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EXPERIMENTAL PHYSICS DIVISION

1. ENERGY DEPENDENCE OF FISSION FRAGMENT ANISOTROPY IN FAST NEUTRON FISSION OF ^{235}U.

(M. M. ISLAM, A. H. KHAN, M. KHALIQUZZAMAN, M. A. RAHMAN, M. ENAYETULLAH AND D. A. M. ABDULLAH)

Studies of fission fragment anisotropy are important because such studies provide information about the nuclei at the saddle point. For each compound nucleus the two principal factors affecting the fission anisotropy are K_0^2 and the mean square orbital angular momentum $<l^2>_{av}$. The quantity K_0^2 is the standard deviation in the Gaussian distribution that is assumed for K, where K is the projection of the total angular momentum in the nuclear symmetry axis.

Below the second chance fission threshold, the expression for anisotropy[1] is given by

$$\frac{W(0°)}{W(90°)} = 1 + \frac{<l^2>_{av}}{4K_0^2} - \frac{<l^2>_{av} I_0^2}{36 K_0^4} \cdots \quad \cdots (1)$$

Here I_0 is the spin of the target nucleus.

From the studies of (d,pf) reaction, it was suggested[2] that the pairing energy gap ($2\Delta_0$) in the transition state spectrum of ^{240}Pu is considerably larger than the energy gap when it is at the equilibrium deformation. Nadkarni et al[3] also reported such observation in ^{235}U (n,f). The quantity is determined from the fact that when the quantity ($E^* - E_f$) of the fissioning compound nucleus reaches $2\Delta_0$, there is a sudden decrease in anisotropy or corresponding step increase in K_0^2 value. The main interest of the present work is also the investigation of this phenomena in the case of ^{235}U(n,f) and the verification or otherwise of the previous observations.

Experimental procedure and data analysis

The anisotropy measurements were done by using 2 heavy ion detectors, 25 mm in diameter made by ORTEC and placed inside a thin walled brass vacuum chamber. The detectors, one at 0° and the other at 90° to the beam direction were used simultaneously to measure the fission yield. The distance between the target and the detectors were 3 cm in each case. The target was $\sim$200 $\mu g/cm^2$ enriched (99%) ^{235}U of 1 cm diameter. The backing material used for the target was 1 mil aluminium foil. The target was placed at 45° to the beam direction. Neutrons were produced by using T(p,n) and D(d,n) reactions with the beam from the 3 MeV Van de Graaff of the Atomic Energy Centre, Dacca. The spread in neurtron energy were calculated from stopping power of protons in the target and also from the kinematic spread due to finite size of the target. Average beam current used was$\sim$40 μA. With such current it was necessary to have arrangements for target cooling. Both water cooling and compressed air cooling with wobling target were tried.

In the spectra obtained from the experiment, slight overlap were noticed between the α and fission peaks. So corrections were applied to fission yields by using an eye estimate tail to fit the fission peak. The corrections arising from such a procedure were of the order of 1-2 percent only and as such uncertainty involved in this correction was very small. Corrections were also applied for finite size of the detectors and for neutron flux variation across the surface of the target.

Results and Discussions

Preliminary results of the present measurements along with the data of other workers[3,4] are plotted in Fig. 1.1. It is seen that the values of anisotropy measured in this work are slightly lower than the values of others. However, we plan to verify these data again with good statistical

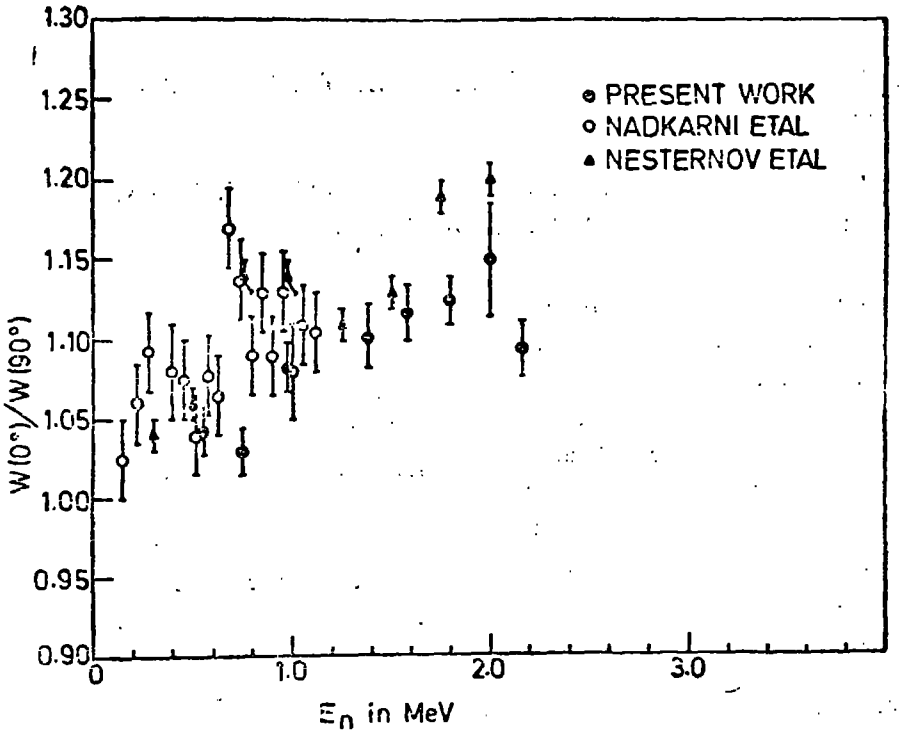

Fig. 1.1. Experimental values of fission fragment anisotropy in ^{235}U versus incident neutron energy

accuracy, and to measure anisotropies for a number of other neutron energies in order to investigate in detail the variation of K_0^2 with E_x^*. The present results also seem to indicate that the anisotropy is a smooth function of energy. But further measurements will be carried out to confirm as to whether or not the anisotropy has a break at $E_n \sim 0.8$ MeV ($E^* - E_f \sim 2.0$ MeV) as observed earlier by Nadkarni et al[3].

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4. V. G. Nesternev, G. N. Smirenkin and D. L. Shpak, Sov. Jr. Nucl. Phys. 4, 713 (1967).

2. TWO PARAMETER STUDY OF FRAGMENT MASS—KINETIC ENERGY CORRELATIONS IN FAST NETRON FISSION.

(M. M. ISLAM, A. H. KHAN, M. KHALIQUZZAMAN, E. HUSSAIN, A. RAHMAN AND P. K. PAL*)

Study of the details of the fragment mass and energy distributions and mass-energy correlations as a function of the compound nucleus excitation energy is important from the point of view of understanding the fission process. A programme has been taken up in our laboratory on this

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topic and some measurements have been performed with a ^{238}U target. Neutrou beam was obtained from the 3 MeV Van de Graaff Accelerator using D (d, n)^3 He reaction.

Two parameter data in 64 x 64 channel configuration were recorded by doing a double energy experiment with two detectors at 180° to each other. Preliminary analysis of data at thermal and 1 MeV neutron energy have been performed using the Grid method of Schimitt et al[1] and the results are shown in Figs. 2.1 and 2.2. From qualitative considerations the results obtained appear satisfactory. Further analysis of data from measurements already done are in progress and further experiments are also planned.

Reference : 1) H. W. Schimitt et al, Phys. Rev. **141**, 114 (1966).

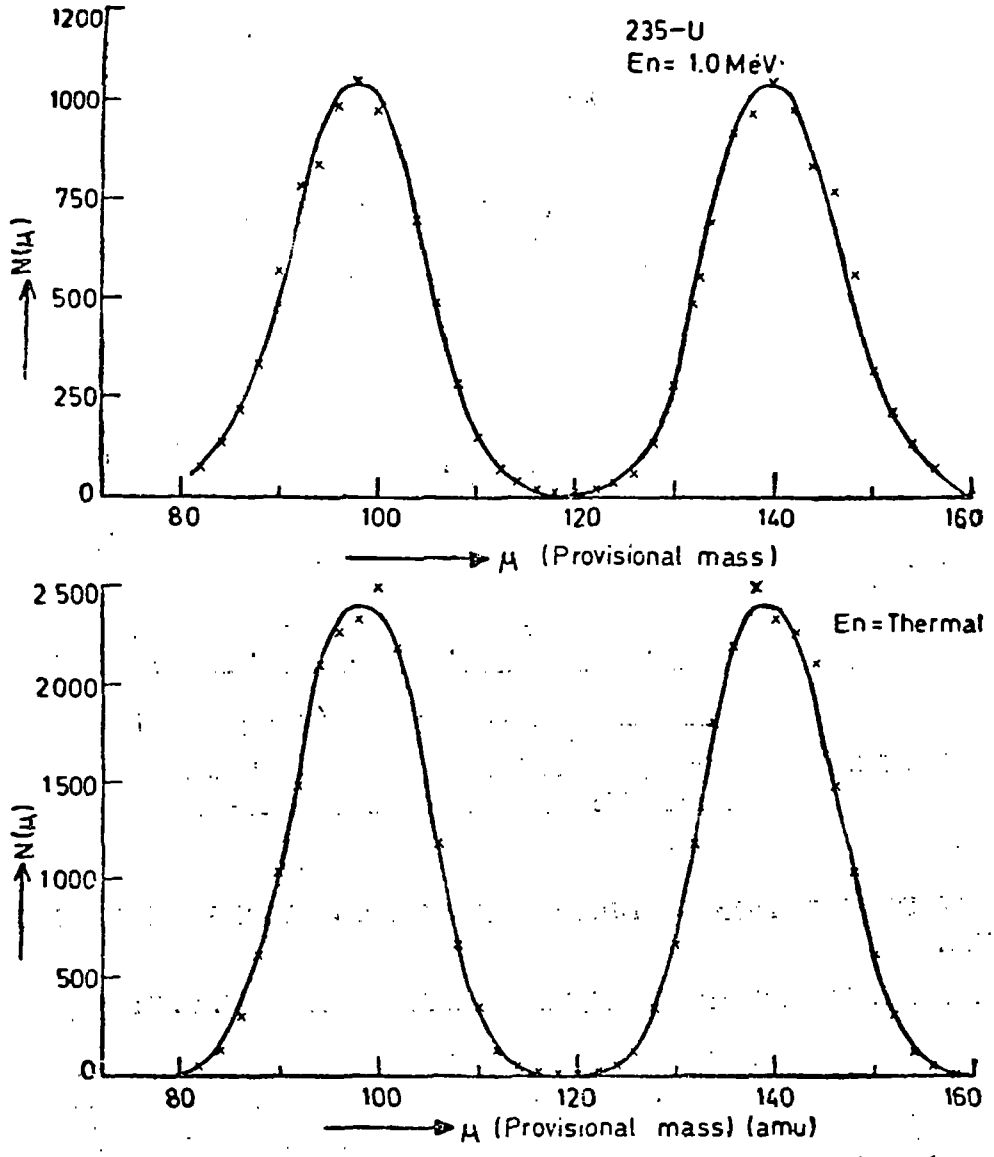

Fig. 2.1. A plot of the counts versus provisional mass for the thermal and 1 MeV neutron induced fission of ^{235}U

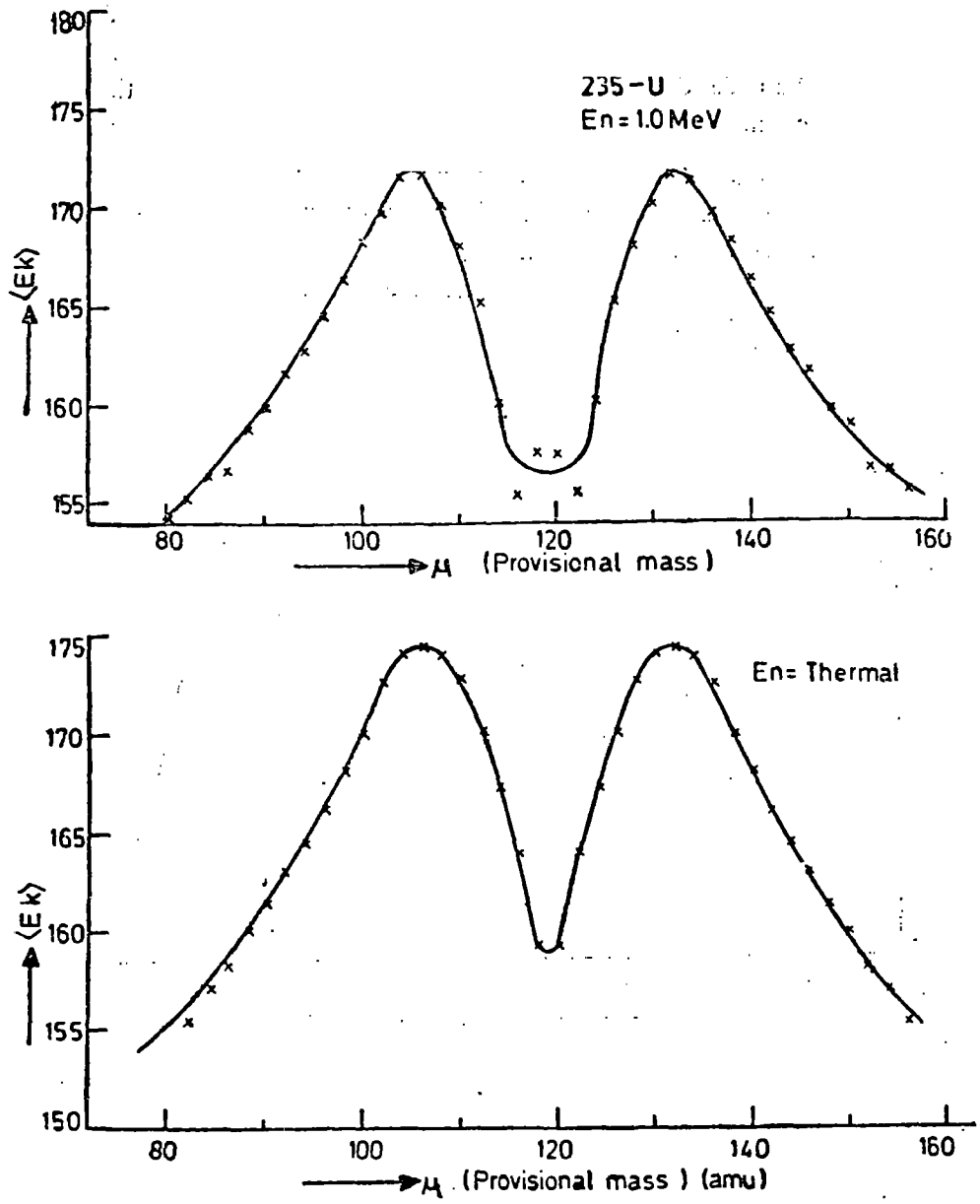

Fig. 2.2. Kinetic Energy distribution against provisional mass in the thermal and 1 MeV neutron induced fission of ^{235}U

3. ANGULAR DISTRIBUTION STUDIES OF PROTON CAPTURE REACTIONS IN ^{43}Ca, ^{51}V AND ^{51}Fe.

(M. A. AWAL, M. A. RAHMAN, H. M. SEN GUPTA* AND G. U. DIN**)

The resonance spectra at $E_p = 1644$ and 1650 keV in the $^{43}Ca(p,\gamma)^{45}Sc$ reaction at 0°, 30°, 45°, 60° and 90° were studied with the help of a 2 MeV Van de Graaff Accelerator of the Australian National University, Canberra, Australia. Gamma rays were detected by a 30 cc Ge (Li) detector

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having a resolution of 5 keV for the 1332 keV gamma line of ^{60}Co source and were recorded with a Nuclear Data 4096 channel pulse height analyser.

The resonance spectra at $E_p = 2329$ keV in the ^{51}V (p,γ)^{52}Cr reaction at 0°, 30°, 55° and 90° and those at $E_p = 1730$ keV in ^{54}Fe (p,γ)^{55}Co reaction at 0°, 30°, 45° and 90° were taken with the help of a 5.5 MeV Van de Graaff Accelerator of the Bhabha Atomic Research Centre, Bombay, India. Gamma rays were detected by a 20 cc Ge(Li) detector having a resolution of 5 keV for the 1332 keV gamma line of ^{60}Co source and were recorded with a 4096 channel pulse height analyser. The energies, relative intensities, probable transitions and branching ratios of the deexciting levels have been obtained.

The data of the above studies were analysed at the AEC, Dacca. The angular distribution fits for a number of gamma rays were obtained with the help of the relation

$$W(\theta) = 1 + a_2 p_2 (\cos\theta) + a_4 p_4 (\cos\theta)$$

From the known knowledge of spin values of the low-lying levels, the possible spin values of the resonance levels were computed from a set of plots of X^2 versus arctan δ. The values of X^2_{min} and mixing ratios at 0.1% confidence level for different spin assignments in all the cases are shown in Table 3.1.

Table 3.1

The values of X^2_{min} and mixing ratios at 0.1% confidence level for different spin assignments

E_p(Lab) (keV)	Primary transition	Branching ratio %	Spin sequences.	X^2_{min}	Mixing ratio at confidence level 0.1%	min	0.1%	gΓ (eV)
	(a)		^{44}Ca(p,γ)^{45}Sc reaction					
	8490	9	3/2—3/2	0.43	0.3	0.30 M2/E1	−0.16	
					11.40	−3.27	−1.64	18.34
1644	8127	23	3/2—3/2	0.32	0.01	0.21 M2/M1	0.33	
	7565	6	3/2—1/2	0.24	−0.27	−0.10 M2/E1	−0.02	
					1.61	2.35	3.74	
	7200	7	3/2—3/2	0.44	−0.01	0.70 M2/E1	0.46	
1650	7568	38	3/2—1/2	0.10	0.066	0.17 M2/E1	0.10	
					1.37	1.66	2.04	
	(b)		^{51}V (p, γ) ^{52}Cr reaction					
	10415	31	4—4	0.24	0.36	0.51 M2/E1	0.63	
2329					4.8	2.60	1.84	
	9172	25	4—5	0.56	0.11	0.92 M2/E1	4.91	
	(c)		^{54}Fe (p,γ) ^{55}Co reaction					
1730	6755	90	7/2—7/2	0.32	0.35	0.46 E2/E1	0.57	

a) The spin assignments of the 1644 and 1650 keV resonances in the ^{44}Ca (p,γ)^{45} Sc reaction.

The sepectra taken at 90° have been considered for the decay scheme. The decay schemes in ^{45}Sc for the 1644 and 1650 keV resonances have been obtained. The angular distribution fits and the X^2 analyses of the 8490, 8127, 7565 and 7200 keV γ—ray transitions from the 1644 keV resonance to the 12.4, 376, 938 and 1303 keV levels and that of the 7568 keV γ-ray transition from the 1650 keV resonance to the 938 keV level have been obtained. The last case is shown in Fig. 3.1 as an example. From the above analyses the spins of both the resonances are found to be 3/2. In the present analyses the spins of the 1555 and 2350 keV levels are confirmed to be ½ and 3/2 respectively.

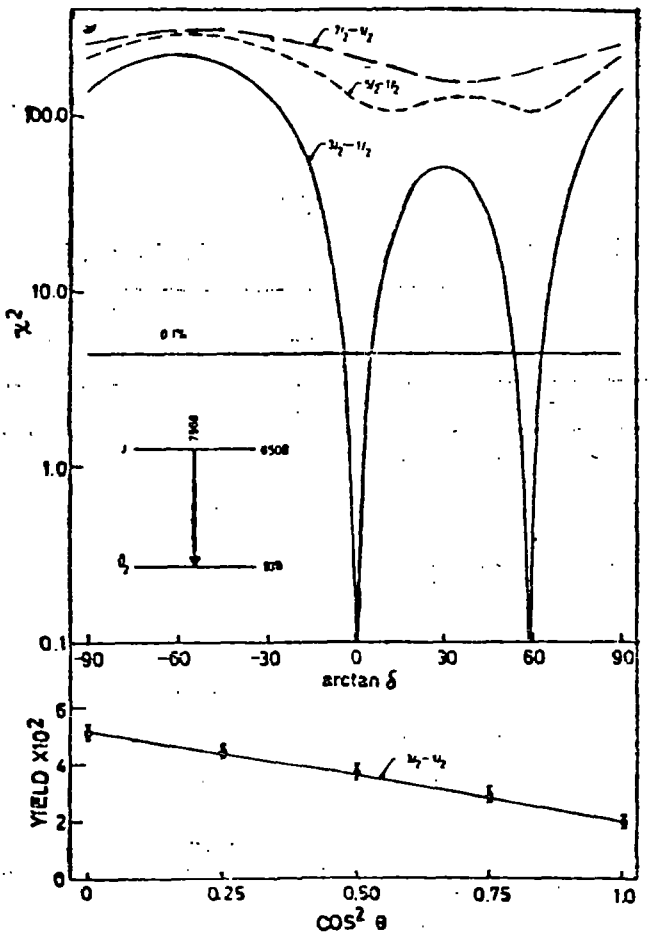

Fig. 3.1. Angular distribution and X^2 analysis of the 7568 keV γ-ray transition from the 1650 keV resonance in ^{45}Sc

b) The spin assignment of the 2329 keV resonance in the ^{51}V (p,γ)^{52}Cr reactions.

The decay schemes of the resonance and the branching ratios of the different states are shown in Fig. 3.2. The angular distribution fits and X^2 analyses of the 10415 and 9172 keV γ-ray transitions from the resonance level to the 2370 and 3613 keV levels have been obtained. From these analyses, the resonance spin has been assigned to be 4. This resonance is thus confirmed to be the analogue state in ^{52}Cr corresponding to the 1559 keV parent state in ^{52}V.

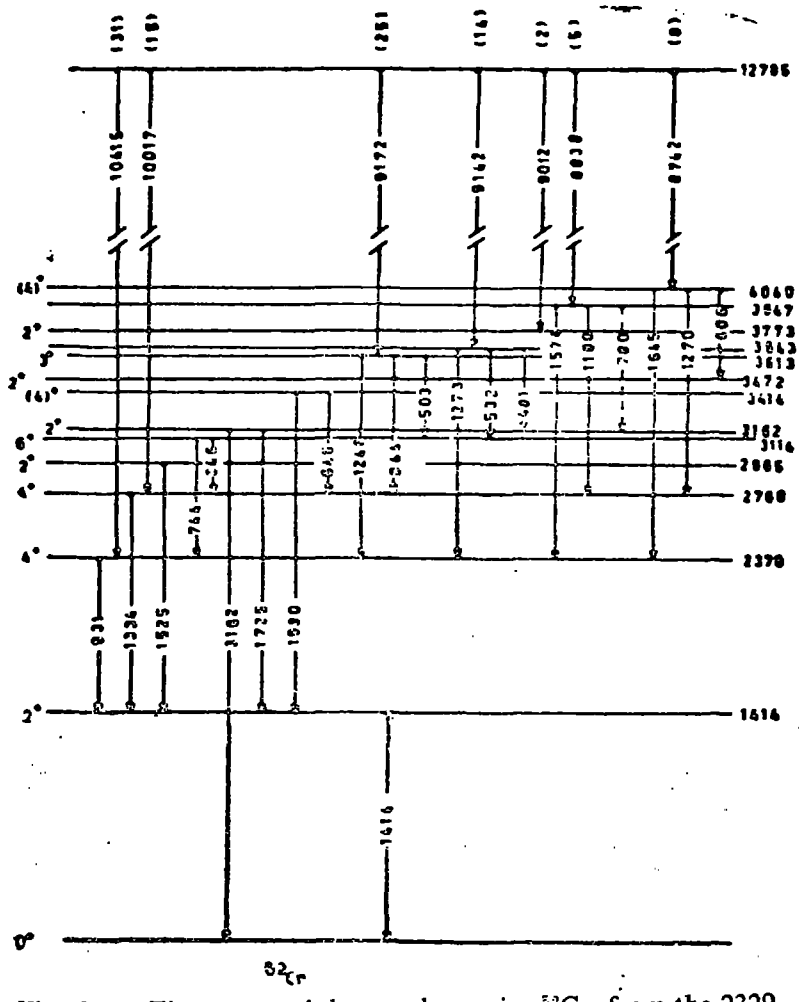

Fig. 3.2. The proposed decay scheme in ^{52}Cr from the 2329 keV resonance in the $^{51}V(p,\gamma)$ ^{52}Cr reaction

c) Spin assignment of the 1730 keV resonance in the ^{54}Fe (p,γ)^{55} reactions.

The χ^2 analyses and the angular distribution fits of the 6756 keV γ-ray transition from the resonance level to the G,S. are shown in Fig. 3.3. From these analyses, it is observed that the spin of the resonance level is ought to be 7/2 since only the 7/2 transition lies fairly below the 0.1% confidence level.

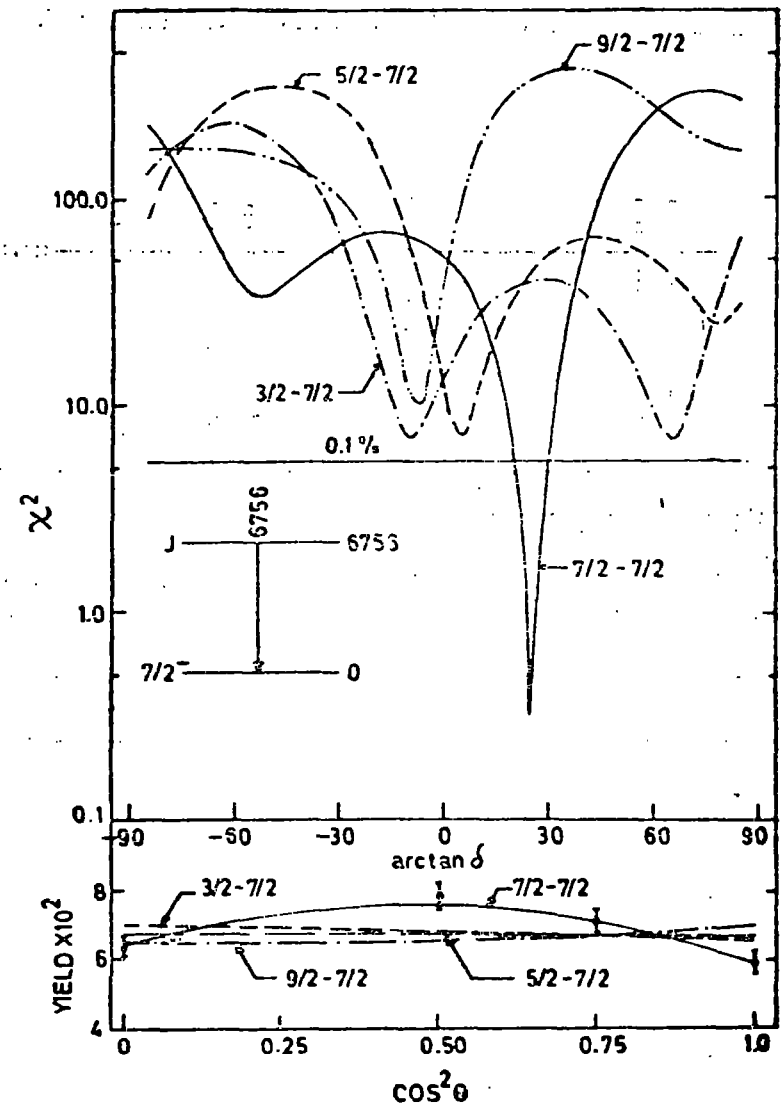

Fig. 3.3. Angular distribution and χ^2 analysis of the 6756 keV γ-ray transition from the 1730 keV resonance

4. THE LEVEL SCHEMES IN ^{56}Co AND ^{57}Co

(M. A. AWAL, H. M. SEN GUPTA* AND G. U. DIN**)

The ^{54,56}Fe(p,γ)^{55,58}Co reactions were employed for constructing the level schemes in ^{55,58}Co nuclei from a number of singles spectra taken at the Australian National University, Canberra, Australia

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with the help of a 2 MeV Van de Graaff Accelerator. Gamma rays were detected with a high resolution 34 cc Ge(Li) detector having a resolution of 2.3 keV for the 1332 keV gamma line of ^{60}Co source. The energies, intensities, probable transitions of the γ-rays and branching ratios of the deexciting levels were obtained. Four resonances at E_p=1286, 1680, 1730 and 1747 keV in the ^{54}Fe $(p,\gamma)^{55}$Co reaction have been utilised to construct the decay schemes in ^{55}Co. A few new levels at 3885, 3906, 3950, 4240 and 4320 keV have been assigned. The agreement between the present work and others [1-3] is fairly good.

The ^{57}Fe(p,γ)^{58}Co reaction has been studied at E_p=1355, 1360, 1436, 1446 and 1583 keV resonances. The 1355, 1360, 1436 and 1446 keV resonances were studied for the first time. The decay schemes of the ^{58}Co nucleus are complex as shown in Fig. 4.1 in the case of the 1360 keV resonance. It may be mentioned that the levels at 458, 1040, 1185, 1814, 1865, 2424, 2686, 2782, 3070, 3125. 3152, 3202, 3263, 3376, 3393, 3418, 3445 keV and those above 3512 keV have not been observed in the only other (p,γ) work of Erlandsson and Marchinkowski[4]. The 2105, 2642 and 3011 keV levels found by them however could not be assigned in the present work. The agreement between the present work and that of Schneider and Daehnick[5] is fairly good.

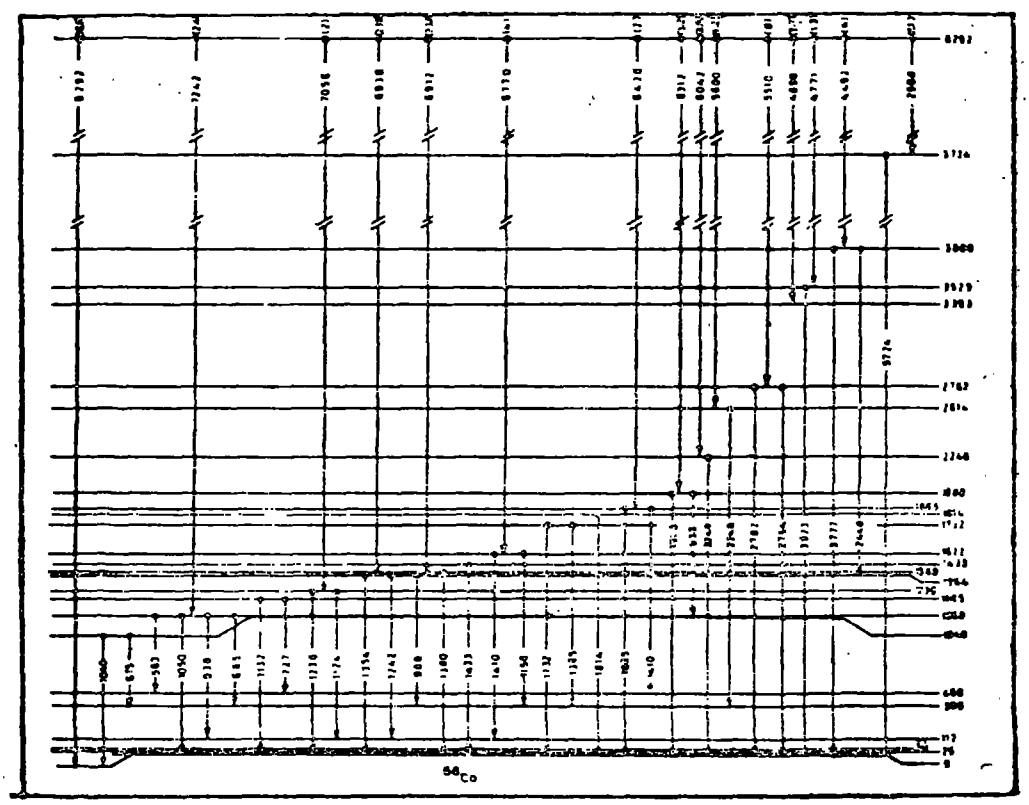

Fig. 4.1. The proposed decay scheme in ^{58}Co from the 1360 keV resonance in ^{57}Fe(p,γ) ^{58}Co reaction

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3. B. Erlandsson, Ark. for Fys. 34, 263(1967).
4. B. Erlandsson and A. Marchinkowski, Nucl. Phys. A 146, (1970).
5. M. J. Schneider and W.W. Daehnick, Phys. Rev. C5, 1330 (1972).

5. THE RELATIVE EFFICIENCY MEASUREMENTS OF 30 CC Ge(Li) DETECTOR

(M. A. AWAL, M. A. RAHMAN AND M. ZAHUR ALI)

The relative efficiency curves of a 30 cc Ge(Li) detector (type 5603 of Philips, Holland) have been measured between 1 and 11 MeV. These curves have been obtained with the help of proton capture reactions in ^{27}Al. It was observed that the 992 keV resonance in the ^{27}Al (p,γ) ^{28}Si reaction was particularly suitable since it emits a number of strong gamma rays from 1.78 to 10.76 MeV and is formed mostly by s-wave proton capture (99% $l=0$, 1% $l=2$). Thus the angular distributions of the gamma rays are particularly isotropic [1]. The resolution of the detector was found to be 0.2 keV for the 1332 keV line of ^{60}Co source. The spectra of the resonance were stored in a 4096 channel Nuclear Data pulse height analyser. The efficiency is defined as the number of events counted in a peak in a gamma ray spectrum divided by the number of events actually produced by the monoenergetic source over 4π geometry. The efficiency ratio of the gamma ray energies is related to the ratio of their peak areas and their relative intensities in the source in the following from

$$\epsilon_1/\epsilon_2 = (N_1/N_2)\,(I_2/I_1)$$

where ϵ_1/ϵ_2, N_1/N_2 and I_1/I_2 are the ratios of the efficiencies, peak areas and intensities respectively for the two gamma rays. The "two line method" based on the measurement of ratios of efficiencies has been used in the present analysis. With the help of the known intensities of the 992 keV resonance[2], it was possible to build up relative efficiency curves for the full energy, single escape, double escape and for the ratio of double escape to full energy as shown in Fig. 5.1.

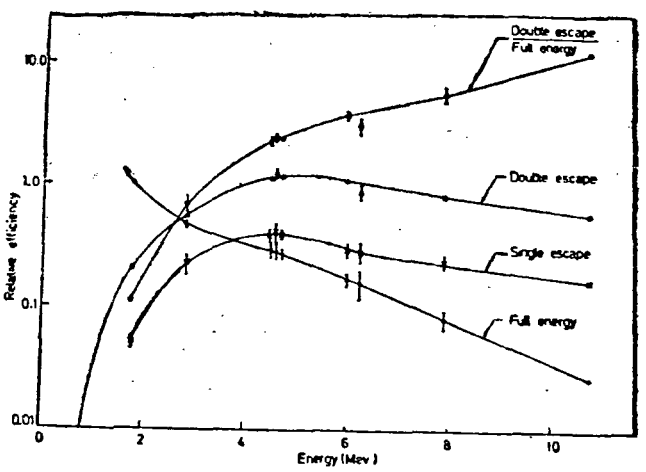

Fig. 5.1. The relative efficieney curves of a 30 cc Ge(Li) detector for the full energy, single escape, double escape and the ratio of the double escape to full energy.

References

1. L. Simons, K.E. Nysten, M. Koskelin, O. Siltanen, E. Spring and G. Wendt, Phys. Lett. 3, 306 (1963).
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6. STUDY OF REACTION MECHANISM AND LIFE TIME MEASUREMENTS

(M. SANA ULLAH, M. DILDER HOSSAIN AND M. KHALIQUZZAMAN)

The data taken from previous measurements on $^{54}Fe(p,\gamma)^{55}Co$ have been analysed. The results obtained are briefly discussed. The yield curve for the reaction was measured for $E_p = 1106-1747$ keV. The resonance energies and the corresponding excitation energies are listed in Table 6.1.

Table 6.1.

The $^{54}Fe(p,\gamma)^{55}Co$ resonance and the corresponding energy levels in ^{55}Co

Proton Energy E_p (KeV)	Excitation Energy in ^{55}Co E_x (KeV)
1106	6150
1161	6204
1224	6266
1286	6327
1328	6368
1369	6408
1474	6511
1638	6672
1653	6687
1666	6700
1679	6712
1721	6754
1747	6780

Q—Value = 5064 ± 2 KeV.

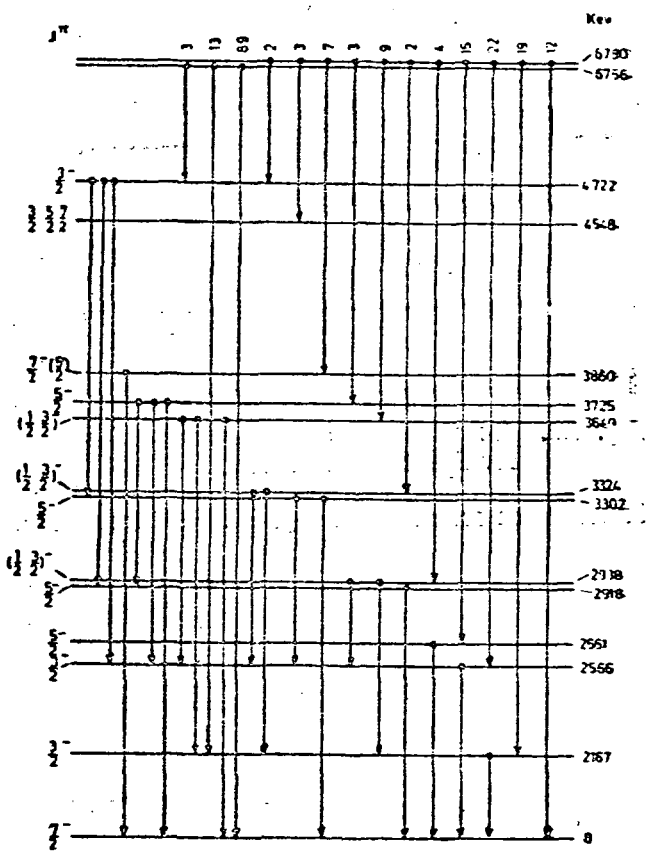

Fig. 6. 1. Decay scheme and branching ratios for $E_p = 1747$ keV resonance

The decay schemes for the resonances at E_p = 1747, 1721, 1679, 1666, 1653, 1474, 1286, 1224, 1161 1106 keV were established by detecting the reaction γ-rays with high resolution co-axial Ge(Li) detectors. Decay schemes and branching ratios of some prominent resonances are shown in Fig. 6.1—6.3. The branching ratios are given in percentages. The γ-decay branching ratios for the low-lying states of ^{55}Co observed in the present

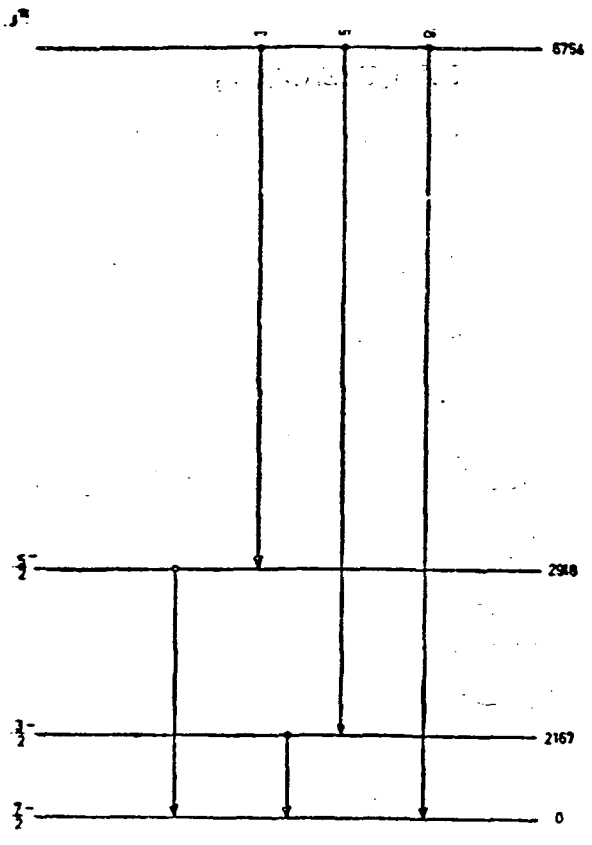

Fig. 6.2. Decay scheme and branching ratios for $E_p = 1721$ keV resonance

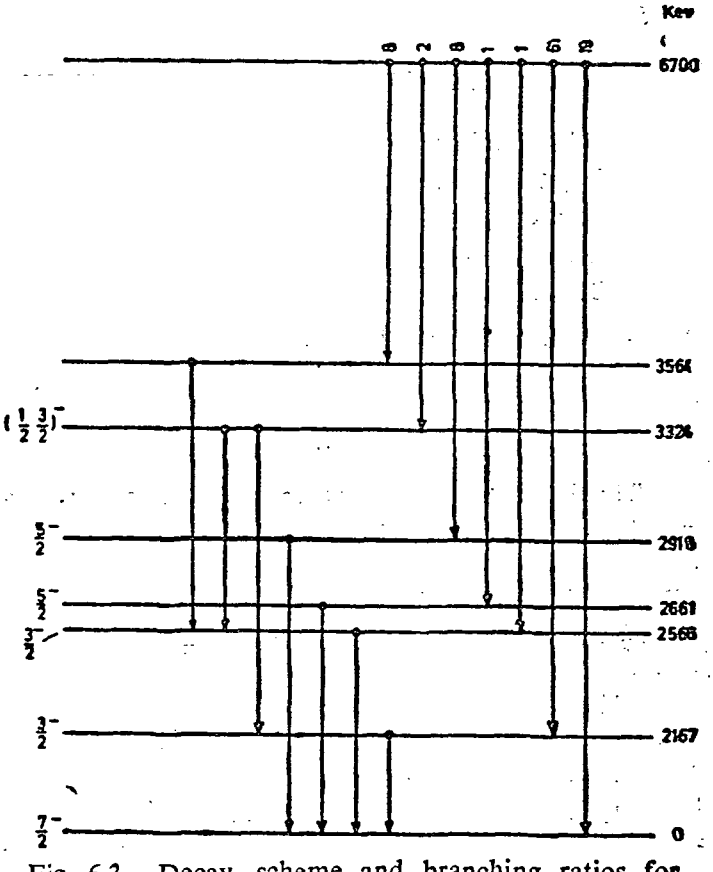

Fig. 6.3. Decay scheme and branching ratios for $E_p = 1666$ keV resonance

investigation are shown in Fig. 6.4. For comparison, the low lying states observed in the present

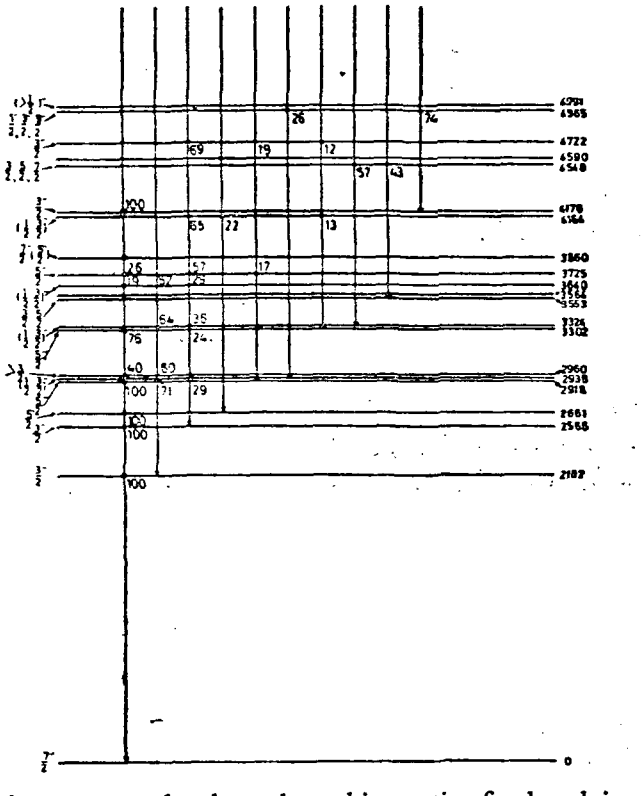

Fig. 6. 4. Spin assignments and γ-decay branching ratios for low-lying states of ^{55}Co

investigation are given along with those of others in Table 6.2. It can be seen from the table that the results of the present investigation are in general agreement with those of others [1-4].

Table 6.2

Energy levels below 5 MeV in ^{55}Co (E_x in MeV)

Present work	^{54}Fe(p,γ)^{55}Co Ref. (1)	^{54}Fe(^{3}He,d)^{55}Co Ref. (2)	^{54}Fe(d,n)^{55}Co Ref. (3)	^{54}Fe(p,γ)^{55}Co Ref. (4)
0	0	0	0	0
2.167	2.17±0.02	2.162	2.16	2.166
2.566	2.57±0.02	2.559	2.56	2.566
2.661	2.66±0,02		2.70	2.660
2.918				2.920
				2.924
2.938		2.938	2.940	2.940
2.960	2.95±0.02			2.976
3.302	3.21±0.02			3.304
3.324			3.33	3.325
		3.37		
3.553				
3.564				3.563
3.640				3.644
		3.657	3.66	
3.725			3.72	3.726
3.860				
		3.87	3.87	
		3.97	3.98	(4.034)
4.164				4.165
4.176				4.177
		4.185	4.19	
				4.264
			4.29	
			4.39	
				4.472
			4.50	
4.548				
4.590			4.58	
				4.629
		4.65	4.65	
4.722				4.722
		4.755	4.75	4.746
			4.94	
4.965				4.961
4.991	5.00±0.05			4.990

A paper on distribution of partial radiation width from $^{58}Ni(p,\gamma)^{59}Cu$ reaction has been published in Journal of Physics G: Nuclear physics **1**, 962 (1975). The paper reports partial radiation widths for about sixty resonances between E_p = 1.30—4.10 MeV in the reaction. These partial widths have been analysed to test the statistical model prediction that the distribution of partial radiation widths follows a X^2 distribution with one degree of freedom. The results have been found to be in qualitative agreement with this predication of statistical model.

A Ge(Li) detector and a number of isotopic targets have been procured during this time. The resolution of the detector was found to be ~4 keV which is very much near to the specified value. However, it has not yet been possible to use the Ge(Li) detector very much for want of beam time. It is hoped that with the availability of beam time, work on angular distribution of the de-excitation γ-rays to determine the possible spins and parities of the resonances and to deduce multiple mixing ratios for electro-magnetic trarsitions and also life time measurements by Doppler Shift Attenuation Method will be done.

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7. STUDIES OF INTERACTIONS AND FISSION OF URANIUM BY FAST NEUTRON EMPLOYING NUCLEAR EMULISON

(M. M. KASIM, ENAYETULLAH MOLLA, A. R. MOLLIK AND H. NABI)

(1) Loaded five K1 emulsion plates with uranium. These plates were numbered as U-17-1, U-17-2, U-17-3, U-4 and U-5. Exposed plate no. U-17-3 to 17.4 MeV neutrons and then processed by usual procedure. Exposed plate no U-4 to 5.76 MeV neutrons from D(d,n) He^3 reactions using deuteron beam of Van de Graaff machine. The plate U-4 has been scanned for fission events. 312 binary and four ternary fission events have been observed. Their angular distribution with respect to the incident neutron has been measured.

(2) Exposed six K1 and five K5 emulsion plates loaded with uranium to 4.7 MeV neutrons. Plate no U 12 has been fully scanned and in this plate 671 binary and 29 ternary fission events have been observed. In plate no U 15 about 200 fission events have been observed of which 2 were ternary fission events. In plate U 13, 180 fission events have been found.

8. CALCULATION OF BINDING ENERGY OF HUPERNUCLEUS He^7 AND Li^6

(M. M. KASIM)

$_{\Lambda}He^7$:—Binding energy of $_{\Lambda}He^7$ hypernuclear events are experimentally found to be widely distributed between 3 to 6 MeV. The possibility of the existence of a long lived isomeric state $(_{\Lambda}He)^{7*}$ is being studied.

$_{\Lambda}Li^6$: The existence of the hypernucleus of mass 6 and charge 3 is controversial. Possible processes of its formation are being investigated.

9. PROTON–INDUCED X–RAY EMISSION (PIXE) ANALYSIS OF TRACE ELEMENTS

(a joint research project of Chemistry and Experimental Physics Divisions)

(A. H. KHAN, M. M. ISLAM, M. B. ZAMAN, M. KHALIQUZZAMAN, M. HUSSAIN, F. MAJID, A. HUSSAIN, M. A. AWAL AND M. A. RAHMAN)

Please see under Chemistry Division.

10. RADIOISOTOPE EXCITED FLUORESCENCE ANALYSIS OF TRACE ELEMENTS

(a joint research project of Chemistry and Experimental Physics Divisions)

(A. H. KHAN, M. M. ISLAM, M. KHALIQUZZAMAN, M. B. ZAMAN, M. HUSSAIN AND F. MAJID)

Please see under Chemistry Division.

11. STUDIES ON ION-SOLID INTERACTION

M. KHALIQUZZAMAN, M. A. SUBHAN, M. D. MIA, T. HUSSAIN* AND A. K. M. SIDDIQ*)

Back scattering measurements with an experimental setup which was previously constructed were done using silicon single crystal with surface cut perpendicular to <111> axis. It was possible to obtain both the planner and the axial dips in these experiments. It was also found that alignment of crystal axis with beam direction could be done with an accuracy of the order of 0.01°.

A method of estimation of beam charge using Rutherford yield from a thin gold film on the crystal was investigated which gave satisfactory results. This had to be done because beam current integration using Faraday cup was not possible with thick crystal target and there was no provision for insulation of the target.

The results of the measurements were reported at the "Nuclear Physics and Solid State Physics Symposium" held at Calcutta in December 1975. The results have also been published as a paper in Nucl. Sci. & Appl. and as an internal AECD report.

During the experiments it was found necessary to incorporate some facilities in the experimental set up in order to circumvent some of the difficulties encountered.

It was found that prolonged irradiation of a single spot on the crystal caused radiation damage whereas it is necessary to do the back scattering measurements without such damage. Hence a system of lateral displacement of the goniometer without breaking the vacuum and without disturbing the crystal orientation with respect to the beam has been introduced.

It was also observed that on continued irradiation there was buildup of carbon on the target with the net result that the depth of the blocking dip was reduced. A liquid nitrogen cooled surface has now been introduced near the target to offset this effect.

Provisions have also been made for target insulation and rotating contact on the target for direct measurement of beam charge using current integrator.

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None of the three systems described above could yet be tested in beam for non-availability of beam time. As the previous target chamber positioning system with the beam pipe had to be dismentled for installation of new experiments, it became necessary to make a new stand for the scattering chamber setup. In this new stand there is provision for forward-backward movement of the target chamber with a screw driven slide system.

At one stage during the present period the heating element of the oil diffusion pump of the vacuum system used by this group burnt out. As procurement from abroad could not be done for want of foreign exchange, attempts were made to make a heating element from locally available raw materials. After repeated failures it has been possible to fabricate a heating element which works satisfactorily.

12. FABRICATION OF SOLID STATE RADIATION DETECTORS

(M. D. MIA, M. A. SUBHAN AND M. K. ZAMAN)

The objective of this group is to produce solid state radiation detectors primarily for the users in the Atomic Energy Establishments in Bangladesh. The programme is at its initial stage and cannot be persued vigoreusly because of the want of proper laboratery facilites. Attempts are being made to procure necessary equipment and materials.

In the meantime a liquid nitrogen cryostat has been designed and fabricated in our workshop. This cryestat can be used for the measurements of transport properties of solids over the temperature range from +27°C to −196°C. Utilizing this facility, a dissertation on the measurements of electrical propertics on three samples of silicon crystals over the temperature range from liquid nitrogen to room temperature was submitted by Mr. Abdur Rashid Mallick to Dacca University for the partial fulfilment of his M.Sc. degree in physics.

We also attempted to produce sintered layes photoconductive cells of cadmium sulphide in large area-form containing deliberately added traces of chlorine and copper. The method followed is essentially that of Thomsen and Bube'. A slurry of cadmium sulphide with requisite amount of impurites in it was painted on a ceramic substrate. The dried layer was then sintered at 600°C in the air for three minutes in a muffled furnace. The ratio of light to dark current in sample doped with chlorine alone is found to be 10^3. In samples doped with capper and chlorine the ratio is observed to be about 10^5.

Reference :

(1) S, M. Thomsen and R. H. Bube, Rev. Sci. Instr. 26, 1664 (1955).

13. RESEARCH AND DEVELOPMENT IN STORAGE BATTERY USING RADIO ISOTOPE TRACERS AND AUTORADIOGRAPHY

(M. M. KASIM, A. AZIZ AND ABDUL HAMID KHAN)

So far we have made fifteen storage batteries of lead-acid type of different capacties and voltages. Work is in progress for the construction of maintenance-free (M.F.) batteries utilising Gell type of electrolyte.

Materials are being procured for research on Silver-Zinc battery.

THEORETICAL PHYSICS DIVISION

1. SEPARABLE POTENTIAL FOR $\alpha-\alpha$ INTERACTION

(S. ALI, M. RAHMAN* AND D. HUSSAIN†)

The study at lower energies has been extended to higher energies. This necessitates the inclusion of non-elastic contribution to phase shifts. This means that the strength of the interaction could no longer be assumed as real.

2. EFFECT OF SHORT RANGE CORRELATION ON THE PHOTODISINTEGRATION OF ^{4}He

(S. A. AFZAL, S. M. M. R. CHOWDHURY AND S. SUHRABUDDIN**)

In the study of ^{4}He$(\gamma,p)^3$H reaction, investigation is mainly concentrated on the effect of strong short range correlation. Initially Jastrow type correlation has been introduced in the wave functions of ^{4}He and ^{3}H and reasonable agreement with experimental result has been obtained. Later on, the calculation has been further improved upon in another study by introducing modified density of states which is different from that of the free particle one, although the ejected proton will be represented by the plane wave asymptotically. This change in form is necessitated due to final state interaction between proton and triton. The ratio of modified density to the free particle density of states is taken to be of the form $(1+AK+BK^2)^2$. The parameters A and B are obtained by a χ^2 fitting. By employing this procedur the result has been much improved. The work has been completed.

3. PAULI PRINCIPLE IN THE ALPHA DEUTERON MODEL AND THE STRUCTURE OF ^{6}Li

(S. A. AFZAL)

Various models have been employed to study the interesting nucleus of ^{6}Li. Among them shell model, collective model, optical model and cluster model are prominent. Cluster model works well in explaining many properties of ^{6}Li where other models fail to reproduce the desired results. In the cluster model study of ^{6}Li there are two approaches that are followed. In one case, effect of Pauli Principle through the introduction of antisymmetrization operator is taken into account while in the other case no antisymmetrization effect is taken. By the study of different works on charge form factor, quadrupole moment, bound state and alpha–deuteron phase shifts it has been shown that in both the approaches inclusion of of Pauli Principle, that is the antisymmetrization operator, is very much a necessity to explain all the above nuclear properties consistently if one is to employ the cluster model calculation for ^{6}Li. This work has been completed and published.

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4. MORE CONSISTENT RESONATING GROUP CALCULATION OF $\alpha-\alpha$ INTERACTION

(S. A. AFZAL AND S. ALI)

All previous resonating group calculations of the interactions have been made with α-particle wave functions, the parameters of which have been fixed not in the usual variational way as should have been the case, but rather from the r.m.s. radius of the $\alpha-$particle. The internal energy of the particle so determined has been used consistently in the subsequent calculations. But in the present calculation α-particle parameter has been determined from variational principle and the calculations have been made for s—, d—, and g- wave α-α scattering. The results point to a force mixture of N-N interaction different from that used in earlier calculations.

5. IMPROVEMENT OF SHELL MODEL WAVE FUNCTION OF TRITON IN THE LOWEST CONFIGURATION

(S. A. AFZAL)

Shell model wave functions of triton have been constructed from the group theoretical point of view. In this study it has been observed that the wave functions of higher quantum number do not contribute much to the binding energy although the construction of the wave function involves huge amount of work. So it seems proper that the main contribution to the binding energy will come from the zero quantum number (for s-state) and two quantum number (for d-state) states. So main effort has been given to the improvement of thse two states. This has been done by constructing additional s and d states by introducing new parameters. The result has been much imporved. This project has been completed and published.

6. BINDING ENERGY CALCULATION OF TRITON WITH REALISTIC POTENTIAL

(I. ZAKIA* AND S. A. AFZAL)

The wave function of triton has been generated from the group theoretical formalism by employing the transformation properties of the partitions of the symmetric group S_3 and in fact set of space and spin-isospoin function is constructed by application of Young operators to some suitable generating functions. By applying a selection rule all the states including the states of higher configuration which make appreciable contribution to the binding energy of the ground state of triton have been taken into consideration. Then a series of nucleon—nucleon interactions including the soft core central and tensor potentials have been employed to calculate the binding energy of triton. Results obtained are satisfactory.

7. ANALYSIS OF THE P$-\alpha$ SCATTERING WITH NON-LOCAL SEPARABLE POTENTIAL

(A. A. Z. AHMAD, S. ALI, N. FERDOUS** AND M. AHMED+)

The above project has been completed. Phase shifts with $l=0$, 1, 2, 3 values have been quite satisfactorily reproduced with a one term potential of the form $K_l(r,r')=\lambda_l g_l(r) g_l(r')$. The paper based on this study has already been published.

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8. SOME ASPECTS OF STUDIES OF INTERACTION BETWEEN TWO LIGHT NUCLEAR SYSTEMS

(S. ALI)

Few—nucleon scattering data have been useful in deriving interactions between light nuclear system. A review has been done of the approaches made so far in understanding the features of the interaction V_{AB} between two light nuclear systems A & B (e. g. N-α, α-α, α-nucleus, ^{16}O-^{16}O etc.)

9. A NEW METHOD FOR SOLVING COUPLED DIFFERENTIAL EQUATIONS IN BOUND STATE PROBLEMS

(S. A. AFZAL AND D. CLEMENT*)

In calculating the binding energy of light perticles like ^{2}H, ^{4}He, ^{6}Li and ^{6}He in group theoretical formalism one finally faces the problem of solving eigenvalues and eigenvectors for a large number of coupled differential equations of the form

$$\frac{d^2f(n)}{dx^2} - \sum_{j=1}^{n} A_{ij}(x)\, f^j(x) = Ef^i(x) \text{ with } i=1,2\ldots, n.$$

There is very limited scope of solving these equations in a small computer. So, a new method for solving these large number of coupled equations has been evolved in which an effective potential has been found out and with that potential a single differential equation is solved for eigenvalues and eigenvectors. Results obtained with this method completely tally with those obtained from the basic principle. As a result, provision of massive storage capacity needed in a computer, which is a prerequisite for solving such problems, may be totally eliminated. Specific problems have been taken as examples and very good results have been obtained.

10. AN ANALYSIS OF ^{12}C (^{16}O, α) ^{24}Mg REACTION

(S. A. AFZAL, A. A. Z. AHMAD AND HABIBUL AHSAN)

A theoritical analysis of the nuclear reaction ^{12}C (^{16}O, α) ^{24}Mg is in progress. The nuclei ^{12}C, ^{16}O and ^{24}Mg are assumed as alpha clusters and their wave functions are taken to be of gaussain forms. Parameters appearing in the expressions for wave functions are found from the r.m.s. radii of the nuclei.

11. PHENOMENOLOGICAL $\alpha-\alpha$ POTENTIAL AND THE GROUND STATE OF ^{8}Be

(S. A. AFZAL AND K. A. MOTAKABBIR)

A series of $\alpha-\alpha$ potentials that have been taken in the recent study of $\alpha-\alpha$ phase shifts are being examined in the light of the ground state of ^{8}Be so that resonance energy E_r for $l=0$ and the resonance width Γ can be evaluated. Finally from this study a more detailed information about the nucleon—nucleon interaction can be obtained.

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12. A REVIEW OF ALPHA – NUCLEON INTERACTION

(A. A. Z. AHMAD, S. ALI AND N. FERDOUS*)

A systematic survey of alpha-nucleon interaction comprising the experimental, phenomenological and fundamental studies has been made. The paper based on this study is complete and will soon be sent for publication.

13. SPIN FLUCTUATION EFFECT IN THE SUPERFLUID PHASES OF FERROMAGNETIC LIQUIDS

(M. Z. H. NUMAN*, S. M. M. R. CHOWDHURY AND A. M. HARUN-AR-RASHID*)

The effect of spin fluctuation on the BCS transition is discussed by extending the theory of Berk and Schrieffer on spin correlation in nearly ferromagnetic Fermi liquids to include triplet as well as singlet pairing.

14. INTRINSIC SURFACE STATE BAND STRUCTURE CALCULATION OF KCL CRYSTAL

(S. M. MUJIBUR RAHMAN* AND S. M. M. R. CHOWDHURY)

The (110) surface state band structure of KCL has been calculated following the method developed by Levine and Freeman. The 4s and 3p orbitals are assigned to the anion and the cation respectively while the bulk conduction band is K-like and the valence band is Cl-like with correct symmetry. The surface distortion parameter is found to change considerabely the surface electronic state.

15. CORE CONTRIBUTION TO THE VALENCE BAND IN KCL CRYSTAL

(S. M. MUJIBUR RAHMAN*' S. M. M. R. CHOWDHURY AND A. M. HARUN-AR-RASHID*)

The core contribution to the valence band in KCL crystal has been taken into account with the help of interpolation scheme developed by Kohn and Slater. This contribution has been found to have a considerable effect on band width and band gap.

16. CRYSTAL FIELD STUDIES OF SOME RARE EARTH METALLIC HYDRIDES

(A. A. Z. AHMAD)

Crystal field level studies of praseodymium hydrides and deuterides have been made. One of the main interests in this study is to know the nature of bonding of the hydrogen or the deuterium. Data analysis is in progress.

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17. ENERGY BAND PARAMETERS OF ALKALI CHLORIDES

(S.M. MUJIBUR RAHMAN*, A.M. HARUN-AR-RASHID* AND S. M.M.R. CHOWDHURY)

Energy band parameters of alkali chlorides have been calculated by using mixed approach of LCAO and OPW. The results obtained are compared with other published theoretical and experimental values and the agreement was found satisfactory.

18. MATHEMATICAL MODEL FOR POPULATION GROWTH AND ITS CONTROL IN BANGLADESH

(S. M. M. R. CHOWDHURY)

A mathematical model which fits the present population growth of Bangladesh has been constructed from the rate equation proposed by Wilhelmsson for the population growth. It is found that the population will reach saturation only when fluctuation rate is negative and time independent. If it is positive or negative but time dependent, as in Bangladesh, then population will explode.

19. LOW TEMPARATURE SPECIFIC HEAT OF AMORPHOUS ARSENIC AND GERMANIA

(M. SAIFUL HUQ* AND S. M. M. R. CHOWDHURY)

A phenomenological frequency distribution, which explains the 'excess' amount of specific heat observed in amorphous arsenic and germania compared to that of the crystalline state, is obtained from the reduction of the probability distribution of the arrangement of the atoms in amorphous solids. This reduction in the probability distribution occurs due to the participation of greater number of atoms in certain cells of phase space in amorphous solids.

20. PHONON FREQUENCY DISTRIBUTION OF AMORPHOUS ARSENIC AND GERMANIA

(M. SAIFUL HUQ* AND S. M. M. R. CHOUDHURY)

The 'excess' of the specific heat observed in amorphous arsenic and germania compared to that of the crystalline state is explained with a phenomenological model for the vibrational denisty of states in amorphous phase. This model has been constructed on the idea of the presence of localized modes, in addition to the Debye type of modes, in amorphous solids.

21. INVESTIGATION OF THERMAL CONDUCTIVITIES OF CERAMIC METERIALS

(S. M. M. R. CHOWDHURY AND M. SAIFUL HUQ*)

The theoretical investigation of thermal conductivities of ceramic materials has recently been started.

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