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REPUBLIC OF SOUTH AFRICA

PROGRESS REPORT TO THE INDC

1971

Compiled by D. Reitmann

IAEA NUCLEAR DATA SECTION, KÄRNTNER RING 11, A-1010 VIENNA

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1. Southern Universities Nuclear Institute, Faure, Cape Province

A 5,5 MeV van de Graaff accelerator, equipped with terminal pulsing and klystron bunching, is used in a wide variety of nuclear physics experiments, including the following which are relevant to the field of neutron data:

1.1 Study of the level structures of ^{232}Th and ^{238}U using the (n,n'γ) reaction

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

Level structure information on these important nuclei is still surprisingly inadequate even at excitations below 1 MeV. The main source of information had been the Coulomb excitation studies of Stephens et al.[1] supplemented in the case of uranium by neutron scattering by Barnard et al.[2] The (n,n'γ) reaction has since been used to provide more detailed information than hitherto available.[3] Further measurements have been undertaken

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1) F.S. Stephens et al., Proc. third Conf. on Reactions between Complex Nuclei (University of California Press, 1963) p.303

2) E. Barnard et al., Nuclear Physics 80 (1966)46

3) W.R. McMurray et al., Int. Conf. on Nuclear Structures, Montreal (1969)

to provide the data reported here. Many of the new levels observed have also been deduced from recent studies of the decay of ^{239}Pa by Herrmann et al.[1] and from a study of the (n,n'γ) reaction undertaken by Poenitz[2].

The present work is based on γ-ray spectra obtained over several years using a time gated Ge(Li) detector to discriminate against neutron induced backgrounds with incident neutron energies between 700 and 1900 keV. New levels are assigned on the basis of the observed γ-ray energy, energy threshold, shape of the excitation curve and the associated γ-ray decays. Branching ratios have been corrected for the relative γ-ray detection efficiency and for the γ-ray attenuated in the sample. The uncertainty on the branching ratios is less than ± 10% except for the very weakest transitions.

Altogether 43 γ-rays were observed in the spectra from a ^{232}Th sample of which 35 have been assigned to levels in ^{232}Th. The other 8 gammas had low yields and poorly defined thresholds and only three of these appeared in spectra obtained below the effective fission threshold at about 1250 keV.

The γ-ray energy uncertainties are derived from the reproducibility of measurements alternated with careful calibrations. The precision of the measurements is also indicated by the level energies determined by different branches of the decay. The results for ^{232}Th are tabulated in Table I. The energy values for the first and second excited states, given as 49,5 ±0,2 and 162,5 ±0,2 keV respectively, were obtained from the decay branching. The position of the level at 1073,28 keV was established from complementary data provided by neutron time-of-flight measurements reported in Item 1.2 of this report. The observation here of new levels and of decay schemes which in significant aspects are different to those reported by Stephens et al, places doubt on their spin assignments and characterisation of collective bands in the level scheme at excitations greater than 700 keV.

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1) G. Herrmann et al., Proc. Int. Conf. on the Properties of Nuclei far from the region of β-stability (Cern, 1970) Vol. II p. 985

2) W.P. Poenitz, Argonne Applied Physics Annual Report 1969/70, p.24

TABLE I

Levels of ^{232}Th and their decay γ-rays deduced from $(n,n'\gamma)$ measurements

Level Energy (keV)	γ-ray Energies (keV) (% branching in brackets)	Level Energy (keV)	γ- ray Energies (keV) (% branching in brackets)
0		1073,28 ±0,2	1023,78(100)
		1077,7 ±0,2	1077,7 (100)
49,5 ±0,2		1078,56 ±0,2	1029,06(100)
162,5 ±0,2		1094,7 ±0,2	1045,13(54) 932,25(46)
(333)		1105,75 ±0,2	1056,06(89) 943,45(11)
(555)		1122,04 ±0,2	1072,43(71) 959,55(29)
714,6 ±0,2	714,51(15) 665,25(85)	1143,44 ±0,2	980,94(100)
730,65±0,2	681,15(100)	1182,57 ±0,2	1133,07(100)
774,5 ±0,2	774,22(24) 725,08(14,5)	1352,2 ±0,5	1302,7 (100)
	612,34(61,5)	1387,55 ±0,3	1387,5 (17) 1338,2(33)
785,5 ±0,2	785,4 (34) 736,07(66)		1125,0(50)
829,85±0,2	780,35(100)	1479,9 ±0,7	1430,4(100)
873,17±0,2	823,67(100)	1484,4 ±0,5	1321,9(100)
890,8 ±0,2	728,3 (100)	1489,0 ±0,5	1489,0(54) 1439,4(46)
960,4 ±0,3	798,0(68) 627,2(32)	1554,4 ±1,0	1504,9(100)
1053,7 ±0,2	1053,5(34) 1004,3(66)		

In the study of ^{238}U, 36 γ-rays were observed and 31 assigned to 20 levels in ^{238}U. The thresholds to three weakly excited gammas were inadequately determined and the level energies are therefore tentative. Three of the unassigned γ-rays are only observed at incident neutron energies exceeding 1400 keV where the fission cross section increases sharply.

The levels of ^{238}U and the branching ratios are tabulated in Table II. There is generally close agreement between the results from the present study and the work reported by Herrmann et al., and Poenitz though some discrepancies remain. We obtain close lying doublets at 927,2 and 930,9 keV and at 1059,7 and 1060,7 keV and a single level at 1167,7 keV. Herrmann et al. find levels at 1167,5 and 1168,9 keV. It is possible that this last doublet was missed by us as the doublet decay schemes are similar.

TABLE II

Levels of ^{238}U and their decay γ-rays deduced from $(n,n'\gamma)$ measurements

Level Energy (keV)	γ-ray Energies (keV) (% branching in brackets)	Level Energy (keV)	γ-ray Energies (keV) (% branching in brackets)
0		(1045,9 ±1,0)	1001(100)
44,9 ±0,2		1059,7 ±0,2	1015,0(69) 911,3(31)
148,3 ±0,2		1060,7 ±0,2	1060,7(100)
(307,1)		1105,6 ±0,2	957,3(100)
(520)		1128,5 ±0,3	1083,7(53) 448,0(47)
680,1 ±0,2	680,0(40) 635,3(60)	(1167,7 ±0,3)	1122,8(100)
731,9 ±0,2	687,0(56) 583,5(44)	1179,0 ±0,3	1179,0(100)
826,6 ±0,5	519,5(100)	(1202,0 ±1,0)	1202,0(100)
927,2 ±0,3	882,3(100)		
930,9 ±0,2	931,1(2) 885,8(98)	(1215,6 ±3,0)	1215,6(100)
950,3 ±0,3	905,4(100)	(1223,5 ±0,4)	1223,5(–) 1179,0(–)
966,3 ±0,2	966,3(9) 921,4(31) 818,0(60)	1278,5 ±0,3	1278,6(30) 1233,4(44) 1130,0(26)
997,35 ±0,2	952,3(53) 849,2(47)		
1037,3 ±0,2	1037,2(55) 992,5(45)		

There are again significant discrepancies between the decay schemes obtained here and those of Stephens et al. Herrmann et al. have found similar differences and have deduced different collective bands and spin values for levels in the excitation energy region from 900 to 1200 keV.

Further work on both ^{232}Th and ^{238}U will therefore be undertaken to combine the data from the direct measurement of inelastic neutrons with the data from the measurement of the decay γ-rays. It is hoped that a comparison of Hauser Feshbach theory with the measured (n,n') cross sections will enable realistic spin assignments (and therefore also of collective bands) to be made for the level schemes which have been determined in the present work.

1.2 Inelastic scattering of neutrons from ^{232}Th

W.R. McMurray and I.J. van Heerden (SUNI)

with

E. Barnard and P. van der Merwe (AEB, Pelindaba)

Neutrons scattered from ^{232}Th have been detected in a time-of-flight system to obtain absolute inelastic cross sections from the levels in ^{232}Th at excitations greater than 700 keV. The measurements will complement the work on the level scheme and decay gammas using the (n,n'γ) reaction. Previous measurements of inelastic cross sections[1)] did not distinguish the separate levels in the excitation region above 700 keV.

Neutron time-of-flight spectra have been obtained at a series of neutron energies using the 3 MeV van de Graaff accelerator at the Atomic Energy Board. The neutron detector incorporated a 2,54 cm thick plastic scintillator on a very low noise photomultiplier tube. With constant fraction timing discrimination, the detector was capable of better than 2nsec timing resolution and bias levels down to about 50 keV neutrons. The observation of inelastic scattering from the levels with excitation greater than 1 MeV is made increasingly difficult by the relative smallness of their cross sections and the growing background particularly from fission neutrons at incident neutron energies exceeding 1200 keV. It has, however, been possible to provide information concerning the

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

existence of a level at 1023,78 keV where the corresponding gamma threshold in the $(n,n'\gamma)$ measurements was not adequately defined. As no neutron peak is observed at the energy corresponding to such a level, the 1023,78 keV γ-ray has been assigned to the decay of a level at 1073,3 keV. The excitation of the group of levels at about this energy is already observable in spectra obtained at En = 1270 keV.

The analysis of the results is continuing.

1.3 Study of the ^{75}As levels using the $(n,n'\gamma)$ reaction

P.J. Celliers and W.R. McMurray

Knowledge of the level structures of ^{75}As was mainly limited to the levels below 800 keV[1] except for less reliable information from energetic photoexcitation[2] and the observation of resonant scattering at E_γ = 822; 865 and 1074 keV.[3] Much more information on the levels and their decay properties was required to assist in the interpretation of the level structure in terms of nuclear models. ^{75}As can be considered as a $2p3/_2$ proton coupled to a ^{74}Ge core in its ground or excited states and this provides an explanation for at least some of the negative parity states.

The present work has used the $(n,n'\gamma)$ reaction to determine a detailed level scheme up to an excitation of about 1800 keV, branching ratios and neutron inelastic scattering cross sections. Incident neutrons of energy between 300 and 2200 keV were used. The final results for the levels up to 1975 keV excitation are listed in Table III. The level structure deduced here is also confirmed by (n,n') measurements undertaken for this purpose (see Item 1.4 of this report).

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1) Robinson et al., Nuclear Physics A104 (1967)104
Anne et al., Phys. Rev. 176 (1968)1329
Raeside et al., Nuclear Physics A130 (1969)677
D.L. Smith, Argonne Applied Physics Annual Report 1969/70

2) Moreh and Shahel, Israel AEC Annual Report (1969)

3) Celliers et al., International Conf. on Properties of Nuclear States, Montreal (1969)

TABLE III

Levels of ^{75}As and their decay γ-rays deduced from $(n,n'\gamma)$ measurements

Level Energy (keV)	Spin	γ-ray Energies (keV), % branching in brackets		
0	$^3/2^-$			
198,8	$^1/2^-$	198,8(100)		
264,8	$^3/2^-$	264,8(100)		
279,8	$^5/2^-$	279,8(100)		
304,0	$^9/2^+$	(304,0(100))		
400,7	$^5/2^+$	400,7(6)	136,0(64)	120,8(30)
468,6	$^1/2^-$	468,6(100)		
572,2	$^5/2^-$	572,2(100)		
618,4	$^3/2^-$	618,4(20)	419,0(70)	353,5(10)
821,9	$^7/2^-$	821,9(86)	542,9(14)	
861,2		861,2(51)	661,8(14)	459,7(35)
865,1	$^5/2$	865,1(96)	293,5(4)	
886,2		621,2(19)	606,5(56)	314,4(25)
1043,9		740,1(35)	643,1(65)	
1064,3		1064,3	799,5	785,0
1075,5	$^1/2$	1075,5(100)		

The observed γ-ray yields have been determined using the programme SAMPO. Absolute normalisation of gamma yields to (n,n') cross sections was accomplished by comparison with the γ-ray yield from the excitation of the first excited state in ^{56}Fe for which the scattering cross section is accurately known.

The deduced inelastic neutron scattering cross sections as a function of energy have been compared with Hauser Feshbach calculations using the ABACUS programme. In this case the optical model parameters could not be determined from elastic cross section data. The parameters were therefore obtained from a best fit to the measured cross sections for the levels with known J^π at 468 keV ($^1/2^-$); 572 keV ($^5/2^-$) and 618 keV ($^3/2^-$). Starting with reasonable values of the parameters only Vo and Wo had to be adjusted to give a satisfactory fit in shape and magnitude to the experimental data. The values used were

Vo	=	44 MeV	(Wood-Saxon form)
Wo	=	14 MeV	(Surface-Gaussian form)
Vso	=	7 MeV	(Differentiated Wood-Saxon)
a	=	0,62 fm	
b	=	0,50	
c	=	0,50	

H-F fits to the measured cross sections for the levels at 822; 865 and 1075 keV indicate spins of $^7/2$; ($^5/2$; $^7/2$) and $^1/2$ respectively. Evidence from the relative excitation of the 822 and 865 keV levels by Coulomb excitation and by resonant scattering favours the J = $^5/2$ assignment for the level at 865 keV.

Angular distribution measurements of the γ-rays from the (n,n'γ) reaction are in this case not very sensitive to spin value. Measurements at angles of 30; 45; 60; 75 and 90^o to the incident neutrons have been compared with theoretical calculations using the programme MANDY. The comparison confirms the spin assignments derived from H-F fits to the excitation cross sections.

1.4 Inelastic scattering of neutrons from ^{75}As

W.R. McMurray and I.J. van Heerden (SUNI)

with

E. Barnard and P. van der Merwe (AEB, Pelindaba)

Measurements of the inelastically scattered neutrons from ^{75}As were undertaken in order to confirm aspects of the level structure of ^{75}As deduced from a study of the gamma decays following inelastic scattering (Item 1.3 of this report).

Neutron spectra were observed using the 3 MeV van de Graaff accelerator at the Atomic Energy Board.

The results obtained at incident neutron energies between 1050 and 1350 keV give direct confirmation of all the low lying levels up to 618,4 keV which were previously found in other investigations. The new levels now deduced in the (n,n'γ) study in the range from 821,9 to 1128,5 are also clearly observed.

These results will be used to obtain absolute cross sections to check on those derived from the measurement of the decay γ-rays.

1.5 A small sample method for investigation of the $(n,n'\gamma)$ reaction

S.A. El Bakr+, I.J. van Heerden, W.K. Dawson+
W.J. McDonald+ and G.C. Neilson+

A technique has been developed to study $(n,n'\gamma)$ reactions using very small scattering samples, in which the scatterer is placed in close proximity to the neutron source. In this arrangement, the neutron beam through the scatterer is neither monoenergetic nor of constant flux, and there is also no possibility of shielding the γ-detector from the neutron beam. To show that reliable yield curves can be obtained with this technique, the excitation for the 847 keV γ-ray in ^{56}Fe has been measured, using a 3,147 gm natural Fe scatterer.

To correct for geometric effects, an unfolding technique was developed to account for the angular distribution and energy distribution of the neutrons through the scatterer, and for the γ-ray attenuation in the scatterer. Time-of-flight gating was used to discriminate against neutron induced events in the Ge(Li) detector. The resulting yield curve that was obtained for the 847 keV γ-ray in ^{56}Fe is in good agreement with previous data.[1)]

A publication describing this method has been published in Nuclear Instruments and Methods, 97(1971)283.

1.6 Energy levels and transitions in ^{114}Cd from the $(n,n'\gamma)$ reaction

S.A. El Bakr+, I.J. van Heerden, W.J. McDonald+ and G.C. Neilson+

The ^{114}Cd nucleus has been the object of a great number of experimental and theoretical investigations. Through (n,γ), (d,p), (p,p'), (d,d') and coulomb excitation, levels have been well established at 557 keV (2^+), 1135 keV (0^+), 1210 keV (2^+), 1283 keV (4^+)

+ Nuclear Research Centre, University of Alberta, Edmonton, Canada

1) R.W. Benjamin, P.S. Buchanan and I.L. Morgan
Nucl. Phys. 79 (1966)241

1305 keV (0^+) and 1363 keV (2^+). The strongly enhanced B(E2) transition strengths observed in coulomb excitation work[1,2] are evidence for a collective nature of the low-lying levels in ^{114}Cd. The four lowest excited states fit well in the picture of one phonon and two phonon quadrupole vibrational excitations. However, levels above 1,4 MeV are not very well known and furthermore, different results have been obtained regarding the mode of decay of the 1210; 1305 and 1363 keV levels.

The small sample method[3] in conjunction with a high-resolution timing Ge(Li) spectrometer have been used to observe γ-rays following neutron inelastic scattering from ^{114}Cd. Gamma-ray excitation curves have been measured in the neutron energy range of 1,1 to 2,1 MeV. The present experiment confirms the existence of levels at 1730; 1840; 1862; 1956 and 2047 keV. The 1210 keV transition is observed at E_n = 1,2 MeV and 1363 keV at E_n = 1,4 MeV. This rules out Smither's suggestion[4] that the 1210 and 1363 keV transitions depopulate a level at 2573 keV (=1209 + 1363 keV). Analysis is in progress to determine spins of levels above 1,4 MeV excitation.

1.7 Levels of ^{154}Sm from the (n,n'γ) reaction

S.A. El Bakr+, I.J. van Heerden, B.C. Robertson+, W.J. McDonald+ and G.C. Neilson+

The ^{154}Sm(n,n'γ)^{154}Sm reaction has been used to study the properties of ^{154}Sm excited states up to 2 MeV excitation. Gamma-ray decay modes and excitation functions have been ueasured using a Ge(Li) detector. The energy resolution of the Ge(Li) detector was sufficient to resolve gamma-rays from the levels at 1178 and 1182 keV excitation. The existence of levels at 1120; 1204; 1338; 1515; 1540 and 1550 keV has been confirmed. Additional new levels have been proposed at 1707; 1756; 1891; 1923 and 2070 keV excitation. Level

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+ Nuclear Research Centre, University of Alberta, Edmonton Canada.

1) P.H. Stelson and F.K. McGowan, Phys. Rev. 121(1961)209

2) F.K. McGowan, R.L. Robinson, P.H. Stelson and J.L.C. Ford, Jr., Nucl. Phys. 66(1965)97

3) S.A. El Bakr, I.J. van Heerden, W.J. McDonald and G.C. Neilson, Nucl. Inst. and Method, 97(1971)283

4) R.K. Smither, Phys. Rev. 124(1961)183

spins have been inferred by comparing the branching ratios to the predictions of the collective model, and by comparing the production cross sections to the predictions of the Hauser-Feshbach statistical model. Spin assignments have been made of 2^+, 5^- and 3^+ to the levels at 1178; 1182 and 1540 keV respectively. The latter has been identified at the 3^+ member of the γ-vibrational band.

The following comments on the decay scheme of ^{154}Sm have to be made:

(a) The 1120 and 1204 γ-rays have two different thresholds and therefore do not belong to the same level. These two levels have been observed at 1120 and 1209 keV by (p,p'). (Phys. Rev. 135 (1964) 3939).

(b) The two γ-rays 1255,9 and 1070,9 keV show a threshold of 1,4 MeV, and therefore they originate from a level at 1338 keV. This level has been observed by (p,p') at 1344 ±10 keV.

(c) At E_p = 4,0 MeV, E_n^{eff} = 2,1 MeV, the following weak γ-rays are observed:

E	Possible origin
743	1756 → 921
839	1756 → 1012
1503	1584 → 82
1540	1540 → 0
1550	1550 → 0
1584	1584 → 0
1660	1660 → 0
1657	1923 → 267
1809	1891 → 82
1842	1923 → 82
1892	1892 → 0
2070	2070 → 0

1.8 The level structure of ^{93}Nb and ^{115}In from (n,n'γ) measurements

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

The decay schemes of ^{93}Nb and ^{115}In mentioned in the previous report were based on γ-ray spectra obtained from inelastic neutron scattering. These spectra have been re-analysed using the SAMPO programme. The γ-ray yields have been corrected for neutron flux, γ-ray attenuation in the scatterer, γ-ray efficiency of the Ge(Li) detector and the effect of the time-gate used to discriminate against neutron induced events in the detector. Absolute γ-ray production cross sections were obtained by comparison to the γ-ray yield of the 847 keV line from ^{56}Fe(n,n'γ) at a few selected neutron energies. Yield curves for neutron inelastic scattering cross sections have been determined from the observed branching ratios and these are now being compared with Hauser-Feshbach predictions.

1.9 The level structure of ^{55}Mn from (n,n'γ) measurements

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

In order to obtain more information about the energies and spins of levels of ^{55}Mn, the γ-ray transitions following inelastic scattering of neutrons have been studied.

A number of γ-ray spectra were obtained for incident neutron energies between 1000 and 2875 keV in 125 keV steps. From the relative excitation cross sections and threshold energies of the observed gammas a level scheme with levels at 125,77; 984,75; 1292,39; 1528,72; 1884,27; 2197,97; 2252,03; 2266,1; 2278 and 2365,16 keV has been deduced. Further work is being planned to resolve the uncertainties which still exist especially with regard to the group of levels above 2198 keV.

1.10 The reaction ^{45}Sc(p,p'γ)^{45}Sc

N.J.A. Rust, W.J. Naudé, J.W. Koen and W.L. Mouton

The investigation of the properties of low-lying energy levels of ^{45}Sc was continued with the intention of describing these in terms of the excited core model. According to this model the coupling of a $^{7}/2^{-}$ proton to the first excited (2^{+}) state of ^{44}Ca gives rise to the splitting of a multiplet of states with spins $^{3}/2^{-}$; $^{5}/2^{-}$; $^{7}/2^{-}$; $^{9}/2^{-}$; and $^{11}/2^{-}$ in ^{45}Sc. Energies and branching ratios of states up to 1,8005 MeV were accurately determined with the reaction ^{45}Sc(p,p'γ)^{45}Sc. The yield of inelastically scattered protons was measured at the laboratory angles 90°; 130° and 150° for incident proton energies from 5,2 to 5,48 MeV. Average cross sections were compared with predictions on the basis of Hauser-Feshbach theory in an attempt to eliminate spin uncertainties. Preliminary results combined with existing knowledge indicate that the levels at 0,3762; 0,7204; 1,2373; 1,4092 and 1,6620 MeV are the members of the above-mentioned multiplet.

1.11 Polarization in n-p and n-d scattering

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

The polarization in n-p scattering has been studied at 16 MeV and 22 MeV using an anthracene scintillation crystal as a polarization analyser. The directional dependence of the pulse shape discrimination properties of the crystal enable one to determine directions of recoil protons within the crystal and thus to determine the left-right asymmetry in the scattering of polarized incident neutrons. Preliminary results obtained at 22 MeV were published in the Proceedings of the Third International Symposium on "Polarization Phenomena in Nuclear Reactions" (ed. H.H. Barschall and W. Haeberli, University of Wisconsin Press, 1971, p.430). Further measurements made at these energies will shortly be submitted for publication. This work has now been extended to other energies in the range 8 to 22 MeV and the polarization in n-d scattering is also being studied by the same technique using a deuterated anthracene crystal.

1.12 Cross sections for the D(n,n) and D(n,2n) reactions

G. Pauletta and F.D. Brooks

The D(n,n) and D(n,2n) reactions have been studied in the neutron energy range 5 to 22 MeV by bombarding a deuterated liquid scintillator with monoenergetic neutrons and using pulse shape discrimination techniques to identify the respective charged particle products, namely recoil deuterons and breakup protons. The two reactions may be separated very clearly in this manner and the ratio of their respective cross sections may thus be obtained directly. The cross sections for the two reactions are then obtained by combining the ratio values with total cross section data taken from the literature. The results obtained in the 12 to 22 MeV region are now being prepared for publication.

1.13 Fission Isomer in Uranium-236

J.V. Pilcher, F.D. Brooks and W.R. McMurray

A search was made for fission isomers produced by bombarding natural and enriched (35% U-236) uranium metal samples with pulsed 30 ± 15 keV neutrons and detecting high energy fission neutrons between accelerator bursts. The samples were 2,5 cm diam discs of mass ~ 15 gm and the fission neutron detector was a liquid scintillator (NE213, volume ~ 1,2 litre) fitted with a pulse shape discriminator. Data were also taken with an indium sample, with pulse shape discrimination off (indium has a relatively high capture cross section), to determine the time distribution of incident neutrons at the sample position.

A least squares analysis of the time distribution of detected fissions indicated a fission isomer in ^{236}U of half life 92 ± 15 nanoseconds. An isomer ratio (ratio of isomeric to prompt fissions) of 0,008 ± 0,004 was also deduced from the data. This half life is in agreement with the values reported by Elwyn and Ferguson (Nucl. Phys. A148(1970)337) and by Boca et al. (Rev. Roum.Phys.Tome 16 No. 4(1971)473). However the present isomer ratio is about a factor of 5 lower than expected on the basis of the results of Boca et al.

1.14 Search for superheavy elements

C. Rudolph, F.D. Brooks and R.D. Cherry

A 4π-six-detector neutron multiplicity counter has been constructed and is now in use on a routine basis to screen natural samples for possible superheavy element content. The six detectors are liquid scintillation counters fitted with pulse shape discriminators to reject gamma-rays. The associated electronic logic includes effective means for vetoing spurious events initiated by energetic charged cosmic ray particles. The sample material is placed at the centre of the system and the search is based on the detection of neutron coincidences from spontaneous fissions within it. Superheavy fissions are expected to show a high fission neutron multiplicity, which should thus render them recognizable.

The samples investigated to date include manganese nodules dredged from the seabed, lead of unknown origin and osmium and iridium ore concentrates. None have so far shown significant evidence of a superyheavy presence.

1.15 The direct excitation of analogue dipole states via (n,p) reactions

B.T. Chait, S.M. Perez and F.D. Brooks

The direct excitation of analogue dipole states in the product nuclei of the $^{28}Si(n,p)^{28}Al$ and $^{40}Ca(n,p)^{40}K$ reactions is being studied using neutrons in the 20–30 MeV energy range. The cross-sections and angular distributions for such transitions are being investigated and compared with predictions based on the theory developed by Clement and Perez (Nucl. Phys. A165(1971)569). At present there is little experimental data available for making such comparisons.

The reaction on ^{28}Si is studied using a pair of silicon surface barrier detectors placed 10–20 cm apart; and that on ^{40}Ca using a CaF_2 scintillation crystal paired with a single surface barrier detector. In each case protons from (n,p) reactions in the first detector, which travel to the second detector are selected. At 22 MeV the discrimination is performed using the time-of-flight technique and at 30 MeV using a ΔE–E telescope.

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

Relevant research facilities include a 2 MeV pressurized Cockcroft-Walton accelerator which was modified for positive ion operation during 1971, a small neutron generator and an EN-tandem, installation of which started at the end of 1971. Major research projects include charged particle reactions, ion channeling and neutron activation studies.

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

Neutron physics research is carried out at a 3 MeV pulsed van de Graaff accelerator, equipped with terminal pulsing and klystron bunching, as well as at the 20 MW research reactor, Safari I. A CDC-1700 computer is used for on-line data collection and processing at the accelerator.

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

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

The tangential thermal beam tube in the reactor, which is used as a neutron source for capture studies, was modified in order to reduce the gamma-ray background. Additional results were obtained on the capture gamma-ray spectra from samples of ^{70}Ge and ^{58}Ni. The behaviour of a neutron wave guide was investigated in some detail.

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

Energy levels in stable nuclei at excitation energies up to about 1,5 MeV were studied by means of (n,n'γ)-reactions, employing the van de Graaff accelerator and the ^{7}Li(p,n)-reaction as neutron source and Ge(Li)-diodes with fast timing as gamma detectors. Results on level schemes of ^{127}I, ^{197}Au, Sb and Br have been published[1-4]. Similar studies on Cs, Rb and Ho are in an advanced stage of preparation for publication.

3.3 Fast neutron scattering

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The results of a detailed study of total-, elastic- and inelastic scattering cross sections for fast neutrons on ^{45}Sc have been published[5]. Inelastic scattering cross sections for Ti, combined with elastic scattering and total cross section measurements done at Argonne, are still being analysed at ANL. Detailed local measurements on Cs and Rb (totals, elastic and inelastic scattering) are being analysed at Pelindaba. Elastic scattering and high resolution differential inelastic scattering measurements on the 126 keV level in Mn have been completed. Some (n,n')-measurements on Ho, to complement the (n,n'γ)-studies mentioned in the previous section, have also been carried out.

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1) Z. Physik 243(1971)121
2) Nucl. Phys. A167(1971)511
3) Nucl. Phys. A172(1971)215
4) Z. Physik 246(1971)424
5) Z. Physik 245(1971)36