levels of ^{139}La. These results agree with the present work if it is assumed that their levels correspond to those observed at 1206 + 2 keV and at 1439 ± 10 keV, to which we assign $J\pi$ values of ($1/2^+$ or $3/2^+$) and $11/2^+$ respectively. On this basis the energies (in keV) of the first nine levels of ^{139}La and their $J\pi$ values are 0($7/2^+$), 166($5/2^+$), 1206($1/2^+$), 1217($7/2^+$), 1255($5/2^+$), 1383($9/2^+$), 1420($5/2^+$), 1439($11/2^-$), and 1475 ($7/2^+$).

1) B.H. Wildenthal, E. Newman and P.L. Auble, Phys. Letters 27B (1968) 628

1.1.2 (n,n'γ) INVESTIGATION OF THE LEVEL STRUCTURE OF Nb

W.R. McMurray, P. van der Merwe and I.J. van Heerden

Measurements of the gammas excited by inelastic neutron scattering from Nb show that the level scheme above 1080 keV is not yet satisfactorily determined. Beghian et al.[1] did not report a 1296 keV gamma observed by us and in work by Mathur et al.[2] This we assign to a level at 1296 keV. Coincidence measurements will be attempted in order to uniquely assign other observed gamma trasitions particularly those from highly excited states.

1) L. Beghian, F. Clikeman, F. Hofmann, F. Mahoney and S. Wilensky, Proc. Int. Conf. on Nuclear structure, Tokyo (1967)

2) S.C. Mathur, P.S. Buchanan and G.H. Williams, Proc. Int. Conf. on Nuclear structure, Tokyo (1967)

1.1.3 THE LEVEL STRUCTURE OF ^{232}Th FROM (n,n'γ) MEASUREMENTS

W.R. McMurray, I.J. van Heerden and P. van der Merwe

Coulomb excitation studies [1] have in the past been the main source of knowledge of the level structure of ^{232}Th. Published neutron scattering measurements have only reproduced some levels. A Ge(Li) detector with time-of-flight gating to discriminate against neutron induced γ-rays was therefore

used to resolve the level structure of ^{232}Th by observing the de-excitation γ-rays from neutron scattering.

A large number of γ-ray spectra were obtained for incident neutron energies between 750 and 1535 keV in energy steps of about 50 keV. Threshold energies of the observed γ-rays were determined from the excitation curves. In addition to the known collective states, levels are observed at 714, (959), 1072, 1079, 1104, 1122, 1143, 1183 and (1207) keV.

The 778 keV gamma which is strongly excited at energies exceeding 850 keV is presumably due to a level in ^{232}Th at 828 keV. A level was found at 820 keV in neutron scattering from ^{232}Th (ref.[2]). From the strength of this gamma ray it cannot result from de-excitation of the 10^+ collective state reported [1] at 828 keV.

Work on this project is continuing.

1) F.S. Stephens, B. Elbek and R.M. Diamond, Proc. Int. Conf. on Reactions between complex nuclei, Asilomar (1963)

2) A.B. Smith, Phys. Rev. 126 (1962) 718

1.1.4 THE LEVEL STRUCTURE OF ^{238}U

W.R. McMurray, I.J. van Heerden and P. van der Merwe

An investigation[1] of neutrons inelastically scattered from ^{238}U showed the presence of levels of a non-collective nature at energies of about 1 MeV and greater. Even the 5^- member of the octupole vibrational triplet could not be definitely identified. Coulomb excitation studies[2] had tentatively specified this level at 827 keV whereas a 5^- level was deduced from inelastic neutron scattering work[1] at 838 ± 5 keV, well outside the energy uncertainties.

Work using the (n,n'γ) reaction and a time-of-flight gated Ge(Li) detector has been undertaken to obtain a more precise level structure for ^{238}U. Spectra were obtained using incident neutron energies from 850 to 1487 keV. An analysis of the relative excitation cross sections and threshold energies for the observed gamma-rays enables a level structure to be deduced. DIN5

The level structure is clearly more complex than previously assumed. There is, however, good agreement (within 1 keV) with the level energies of the better known collective states. The observed branching of the decay gammas to the first three levels of ^{238}U is also in qualitative agreement with previous spin assignments. Additional work is planned to confirm the deduced

level scheme.

1) E. Barnard, A.T.G. Ferguson, W.R. McMurray, and I.J. van Heerden, Nuclear Physics 80 (1966) 46

2) F.S. Stephens, B. Elbek and R.M. Diamond, Proc. Int. Conf. on Reactions between complex nuclei, Asilomar (1963)

1.1.5 INELASTIC SCATTERING OF NEUTRONS TO THE 59 keV LEVEL OF ^{127}I

XY 30124.

C.A.R. Bain and F.D. Brooks (UCT)

The excitation of the 59 keV level of ^{127}I by neutron inelastic scattering was studied using a small NaI scintillation crystal as both target and detector. Measurements were carried out in the incident neutron energy range 50-500 keV, and the neutron flux incident on the crystal was monitored with a ^{6}Li loaded glass scintillator. The cross sections obtained are compared with those calculated from Hauser-Feshbach theory. This work has now been published (Nucl. Phys. A125 (1969) 312)

1.2 NEUTRON CAPTURE REACTIONS

XY 30114.

L.M. Spitz (UCT), E. Barnard (AEB) and F.D. Brooks (UCT)

The investigation of neutron capture by several elements in the energy range of 8 to 120 keV has been completed and published (Nucl. Phys. A121 (1968) 655). The abstract of the paper reads as follows:

> Moxon-Rae detectors were used to measure ratios of the radiative capture cross section of elemental Cr, Mn, Ni, Nb, Ag, Sb and Au to that of In for neutrons of energy 8 to 120 keV. Relative capture cross sections of In for 8 to 30 keV neutrons were also measured. These were converted to absolute cross sections by using the In capture cross sections determined by Gibbons et al. The data were analysed to determine p-wave strength functions for Nb, Ag, Sb and Au, and average radiation widths for Cr, Mn and Ni.

2. ATOMIC ENERGY BOARD, PELINDABA, PRETORIA

Major facilities for neutron data measurements at the AEB are the pulsed 3 MeV van de Graaff and the 20 MW research reactor, Safari 1. Neutron physics research carried out during 1968 includes the following:

X4 30178
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2.1 SCATTERING OF FAST NEUTRONS

E. Barnard, N. Coetzee, J.A.M. de Villiers, C.A. Engelbrecht, D. Reitmann and J.W. Tépel.

The high resolution study of inelastic scattering of fast neutrons from Fe was completed and published jointly with A.B. Smith of the Argonne National Laboratory (PEL-180 and Nucl. Phys. A118 (1968) 321). These measurements indicated a considerable amount of structure in the excitation curve for the 845 keV level in ^{56}Fe. Attempts were made to explain this phenomenon on theoretical grounds.

A detailed study of the energy levels in ^{197}Au, excited by inelastic scattering of neutrons below 1.5 MeV, was made and several new levels were discovered. Spins and parities were assigned to these levels on the basis of Optical Model and Hauser-Feshbach calculations. Since publication of these results (Nucl. Phys. A107 (1968) 612), Ge(Li) detectors with time-of-flight gating were used to investigate the level scheme in even more detail by means of the Au(n,n'γ) reaction. Indications were found of even more energy levels and this work is being continued.

In the case of Sc very little was known about fast neutron cross sections. A complete investigation of elastic and inelastic scattering (as well as total cross sections) for neutrons with energies up to 1.5 MeV has been undertaken. This was supplemented with (n,n'γ) studies employing a Ge(Li) detector.

Similar situations to that for Sc, existed for natural Cs and Rb. Measurements of total-, elastic- and inelastic scattering cross sections were made and new energy levels were discovered. This experiment is also nearing completion.

The excitation curves for the 900 keV level in ^{209}Bi as well as low-lying levels in isotopes of Ti, have also been measured in detail up to 1.5 MeV and a considerable amount of structure was discovered. These results will be combined with total- and elastic scattering cross sections measured at ANL into joint publications.

D. Reitmann.

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