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GOVERNMENT OF INDIA
ATOMIC ENERGY COMMISSION

PROGRESS REPORT ON NUCLEAR DATA ACTIVITIES IN INDIA - V

Compiled by

M. Balakrishnan
Nuclear Physics Division
Indian Nuclear Data Group

BHABHA ATOMIC RESEARCH CENTRE
BOMBAY, INDIA
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INDIAN NUCLEAR DATA GROUP

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3. A.S. Divatia (Convener)	Nuclear Physics Division, BARC
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5. D.N. Kundu	Saha Institute of Nuclear Physics
6. C.S. Pasupathy	Reactor Engineering Division, BARC
7. B.P. Rastogi	Reactor Engineering Division, BARC
8. N.S. Satyamurthy	Nuclear Physics Division, BARC
9. S.B. Garg (Co-opted)	Reactor Engineering Division, BARC
10. M.C. Joshi (")	Tata Institute of Fundamental Research
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12. M.P. Navalkar(")	Nuclear Physics Division, BARC
13. P.K. Patwardhan(")	Electronics Division, BARC

PREFACE

The fifth Progress Report on Nuclear Data Activities in India incorporates work done upto December 1968. It is being published after about 16 months since the publication of the fourth progress report.

A special item of interest to be mentioned is the visit to India of Mr.Alex Lorenz from the Nuclear Data Unit of the International Atomic Energy Agency. On behalf of the IAEA he visited the major centres of nuclear data activity in India and participated at the Nuclear Physics & Solid State Physics Symposium held at Madras during February 1968. The visit, the paper presented by Mr.Alex Lorenz at the Symposium, and informal discussions were helpful in clarifying the important role of nuclear data activity.

CINDA entries have been sent to the IAEA as usual. The number of entries sent during the period of the report is 57. The total number of CINDA entries pertaining to work done in India is now over 1200. All these entries have been rechecked and corrected. A number of DASTAR entries, representing the actual data storage at the IAEA, have also been sent on a continuing basis.

The number of reports submitted to the International Nuclear Data Committee during the period of the report is 4. The total

number of such reports submitted to the IAEA from India, by now is 20. A new report regarding the facilities available in India is under preparation.

Recently it has been decided to organize a Nuclear Data Library on magnetic tape at Trombay. A number of magnetic tapes containing the data requested are being received from the IAEA. This data is transferred and stored on our tapes at Trombay. Since the amount of data stored has become quite significant it is necessary to organize the library on a proper footing. A proposal regarding this library is being worked out in collaboration with the Computor Facility Section of the Electronics Division at Trombay.

A.S. Divatia

(A.S. Divatia)
Convener,
Indian Nuclear Data Group

A. BHABHA ATOMIC RESEARCH CENTRE, TROMBAY, BOMBAY 74

1. Yield of K X Rays Emitted From ^{236}U Fragments - S.S. Kapoor, V.S. Ramamurthy and R. Zaghloul* - Nuclear Physics Division - The yield of K X rays from different fragment masses have been determined in the thermal neutron induced fission of ^{235}U. The energies of the pairs of fragments were measured with two semiconductor detectors placed on either side of a thin ^{235}U foil. The K x rays from the light and the heavy groups of fragments were separated by measuring the x-ray energies with a 1 mm NaI(Tl) crystal. The fragment mass distributions in coincidence with the group of K x rays, heavy group of K x rays and without regard to any secondary radiations were simultaneously recorded in different quarters of a 1024 channel analyser memory. From these distributions, after suitable corrections for the background, x-ray detection efficiencies and finite energy resolution effects, the number of x rays yield per fission is found to be (0.08 ± 0.01) for the light fragment group, and (0.30 ± 0.02) for the heavy fragment group. The gross features of the yield as a function of mass are similar to those observed earlier for emission from ^{252}Cf fragments. However, unlike the case of ^{252}Cf, for masses greater than 144 the striking increase in the yield is not observed. The present results are consistent with the earlier interpretation that the x-ray yield

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* On leave from U.A.R. Atomic Energy Establishment, Cairo. Present Address : Reactor Physics Group, A.E.E. Cairo, U.A.R.

depends both on the characteristics of the low lying states and the initial spin of the fragments.

2. Angular Correlation Studies in the Reaction $^{26}Mg(d,p\gamma)^{27}Mg$ with proton detection near 180°** - M.A. Eswaran, M. Ismail and N.L. Ragoowansi - Nuclear Physics Division - The low-lying excited states of ^{27}Mg have been studied by means of the proton- angular correlation measurements in the reaction $^{26}Mg(d,p\gamma)^{27}Mg$ employing the method of Litherland near 180° to the beam in a solid state annular detector and γ-rays in a 12.7 cm (dia) x 15.2 cm. NaI(Tl) detector at seven angles between 0° and 90° using a fast-slow coincidence system of 50 ns resolving time and a 400 channel pulse height analyser. Random coincidences were recorded simultaneously making use of the proton group feeding the ground state in ^{27}Mg. Using the analysis procedure which is independent of any assumption regarding reaction mechanism and analysing the data with the CDC - 3600 computer at TIFR, spin assignments of 3/2,5/2 and 5/2 to the 0.984, 1.69 and 1.94 MeV levels of ^{27}Mg have been made and the gamma ray branching ratios of the 1.69 and 1.94 MeV levels have been determined. The multipole mixing ratios of the 1.69 $\rightarrow$ 0 MeV and 1.94 $\rightarrow$ 0.984 MeV transitions have been deduced and the latter is found to be consistent with that obtained from Nilsson model prediction, following the conjecture that 0, 9.984 and 1.94 MeV states form the ground state rotational band.

1) A.E. Litherland and A.J. Ferguson Can.J. Phys.39 788 (1961)

** A detailed paper on this will be published in the Physical Review.

3. Observations on the reaction $^{26}Mg(^{3}He,p)^{28}Al$ - M.A. Eswaran, N.L. Ragoowansi and M. Ismail - Nuclear Physics Division - An istopically enriched (> 99%) ^{28}Mg target on tantalum backing was bombarded with 4.25 MeV ^{3}He beam from the Trombay Van de Graaff accelerator. Stopping the beam on a thick enough tantalum foil, the outgoing charged particles from the reactions produced, were detected at 0° in a solid state detector. Several proton groups feeding the excited states in ^{28}Al below 2 MeV have been observed arising from the reaction $^{26}Mg(^{3}He,p)^{28}Al$. Further studies on this reaction are in progress.

4. Measurement of Recoil Ranges in Thermal Neutron Induced Fission of ^{233}U and ^{239}Pu - Satya Prakash, S.B. Manohar, S. P. Dange, A. Ramaswami and M.V. Ramaniah - Radiochemistry Division - Using high resolution Ge(Li) detector the ranges of fission fragments in aluminium were determined for the thermal fission of ^{233}U and ^{239}Pu. Using various range energy correlations kinetic energy distribution was also obtained for both the systems.

5. The T = 2 State in ^{28}Si - S.K. Gupta, S.S. Kerekatte and M.K. Mehta - Nuclear Physics Division - The lowest T = 2 state has been located at 15.2 MeV in ^{28}Si which is identified as an isobaric analogue of the ground state of ^{28}Mg[1]. It is observed to have a 90% decay to the $^{24}Mg + \alpha$ channel[1]. The excitation

1. M. Balakrishnan, S.K. Gupta, M.K. Mehta and K.B. Nambiar, Proceedings of NP and SSP Symposium (Madras 1965) p.218.

function for the reaction $^{27}Al(p,\alpha_0)^{24}Mg$ at 94° c.m. shows two resonances in the vicinity of the 15.2 MeV excitation[2]. The angular distribution measured on the stronger of the two shows almost isotropy indicating a spin and parity of 0^+ which makes it the most likely candidate for the probable T = 2 analogue of the ground state of ^{28}Mg.

1. R.L. McGrath, J.C. Hardy and J. Cormy, Physics Letters 27B (1968) 443.

2. M.K. Mehta, J.John, S.S. Kerekatte and A.S. Divatia, Nuclear Physics 89 (1966) 22.

6. Absolute Differential Cross Sections for the reaction $^6Li(\alpha,\alpha)^6Li$ Between 3.5 and 5.0 MeV and Shape Analysis of the resonance at 4.25 MeV.- M. Balakrishnan, K.K. Sekharan, M.K. Mehta and A.S. Divatia,- Nuclear Physics Division - Absolute differential cross sections have been measured for the reaction $^6Li(\alpha,\alpha)^6Li$ between 3.5 and 5.0 MeV in 5 and 10 keV steps at four angles (c.m.) of 70°, 90°, 125° and 141°. In addition to the previously reported resonance at 3.5 MeV[1] another resonance is observed at about 4.25 MeV bombarding energy. A preliminary shape analysis of this resonance rules out odd values of ℓ and indicates a mixture of $\ell = 0$ and $\ell = 2$ giving rise to probable value of 1^+ for the spin and parity of the level around 7.02 MeV excitation in the compound nucleus ^{10}B.

1. M. Balakrishnan, S.K. Gupta, M.K. Mehta and K.B. Nambiar, Proceedings of NP and SSP Symposium (Madras 1968) p.218.

7. Study of the isobaric analogue resonance at 2.340 in the reaction $^{51}V(p,n)^{51}Cr$ - K. K. Sekharan and M. K. Mehta - Nuclear Physics Division - The absolute reaction cross section for the reaction $^{51}V(p,n)^{51}Cr$ has been measured in fine steps ($\sim$1.5 MeV) in the neighbourhood of the resonance observed at 2.340 MeV in the previous study of this reaction[1]. This resonance has been identified as an analogue of the 4^+ level at 1.55 MeV in ^{52}V formed by capture of $l = 1$ protons[2]. The shape of the resonance is fitted with the proper expression for an isobaric analogue resonance and the relevant parameters are extracted. The measured total width and the maximum cross section yield partial widths for the proton and the neutron and from this a spectroscopic factor of 0.75 is determined for this level at 12.8 MeV excitation in the compound nucleus ^{52}Cr.

1. E. Teranishi and B. Furubashi, Proc. of the Conf.on Isobaric Spin in Nucl. Phys. Tallahassee (1966) p.640.

2. J.J. Egan, P. Gabbard, G.C. Dutt, B.E. Barnes and T. Young, Bull. Am. Phys. Soc. 11, 840 (1966) and Private Communication.

8. Elastic Scattering of Alpha Particles From ^{19}F Between 3.3 to 5.0 MeV - M. Balakrishnan, M.K. Mehta and A.S. Divatia - Nuclear Physics Division - Excitation functions for the reaction $^{19}F(\alpha,\alpha)^{19}F$ have been measured in 5 keV steps between 3.3 and 5.0 MeV bombarding energies, at lab angles of 43° and 56°. The cross section generally follows the Rutherford expression at the both angles. Anomalies are observed at 3.40, 3.67, 3.80, 3.89, 4.19 and 4.5 MeV. These

anomalies correlate very well with the resonances seen in the $^{19}F(\alpha,n)^{22}Na$ reactions by K.K. Sekharan et al[1] indicating levels in the compound nucleus ^{23}Na near an excitation energy of 14 MeV to be the origin of these anomalies.

1. K.K. Sekharan, M.K. Mehta and A.S. Divatia, Proceedings of the NP & SSP Symposium 1965, p.1999.

9. The $^{29}Si(\alpha,n)^{32}S$ Reaction Cross Section from 3.0 to 5.4 MeV - M. Balakrishnan, K. K. Sekharan, M. K. Mehta and A. S. Divatia - Nuclear Physics Division - The flat response 4π geometry neutron counter was used to measure the absolute reaction cross section for the reaction $^{29}Si(\alpha,n)^{32}S$ in 10 keV steps in the bombarding energy range from 3.0 to 5.4 MeV using enriched imported target. This was converted to the reaction cross section for the reaction $^{32}S(n,\alpha)^{29}Si$ by means of reciprocity theorem. The excitation function exhibits a large amount of sharp structure which could be resonances for "fluctuations". Three very strong peaks are observed at 4.90, 5.04 and 5.4 MeV bombarding energies.

10. Search For Isobaric Analogue States in ^{73}As - M. G. Betigeri, S. M. Lamba, D. K. Sood*, N. S. Thampi and N. Sarma - Nuclear Physics Division - Study of isobaric analogue states through proton elastic scattering has been established to be as powerful a tool as (d,p) reactions to obtain detailed properties of the low lying levels of nuclei. The information available at present on the low lying

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* D.A.E. Fellow from I.I.T., Kanpur.

levels of ^{73}Ge is scanty. High resolution ($\sim$ 1 keV) study of elastic scattering of protons on ^{72}Ge has been undertaken at 90°, 125°, 149° and 165° in the incident proton energy range 3.300-3.770 MeV. Levels in the compound nucleus ^{73}As have been identified which correspond to the 13.5 keV, 67 keV and 363 keV levels in the analogue nucleus ^{73}Ge. Detailed fits based on the theory of Robson are in progress to determine properties of these levels in ^{73}Ge.

11. Resume of Nuclear Data Work in the Theoretical Physics Section - S.B. Garg - Reactor Engineering Division - The subject of nuclear cross-section studies is subdivided into three categories namely evaluation, derivation and compilation. The present status of each one of these three aspects in Trombay is reviewed below :

Evaluation : It has two facets

i) To calculate cross-sections desired in the reactor analysis with appropriate nuclear models in those energy regions where the measured information is scanty.

ii) To compute energy point cross-sections with the known resonance parameters and to evaluate data measured at different laboratories with different techniques and resolutions.

Work was initiated on these two facets but no attempt has been made to evaluate the data measured at different laboratories since this part of the work is time consuming and laborious. Several computer codes were adapted to carry out these studies.

The materials studied and the codes used are :

Codes : ABACUS, NEARREX, MLBW, PIXSE, CAMEPCM & IRCLMIKP.

Materials : Cr, Ni-58, Ni-60, Mo, Cd, Na, Pb, Th, U-235,U-238, Pu-240, Pu-239, Al, Na, Fe & Pu-241.

Derivation :

Energy point cross-sections are needed in order to derive entities suitable for use in reactor studies. Various cross-sections desired in the multigroup form with temperature dependence and self-shielding effects are σ_t, σ_f, σ_c, σ_s, σ_{in} & $\sigma_{n,\ 2n}$

A new 26 group cross-section set has been obtained for fast reactor studies. The materials included are H,Be,C,O,Cr,Fe,Ni, Th,U-235,U-238,Pu-239,Pu-240 and Pu-241. The computer codes adapted for this study are :

Codes : DOPINT, ZUT, TEMPO & RESPECT

Compilation :

It deals with the computer-storage of energy point cross-section. There is an obvious advantage of having evaluated cross-sections on magnetic tapes since they can be directly fed to the computer codes to generate multigroup constants. Brookhaven ENDF/B File contains evaluated point data for 77 materials and is of great use in reactor studies. Request to obtain this file has already been made. With the assistance of IAEA, however, it has been possible to store data both in the form of raw and evaluated only for a few materials.

Raw date : U-233,U-235,Pu-239,Pu-241,Si, S, Fe,Pr,Gd & Ho

Evaluated data : Zr,Th-232,Pu-239,U-235,Li-6 & Li-7

Computer Codes : Available with us for checking and up-dating the evaluated data are :
CHECKER, CRECT & DAMMET

12. Neutron Diffraction of Magnetic Materials - N.S. Satya Murthy, R.J. Begum, C.S. Somanathan, L. Madhav Rao, B.S. Srinivasan, and M.R.L. N. Murthy - Nuclear Physics Division - Extensive diffraction studies have been made on the mixed ferrite systems $Zn_xNi_{1-x}Fe_2O_4$ and $Mg_xMn_{1-x}Fe_2O_4$ (with x = 0, .25, .5, .75 and 1.0) using both polarised and unpolarised neutrons. The results on Zn-Ni system can be best explained in terms of Yafet-Kittel type of spin arrangement. The exchange constants in this system have been evaluated using the molecular field formalism and a 3-sublattice model. A comprehensive paper describing these results has been sent for publication. The polarised neutron technique has been successfully employed to determine the cation distribution in $NiFe_2O_4$.

Further studies on the ternary alloy FeMnGe have been carried out to solve its magnetic structure. The study of another mixed ferrite system $Zn_xCo_{1-x}Fe_2O_4$ is in progress. $CoFe_2O_4$ has shown interesting magnetic features on heat treatment.

Paramagnetic scattering of cold neutron by FeF_2 and CrF_2 has been investigated on the rotating crystal spectrometer and

the respective exchange constants have been determined. A model to explain the neutron scattering from short range ordered paramagnets has been developed, in analogy with the existing models in the case of liquids. In particular, inelastic neutron scattering results from paramagnetic MnO have been explained by this models and the energy shifts observed at two widely differing temperatures have been explained without assuming the existence of spin-wave like excitations in paramagnetic MnO.

Several new experimental facilities have been added to the group. All the studies on the magnetic field dependence of the Bragg reflections have been made using the new wide angle electomagnet which gives a maximum field of 12 KOs for a 15 mm gap at 100 Amps. A new transistorised magnetic current supply provides upto 140 Amps of regulated current at 25 volts. An automatic programming unit for the selection of the counter angle has been incorporated in the control unit of the polarised neutron spectrometer.

An alloy Ni_3Fe has been prepared and the possibility of magnetic critical scattering measurements on it is being examined.

The programme of developing cryogenic facilities for the various experiments such as neutron scattering and Mossbauer effect of the division has made good progress. A number of liquid nitrogen and liquid helium cryostats have been designed, fabricated and successfully tested. This has involved the use of thin walled stainless stell tubing and sophisticated welding techniques. The

division is now in a position to fabricate cryostats for any research equipment.

List of Publications

1. Neutron Scattering from Paramagnetic Chromium Halides - Phys. Letters 26A 108 (1968).

2. Exchange Integrals in CrF_2 and FeF_2 by Paramagnetic Neutron Scattering - Solid State Comm. 6, 593 (1968).

3. Neutron Scattering from Short-Range Ordered Paramagnets - Solid State Comm. (in Press).

4. Ferrimagnetic Structure of Mn_2Co_2C - J. Phys.Chem.Solids - (in Press).

5. Magnetic Structure of MnAlGe - J. Appl.Phys.(in Press).

6. Yafet-Kittel Angles in Zinc-Nickel Ferrites - accepted for publication in Physical Review

7. Neutron Diffraction Study of Nickel Ferrite (Submitted to J. Phys. Chem. Solids)

8. A. Polarised Neutron Spectrometer for Magnetic Scattering Studies (Submitted to Ind.J. Pure and Applied Physics).

13. Neutron Crystallography Section - R. Chidambaram, A. Sequeira, S.K. Sikka - Nuclear Physics Division - The fully-automatic 3-dimensional neutron diffractometer 3-D FAD was commissioned during the year with paper-tape control on two angles, 2θ and φ. Commissioning of the automation on χ awaits the delivery of the third reversible forward-backward counter unit by the Electronics Division. The output of the diffractometer is right now being transferred to an ordinary printer. The signal counter unit with interfacing for teleprinter transfer has been designed and is being fabricated. That will complete the 3-D FAD construction.

Meanwhile, with the existing automation, 3-D FAD has been used to collect data on two crystals, $K_2C_2O_4 \cdot H_2O$ and $K_2CuCl_4 2H_2O$, and to solve their structures. These have refined to R-indices of 0.03 to 0.04 which are comparable to the best achieved anywhere in the world, and are indicative of the exceptionally good alignment of the diffractometer.

The oldest diffractometer DCD is being used essentially for taking powder patterns and for aligning crystals. The semi-automatic diffractometer SAND was contaminated due to radioactive water spillage from a punctured valve in the reactor cooling system during the early part of the year; this has ruined the electromechanical automation system of SAND, which has been essentially out of commission since then. It has not been considered worthwhile to renew this obsolute automation. Drawings have been made to modify it along the lines of 3-D FAD but with facility to attach a cryostat to the full-circle goniometer.

14. Crystal Structure Investigations - Complete three-dimensional neutron data have been collected from single crystals of $K_2C_2O_4 H_2O$ and $K_2CuCl_3 2H_2O$ on 3D-FAD. The data corrected for absorption and secondary extinction have been used to refine the structure down to R-indices of 0.03--0.04. The bond lengths determined have standard deviations of about 0.003 A or less. The neutron structure of $K_2C_2O_4 \cdot H_2O$ is in excellent agreement with a recent X-ray structure of the same crystal of equivalent accuracy and determined

15. Establishment of a Standard Thermal Neutron Flux Density at B.A.R.C. - M.G. Shahani and D. Sharma - Electronics Division - A standard of thermal neutron flux density has been established for calibrating thermal neutron detectors. The moderating geometry consists of six $^{241}Am - Be_6(\alpha,n)$ sources having total neutron emission rate of 6.6×10^6 neutrons per sec. imbedded in a graphite pile (160 cms x 120 x 150 cms). The thermal neutron flux density in a small air cavity (5 cms x 5 cms x 15 cms) at the centre of the assembly has been absolutely measured in terms of ^{197}Au neutron capture cross section by $4\pi\beta-\gamma$ coincidence counting of high purity circular gold foils. Various corrections hav been applied and sources of errors have been discussed. The Westcott flux density below cadmium cut-off energy at the centre of the cavity is estimated to be 6438 $\pm$ 1.8 per cent neutrons/cm^2,sec. The flux density in the central 5 cm. region of the cavity has been found to be constant to better than 0.7 percent by $4\pi\beta$ counting of irradiated In-Ni foils.

B.A.R.C. flux standard has been directly compared with the standards maintained at the National Bureau of Standards, Washington and Electrotechnical Laboratory, Tokyo by exchanging irradiated gold foils.

To be published in the proceedings of the IAEA Symposium on " Radiation Protection Monitoring " held in Bombay in December 1968.

by Hodgson and Ibers (Acta Cryst., under publication).

A programme of study of ferroelectric crystal structures with neutrons has been initiated by starting on the room-temperature paraelectric phase of Rb H_2PO_4 (none of the KDP class of crystals has so far been studied using three-dimensional neutron data). About 75 pices of data have been collected up till now on 3-D FAD.

Chemical Physics

A bent hydrogen bond model with special reference to O-H...O bonds in crystals has been developed. It explains the range of bending angles δ as a function of O...O bond length R observed in structures and also the variation of O--H distance as a function of R and δ.

This model has also been used to calculate successfully the vibrational frequencies observed in $K_2C_2O_4.H_2O$, $Ba(ClO_3)_2.H_2O$ and $BeSO_4.4H_2O$.

Computer Programs

The library of crystallographic programs available with us has been streamlined by putting them on magnetic tapes in successive files and also extended by writing three more programs:

i) for refining unit cell parameters and crystal orientation based on observed Bragg angles;

ii) for processing the raw data into structure factors corrected for absorption and

iii) for punching paper tape in the format suitable for 3D-FAD.

16. Measurement of the Half Life of 1.208 MeV Excited State of ^{91}Zr - N.P.S. Sidhu - Electronics Division - This state is populated by the decay of radioisotope ^{91}Y. Radioisotope ^{91}Y decays[1,2] in 99.7% of disintegration through 1.54 MeV to ground state of ^{91}Zr while only 0.3% of the disintegrations through 0.33 MeV β result in 1.208 MeV state of ^{91}Zr. The life-time of this state has been measured by $\beta-\gamma$ coincidence using a fast slow coincidence setup described elsewhere[3]. To get sufficient coincidence counts, inspite of the low intensity of 0.33 MeV-β-1.208 MeV γ- transition; β and γ detection efficiency was increased by using $4\pi\beta$ plastic scintillator for β detection and a NaI(Tl) well type crystal for γ detection.

Half life was evaluated by centeroid shift method. Radio-isotope ^{60}Co was used as a prompt source. The prompt curve had a FWHM of 3 nscc. The half life of 1.208 MeV excited state in ^{91}Zr found to be $\geq$ 0.1 nscc.

1. M.E. Bunker et.al. Phys. Rev. 94 1694 (1954)
2. O.E. Johnson and W.G. Smith Phys. Rev.118;1315 (1960)
3. N.P.S. Sidhu and U.C. Gupta Nuc/Phys. A 91,557(1967)

17. Determination of source self Absorption in Neutron Source Standardization - N.C. Jain and U.C. Gupta - Electronics Division - A correction due to the absorption of the neutron in the source is applied in standardization of neutron source. This correction, known as source self absorption correction is one of the important factors that limits the accuracy of standardization. Usually this correction is applied from the constructional

details of the source and the experimentally measured value of the flux at the surface of the source in water. A new method to determine the source self absorption is developed. In this method, two similar neutron sources are used. The neutron sources and a detector are put in an infinite moderating medium viz water tank. The counting rate is taken with both the sorces together as well as individually. The difference between the sum of the individual counting rates and the two sources together is used to determine the self absorption correction.

This correction comes out to be 1.5% of the total neutron emission rate for Ra-α-Be source as compared to 1% by conventional method of estimation. This difference could be due to absorption of epithermal neutrons in the source.

18. $\pi\sqrt{2}$ Magnetic Beta ray Spectrometer - H.K. Sahoo and S. C. Misra - Electronics Division - A double focussing magnetic beta ray spectrometer has been designed and set up. The spectrometer has a conical field shape. The mean radius of the electron trajectory is 12.5 cms. Low carbon Tata Grade 'A' iron has been used for the pole pieces. The useful energy range of the spectrometer is 100 keV to 2 MeV. The low energy cut off for electrons is 25 keV. The resolution of this spectrometer is 1% for source and detector slit as wide as 4 m m, the transmission at this setting is 0.05 p. Other details of the spectrometer are similar to the semicircular type spectrometer developed earlier in this laboratory[1]. Design construction and performance of a flat type spectrometer by U.C. Gupta, S.C. Misra, and H.K. Sahoo.

Accepted for publication in Indian Journal of Pure & Applied Physics

19. International Intercomparison of Co-60 - P.K. Srivastava and G.D. Khera - Electronics Division - The Bureau Internation des Poids at Mesures, France, organized the International intercomparison of the methods of dilution using the radionuclide Co-60, in which some 25 national and international laboratories of the world including BARC, participated. The main aim of the intercomparison was to assess the errors arising due to the dilution of the stock solution. For this, National Physical laboratory, Teddington distributed two solutions, one weak and the other strong to each participating laboratory for standardization.

Four dilutions were made from the strong solution on a Mettler Analytical Balance. Ten sources were prepared from each of the four dilution and twenty sources were prepared from the weak solution by weighing on a Micro-balance using a long and narrow necked polythene Pyconometer. All the sources were counted on a $4\pi\beta$-γ coincidence set up. The data were analyzed on the computer CDC 3600. The internal and external consistency was checked for each source. The entire data and the computed results were sent to BIPM for compilation and analysis. The final BARC results are given below.

Strong Solution			Weak Solution		
Dilution No.	Activity g^{-1} / Mg^{-1}	Standard Deviation	Part	S^{-1} / Mg^{-1}	Deviation
1	2919.78	2.99	1	136.774	0.060
2	2927.99	1.11	2	136.555	0.041
3	2926.96	0.92			
4	2913.93	1.13			
Weighted Mean	2923.5	3.45	Weighted Mean	136.63	0.034

B. TATA INSTITUTE OF FUNDAMENTAL RESEARCH, BOMBAY-5.

1. Fragment Mass-Distributions in Photofission and Neutron Induced Fission of ^{238}U - K. N. Iyengar and R. Rangarajan* - The fragment mass distributions have been obtained for the cases of 14.0 MeV neutron induced fission and 17.0 MeV gamma ray induced fission of ^{238}U employing Lexan detector and nuclear emulsion technique. Fragment mass distributions were also obtained in the thermal fission of ^{235}U employing Lexan detector to ensure mass calibration. The 14.0 MeV neutron induced fission was studied only with the Lexan detector while the photofission mas distributions were obtained using both nuclear emulsions and Lexan detector and were found to be mutually consistent. The fragment mass distributions in neutron fission and photofission are found to be significantly different. Possible reasons for this observed difference are discussed.

2. Nature of the 268 keV Excited State in ^{197}Au - K.G. Prasad and R.P. Sharma - The K-conversion coefficient of 191 keV transition from the 268 keV state in ^{197}Au has been measured taking all possible precautions. The reduced E2 transition probability of the same transition has also been measured by Coulomb excitation with 4.5 MeV alpha particles. The results have been discussed in the light of recent developments in nuclear structure theory.

* Present address: University of Saskatchewan, Saskatoon, Canada.

3. Level Structure of ^{111}Ag - K.G. Prasad and R.P. Sharma - The energy levels of ^{111}Ag have been established from the s tudy of singles and coincidence spectra with a Ge(Li) detector. The nature of the various levels has been discussed in the light of conversion coefficient and angular correlation measurements. The possible spins and parities have been indicated.

4. Fermi Matrix Elements in the Beta Decays of ^{59}Fe - S.K. Mitra and H.C. Padhi - Fermi matrix elements in the 275 keV and 475 keV beta transitions in the decay of ^{59}Fe have been measured by using the beta gamma circular polarization correlation method. The asymmetry parameter measured in the two beta transitions are $A = -0.17 \pm 0.04$ for the 475 keV beta group and $A = -0.29 \pm 0.15$ for the 273 keV inner beta group. The Fermi matrix elements obtained are

$$M_F = (2.5 \pm 2.5) \times 10^{-3} \text{ for the 475 keV}$$
$$M_F = (31 \pm 31) \times 10^{-3} \text{ for the 273 keV}$$

5. 'g' Factors of the 322 and 462 keV Levels of ^{125}Te - Vikram Singh*, P.N. Tandon, S.H. Devare and H.G. Devare - The integral reversed field method of perturbed angular correlations has been used to measure the g factors of the 322 and 462 keV states of ^{125}Te excited in the beta decay of ^{125}Sb. In the case of the 322 keV state external fields of 12.6 and 19.5 k gauss were used. The 462 keV state has a very short life time of 19 ± 3 p sec and

* Guest worker from Kurukshetra University

the high internal field in iron was used for this measurement. The results are, $g = -(0.58 \pm 0.06)$ for the 322 keV state and $g = -(0.74 \pm 0.26)$ for the 462 keV state. The nature of these excitations is discussed on the basis of these measurements.

6. Particle Parameters for Conversion Electrons in ^{152}Sm, ^{152}Gd and ^{160}Dy - Y.K. Agarwal, C.V.K. Baba and N.C. Mukhapadhyay - The internal conversion-electron particle parameters for several low lying E2 transitions in ^{152}Sm, ^{152}Gd and ^{160}Dy have been determined by making $e^- - \gamma$ and $\gamma - \gamma$ directional correlation measurements on the same source. In several of these cases both b_2 (E2, K) and b_4 (E2, K) have been measured. The results are: (i) 122 keV transition in ^{152}Sm: $b_2(K) = 1.82 \pm 0.05$, $b_4(K) = -1.06 \pm 0.14$, and $b_2(L) = 1.30 \pm 0.07$, (ii) 344 keV transition in ^{152}Gd: $b_2(K) = 1.62 \pm 0.13$, (iii) 87 keV transition in ^{160}Dy: $b_2(K) = 1.90 \pm 0.07$, $b_4(K) = -1.25 \pm 0.19$ and $b_2(L) = 1.37 \pm 0.18$. The measured values of $b_4(K)$ have also been used in determining $b_2(K)$. In all the cases measured, no deviations from the theoretical values have been observed within the experimental errors.

C. SAHA INSTITUTE OF NUCLEAR PHYSICS, CALCUTTA 9

1. Energy Levels in ^{74}Se and ^{71}Ge - B.B. Baliga, B. Basu and A.P. Patro - With the external beam of the Calcutta Cyclotron a programme to study level schemes using (p,n)reactions has been undertaken recently with the help of high resolution Ge-Li drifted detector. Natural samples of arsenic oxide and gallium oxide were bombarded with the proton beam of 3.8 MeV. Energy levels in both the isotopes ^{75}Se and ^{71}Ge will be presented.

2. Single Particle Effects in Past (n,2n) Reactions - Miss S. Chatterjee and A. Chatterjee - A survey of fast neutron (n,2n) reaction cross-sections at excitation energies of 3, 6 and 7 MeV reveals a few inteteresting overlapping trends. Plotted against neutron excess, a structureless gross trend is seen throughout the mass region; the second trend shows the Csikai-Petro effects; the third trend exhibits the shell effects. An attempt has been made to understand these trends as a compound nuclear decay process where the residual excitation is properly treated in terms of Rosenzeig shift functions. It is found that the predicted behaviour agrees well with observations in medium weight and heavy nuclei.

3. Energy Distributions in Neutron Induced Prompt Fission Fragments - Miss Ratna Sarkar and Aparesh Chatterjee - The excitation and kinetic energy distributions in prompt fission fragment masses

have been theoretically estimated in the neutron induced fission of ^{229}Th, ^{230}U, and ^{239}Pu. Excitation energies have been calculated in the framework of the renormalised fermi-surface model in which the nuclear ground states are correlated with both single-particle and collective interactions (the shell, pairing, and deformation effects) in a system of interacting fermions. The calculated energy spectra based on the readjusted fermi surfaces show fair fit with observations. The theory may be used to predict the excitation and kinetic energy mass spectra of neutron induced fission fragments.

4. Decay of ^{96m}TC and the Level Scheme of ^{96}MO - S.K. Basu and A.P. Patro - The γ-spectra following the decay of ^{96m}TC(52 m) have been studied with a high resolution Lithium-drifted Germanium detector with a view to see the low spin excited states of ^{96}Mo. Several lines due to decay from the metastable state have been observed. On the basis of the γ-spectra obtained from the decay of ^{96m}Tc and ^{96}Tc, the level scheme of ^{96}Mo will be presented.

5. The Gyromagnetic Ratio of the 316 keV State of ^{169}Tm - A.K. Nigam and R. Bhattacharya - The gyromagnetic ratio of 316 keV, $7/2^+$ excited state (half-life $T_{\frac{1}{2}} = 0.66$ /usec) of ^{169}Tm has been measured under an external magnetic field using perturbed angular correlation (PAC) technique. The Differential Delay Constant Angle (DDCA) method was applied.

6. Half Lives of the Excited States of ^{37}Cl, ^{38}Ar, ^{41}K, ^{88}Sr, ^{131}Xe and ^{186}Os - B.P. Pathak, K.S. N. Murty and S.C. Gujrathi - The half lives of the excited states of the following nuclei have been measured.

Nucleus	Level energy in MeV(J^π)		$T_{1/2}$(sec)
	Initial	Final	
^{37}Cl	3.105($7/2^-$)	0 ($3/2^+$)	$(1.56\pm0.18)\times10^{-10}$
^{38}Ar	3.77 (3^-)	2.17(2^+)	$(2.2\pm0.2)\times10^{-10}$
^{41}K	1.29 ($7/2^-$)	0 ($3/2^+$)	$(6.67\pm0.1)\times10^{-9}$
^{88}Sr	2.734(3^-)	1.836(2^+)	$(9.8\pm1.2)\times10^{-11}$
^{131}Xe	0.364($5/2^+$)	0 ($3/2^+$)	$(2.8\pm0.9)\times10^{-11}$
^{186}Os	0.137(2^+)	0 (0^+)	$(0.85\pm0.01)\times10^{-9}$

A computer programme has been written for the analysis of the delayed coincidence data. The results are discussed in the light of collective nuclear models and also compared with the theoretical predictions given in the literature.

7. Decay of 1.6 min ^{185m}W - B.P. Pathak, S.C. Gujrathi, and S.K. Mukherjee - The γ-decay characterstics of 1.6 min ^{185m}W have been studied using Ge(Li) and NaI(Tl) detectors. The samples of ^{185m}W have been produced by the (n,2n) reaction with 14.8 MeV neutrons on enriched ^{186}W. The decay of the individual γ-rays has been studied using a Ge(Li) detector. The γ-rays decaying with a half-life of 1.6 min have their energies 20, 60, 66.5, 107, 132, 164.5, 173.5 and 187 keV. A few γ-ray energies reported earlier by various authors tally with present measurements, rest of the

γ-rays are reported for the first time. A decay scheme, based on the γ-γ coincidence experiments and relative intensities of γ-rays, is proposed and the corresponding excited states of ^{185}W are discussed in the light of the unified model.

8. Life-Time Measurements of the Excited States in ^{75}As, ^{123}Sb, ^{147}Pm and ^{199}Hg - H. Singh, B. Sethi and K.S. Murthy - The life-times of the excited states of a few odd-mass nuclei have been measured by the delayed coincidence technique using a time-to-amplitude converter. The results obtained are as follows:

Nucleus	Level (keV)	Half-life (nsec)
^{75}As	199	0.75 $\pm$ 0.15
	265	0.08
^{123}Sb	160	0.60 $\pm$ 0.10
^{147}Pm	91	2.67 $\pm$ 0.03
	531	0.22 $\pm$ 0.03
^{199}Hg	158	2.46 $\pm$ 0.02

D. LABORATORIES FOR NUCLEAR RESEARCH, ANDHRA UNIVERSITY, WALTAIR

1. Angular Correlation of the 325-177 keV Cascade in ^{131}Xe - P.B. Rao and V. Lakshminarayana - The 325-177 keV cascade connects the three odd parity states in ^{131}Xe at energies 667, 341 and 164 keV. The angular correlation on this cascade is carried out for the first time using 'Sum-coincidence' technique. The sum-coincidence spectrum with gate at 503 keV recorded this only cascade. From the spectra recorded with 180°, 135° and 90° between the detections, the correlation coefficients are obtained, using White's method and corrected for finite size effects using Frankel's method. The final values are $A_2 = 0.07 \pm 0.01$ and $A_4 = 0.10 \pm 0.02$. Assuming the spin of the 164 keV state to be 11/2 and possible spins of the 341 and 667 keV states to be (7/2, 9/2, 11/2, 13/2) and (5/2, 7/2, 9/2) respectively the theoretical values of the correlation coefficients are estimated for E2 character of both the transitions. The theoretical values for the spin sequence $7/2 \rightarrow 9/2 \rightarrow 11/2$ for 667, 341 and 164 keV states are $A_2 = 0.05$ and $A_4 = 0.09$ in approximate agreement with the experimental values. No other spin sequence yields suitable values both for A_2 and A_4. A spin of 9/2 for the 341 keV state together with a value for log fit >10, however, indicates a large hindrance for the beta transition feeding the 341 keV state in ^{131}Xe.

2. Angular Correlation Studies in the decay of ^{139}Os - P.R. Rao, and V. Lakshminarayana - The angular correlation of three cascade

(388-73) keV, (322-139) keV and (281-180) keV are studied for the first time. The source is produced by neutron irradiation of enriched stable isotope ^{192}Os and the angular correlations are carried out in sum-coimcidence mode. The sum coincidence spectrum with gate at 461 keV is used to study these angular correlations simultaneously. The spectra are recorded with angles 180°, 135° and 90° between the detectors. The final corrected correlations coefficients are given below:

(388-73) keV cascade	: $A_2 = 0.008 \pm 0.010$
	: $A_4 = 0.005 \pm 0.010$
(322-139) keV cascade	: $A_2 = -0.47 \pm 0.03$
	: $A_4 = +0.04 \pm 0.02$
(281-180) keV cascade	: $A_2 = 0.34 \pm 0.02$
	: $A_4 = 0.005 \pm 0.008$

The three cascades connect the 461 keV and the ground states in ^{193}Ir through the intermediate state 73, 139 and 180 keV. Assuming the spin of the ground state to be 3/2, the spins of the states at 73, 139, 180 and 461 keV are found to be $\frac{1}{2}^+$, $5/2^+$, ($3/2^+$ or $5/2^+$) and $3/2^+$ by a qualitative analysis. The mixing parameter δ for the 322 keV gamma is found to be + 1.5. The mixing ratios of the 139 and 180 keV transitions need a redetermination to obtain quantitative fits for the correlation data.

3. Life time of the 342 keV State in ^{111}Cd - V. R. Ramamurthy, M.T. Rama Rao and V. Lakshminarayana - The meanlife of the 342 keV states in ^{111}Cd (decay of ^{111}Ag) is measured for the first time

by beta-gamma coincidence method and using 'centroid shift'technique. A value of (85 ± 21) PS is obtained for the meanlife in wide divergence to the previous coulomb excitation value. Assuming the conversion coefficient,relative branching and mixing ratios the transition probabilities are estimated and compared with single particle estimates. An M1 hindrance of 129 ± 30 and a enhancement of 7.5 ± 2.0 is, noticed. The transition probabilities estimated from Kisslinger-Sorenson[1] wave functions showed agreement in E2 case while the M1 case has deteriorated by an additional factor. of about 25. The relative amplitudes of the 342 keV and the ground state wave function of Kisslinger and Sorensen[1] are empirically adjusted to yield agreement in both B(E2) and B(M1). The resultant wave functions indicated coinsiderable $5/2^+$ phonon amplitudes, thereby suggesting the suitability of an intermediate coupling calculations with $d_{3/2}$; $s_{1/2}$, $d_{5/2}$ orbitals available to the odd neutron.

1. Kisslinger and R.A. Sorensen Rev. Mod., 35,853 (1963)

2. P.D. Barnes et al Phys. Rev.,155,1319 (1967).

4. Matrix Elements of the 1.492 MeV Beta Transition in ^{152}Eu - The angular correlation of the 3^- $\xrightarrow[1.492\ \text{MeV}]{\beta}$ 2^+ $\xrightarrow[0.342\ \text{MeV}]{\gamma}$ 0^+ cascade in ^{152}Eu decay was measured as a function of beta energy in the region 950-1400 keV. The present angular correlation results were combined with those on spectrum shape factor and beta-gamma circular polarization available from previous works to determine nuclear matrix elements governing the 1.492 MeV beta

transition in ^{152}Eu. The analysis was conducted on a CDC 3600 type computer employing the exact electron radial wave functions and taking into account the finite nuclear size effects. A comparison of the matrix elements obtained here with those determined by earlier workers who used the approximate formulae of Kotani, has shown that the present value of $\int \vec{\pi}$ is enhanced considerably while the values of $\int i\vec{\alpha}$ and $\int i\vec{\sigma}\times\vec{r}$ and agree with the previous results within experimental errors. The experimentally determined ratio of the $\int i\vec{\alpha}$ to $\int \vec{\pi}$ matrix elements is found to be 16.0 ± 5.0, which is not in agreement with the CVC prediction. The energy dependence of the circular polarization of the 343 keV gamma radiation is also predicted at an angle of 157° consistent with the matrix elements reported here.

5. Thermal Neutron Capture Gamma Rays from Natural Cerium - Surya N. Chintalapudi, D.L. Sastry and S. Jnanananda - Thermal neutron capture gamma ray spectrum below 900 keV, from natural cerium was investigated with a scintillation system and a 400 channel pulse hight analyser; at the CIRUS reactor of the Bhabha Atomic Research Centre, Trombay. The observed spectrum exhibited gamma components at energies 0.820 MeV, 0.668 MeV, 0.628 MeV 0.510 MeV, 0.448 MeV, 0.352 MeV, 0.179 MeV, 0.145 MeV and 0.091 MeV. The relative intensities of these gamma rays are estimated and reported.

6. Low Lying Levels of ^{60}Co from $^{59}Co(n,)^{60}Co$ Reaction - Surya N. Chintalapudi, D.L. Sastry and S. Jnanananda - Thermal neutron

capture gamma rays below 600 keV and the generic relations among them were investigated in the $^{59}Co(n,\gamma)^{60}Co$ reaction at one of the 4" neutron beam holes of the CIRUS reactor, BARC, Trombay, employing a fast-slow triple coincidence scintillation spectrometer. The low-lying levels of the odd Z-odd N ^{60}Co nucleus were deduced from the above studies and discussed in the light of the hole-hole, hole-particle and particle-particle type interaction. A new level at 338 keV was proposed and discussed on the basis of the present studies and the questionable level at 756 keV has been confirmed in the present results. It was also pointed out that some of the gamma rays were not due to transition between a single pair of states but may possibly belong to triple cascade transitions. The levels of the present investigations are compared with those of the earlier works and with the (d,p) reactions studies.

7. Gamma-gamma Directional Correlation Measurements in the $^{89}Y(n,\gamma)^{90}Y$ Reaction - Surya N. Chintalapudi, D.L. Sastry and S. Jnanananda - Gamma-gamma directional correlational correlation measurements for the transition 6.84 MeV-0.7767 MeV-0.0 MeV involving the 6.07 MeV $\longrightarrow$ 0.776 MeV gamma-gamma cascade from the $^{89}Y(n,\gamma)^{90}Y$ reactions were conducted employing a fast-slow triple coincidence scintillation system and a fully automatized angular correlation system. The measurements were conducted at one of the 4" neutron beam hole of the CIRUS reactor, BARC, Trombay. The values of the measured correlation coefficients after corrections are obtained as $A_2 = -0.1397 \pm 0.005412$ and $A_4 = 0$ (within experimental errors). The correlation measurements were consistent

with a spin and parity assignment of 2^+ to the 0.776 MeV state and a spin sequence of $1^- \longrightarrow 2^+ \longrightarrow 2^+$ to the transition in ^{90}Y. The assignment is also in accordance with the shell model predictions of the ^{90}Y nucleus. The present results also suggest that the population of the neutron capture state with the 6.849 MeV in ^{90}Y will be largely with unit spin and negative parity.

8. Gamma-gamma Directional Correlation Measurements in the Reaction $^{95}Mo(n,\gamma)^{96}Mo$ - Gamma-gamma directional correlation measurements were conducted for the transition 1.61 MeV-0.840 MeV 0.0 MeV involving the 0.776 MeV-0.840 MeV gamma-gamma cascade in the $^{95}Mo(n,\gamma)^{96}Mo$ reaction. The measurement were carried out at the CIRUS reactor of the Bhabha Atomic Research Centre, Trombay. The final values of the measured correlation coefficients are $A_2 = + 0.09821 \pm 0.008577$ and $A_4 = + 0.03968 \pm 0.008447$. Spin and parity assignments of 4^+ to the 1.61 MeV level and a $4^+ \longrightarrow 2^+ \longrightarrow 0^+$ to the transition are found to be consistent with the present correlation measurements and also with the quadrupole vibrational spectra which are characteristic of the even even nuclei. The nature of the 840 keV transition was examined on the basis of the parametric plot analysis and was concluded to be of pure quadrupole type.

9. Studies on (n,2n),(n,α) and (n,p) Reaction Cross-Sections at 14.2 MeV in Rare-earth Isotopes - P. Rama Prasad, J. Rama Rao and E. Kondaiah - Absolute cross-sections for the (n,2n),(n,α) and

(n,p) reactions have been measured at an incident neutron energy of 14.2 ± 0.2 MeV as a number of isotopes of the rare-earth group. Irradiations are performed with the T-D neutrons obtained from the 300 keV Cockcroft-Walton Accelerator of the Tata Institute of Fundamental Research and the induced activities are measured in a fully shielded well-type NaI(Tl) scintillation spectrometer coupled with a TMC-1024 channel pulse height analyser. The results include the following cross-sections which have been determined for the first time.

$^{153}Eu(n,2n)^{152m_2}Eu(96\ mts)$: 91 ± 12 mb;

$^{162}Er(n,2n)^{161}Er$: 1870 ± 300 mb

$^{144}Nd(n,\alpha)^{141}Ce$: 9.0 ± 1.7 mb; $^{151}Eu(n,\alpha)^{148m}Pm$: 19.1± 3.6 mb;

$^{158}Gd(n,a)^{155}Sm$: 2.3 ± 0.4 mb; $^{165}Ho(n,a)^{162}Tb$: 1.2 ± 0.3 mb;

$^{148}Sm(n,p)^{148m}Pm$: 18.8 ± 4.4 mb; $^{148}Sm(n,p)^{148G}Pm$; 14.3 ± 2.3 mb;

while the rest are consistent with those earlier reported. The experimental values of the cross-sections have been compared with the theoretical values calculated on the basis of the compound nucleus theory using a level density parameter, a = A/8 In the case of (n,2n) reaction, there is good agreement between the two values, while in the case of (n,a) and (n,p) reactions, the experimental values are found to be larger than the theoretical values by more than one order of magnitude, indicating the significance of the Direct Interactinn process in the latter case.

10. The accompanying list* comprises the results of systematic

* Communicated to Nuclear Physics for publication (1968-69).

investigations of neutron activation cross-sections in selected regions of the periodic table of elements, carried out at Atlanta(U.S.A.) and Waltair 'India. The results are classified according to the energy of the incident neutrons employed in the investigations, namely, thermal, 14.2 and 14.4 MeV. The thermal neutron cross-sections were measured in Krypton and Xenon isotopes using the external beam from the Georgia Tech. Research Reactor (U.S.A.) The mixed powder method with Ge(Li) detectors for absolute gamma counting was employed. Using the same method and the 14.4 $\pm$ 0.3 MeV T-D neutrons from the Georgia Tech. 200 KV accelerator, (n,2n),(n,p) and (n,α) cross-sections have also been measured in Si, Zn, Kr and Xe isotopes. Measurements at a neutron energy of 14.2 $\pm$ 0.2 MeV have been carried out in the rare-earth region using the Cockcroft-Walton accelerator at the Tata Institute of Fundamental Research, Bombay(India). The induced activities were determined using a calibrated well-type NaI(Tl) scintillation spectrometer.

Energy of the Neutron	Target	Reaction	Residual Nucleus	Half-life of Activity	Measured cross section	Neutron source & Method	Authors.
Thermal	Kr^{78}	(n,γ)	Kr^{79}(m+g)	34.9 h	4.71±0.68 b	A	EK,NBK, RWF
			Kr^{79m}	55 S	0.21±0.03 b		
	Kr^{80}	(n,γ)	Kr^{81m}	13 S	4.55±0.65 b		
	Kr^{82}	(n,γ)	Kr^{83m}	1.86 h	20.0±3.5 b		
	Kr^{84}	(n,γ)	Kr^{85m}	4.4 h	0.090±0.013 b		
	Xe^{124}	(n,γ)	Xe^{125}(m+g)	16.8 h	144±11 b		
			Xe^{125m}	55 S	23.6±2.5 b		
	Xe^{126}	(n,γ)	Xe^{127}(m+g)	36.4 d	4.27±0.60 b		
			Xe^{127m}	75 S	0.435±0.140 b		
	Xe^{128}	(n,γ)	Xe^{129m}	8 d	0.29±0.12 b		
	Xe^{130}	(n,γ)	Xe^{131m}	11.8 d	0.495±0.170 b		
	Xe^{132}	(n,γ)	Xe^{133g}	5.27 d	0.415±0.045 b		
			Xe^{133m}	2.26 d	0.030±0.005 b		
	Xe^{134}	(n,γ)	Xe^{135}(m+g)	9.14 h	0.265±0.020 b		
			Xe^{135m}	15.6 m	0.0030±0.0003 b		
	Xe^{136}	(n,γ)	Xe^{137}	3.9 m	0.130±0.015 b		
14.2±0.2 MeV	As^{75}	(n,2n)	As^{75}	18 d	1170±117 mb	B	PRP,JRR,EK
		(n,α)	Ga^{72}	14 h	13.6±1.6 mb		
		(n,p)	Ge^{75m}	49 S	8.0±1.0 mb		
			Ge^{75g}	82 m	16.0±2.4 mb		
	Nd^{142}	(n,2n)	Nd^{141m}	63 S	628±63 mb		
			Nd^{141g}	2.5 h	1447±210 mb		

.00?
.00?
.004 Nd^{142}(n,2n) G+M

Energy of the Neutron	Target	Reaction	Residual Nucleus	Half-life of Activity	Measured cross-section	Neutron source & Method	Authors
.013 →	Nd^{144}	(n,α)	Ce^{141}	33 d	9.0±1.7 mb		
.007 →	Nd^{148}	(n,2n)	Nd^{147}	11 d	1626±200 mb		
14.2±0.2 MeV	Sm^{144}	(n,2n)	Sm^{143M}	1 m	554±55 mb	B	PRP,JRR,EK
			Sm^{143g}	9 m	761±107 mb		
.018 →	Sm^{148}	(n,p)	Pm^{148m}	43 d	18.8±4.4 mb		
			Pm^{148g}	5.4 d	14.3±2.3 mb		
.008 →	Eu^{153}	(n,2n)	Eu^{152m_2}	96 m	91±12 mb		
.009			Eu^{152m_1}	9.3 h	652±90 mb		
.014 →	Eu^{151}	(n,α)	Pm^{148m}	43 d	19.1±3.6 mb		
.015 →	Gd^{156}	(n,α)	Sm^{153}	47 h	8.5±1.3 mb		
.016 →	Gd^{158}	(n,α)	Sm^{155}	22 m	2.4±0.4 mb		
.011 →	Gd^{160}	(n,2n)	Gd^{159}	18 h	1675±160 mb		
.010 →	Tb^{159}	(n,2n)	Tb^{158m}	11 S	524±70 mb		
.020 →		(n,p)	Gd^{159}	18 h	15.8±2.5 mb		
.017 →	Ho^{165}	(n,α)	Tb^{162}	8 m	1.2±0.4 mb		
.012 →	Er^{162}	(n,2n)	Er^{161}	3.1 h	1870±300 mb		
14.4±0.3 MeV	Si^{28}	(n,p)	Al^{28}	2.238 m	252±15 mb	C	NRK,EK,RWF
	Si^{29}	(n,p)	Al^{29}	6.6 m	130±16 mb		
	Si^{30}	(n,p)	Al^{30}	72.5 S	≤ 7 mb		
		(n,α)	Mg^{27}	9.46 m	68±8 mb		
	Zn^{64}	(n,2n)	Zn^{63}	38.4 m	150±12 mb		
		(n,p)	Cu^{64}	12.8 h	210±20 mb		
	Zn^{66}	(n,2n)	Zn^{65}	245 d	650±150 mb		
		(n,p)	Cu^{66}	5.1 m	65±6 mb		

Energy of the Neutron	Target	Reaction	Residual Nucleus	Half-life of Activity	Measured cross-section	Neutron source & Method	Authors
	Zn^{68}	(n,p)	Cu^{68}	30 s	8±1 mb		
		(n,α)	Ni^{65}	2.56 h	9±1 mb		
	Zn^{70}	(n,2n)	Zn^{69m}	13.8 h	600±40 mb		
14.4±0.3 MeV	Kr^{78}	(n,2n)	Kr^{77}	1.19 h	245±20 mb	C	EK,NRK,RWF
	Kr^{80}	(n,2n)	$Kr^{79(m+g)}$	34.92 h	810±60 mb		
			Kr^{79m}	55 s	415±50 mb		
		(n,p)	Br^{80m}	4.38 h	55±9 mb		
	Kr^{82}	(n,2n)	Kr^{81m}	13 s	160±15 mb		
		(n,p)	$Br^{82(m+g)}$	35.34 h	23±4 mb		
	Kr^{84}	(n,p)	Br^{84}	31.8 m	8.5±1.5 mb		
	Kr^{86}	(n,2n)	Kr^{85m}	4.4 h	350±35 mb		
		(n,α)	Se^{83g}	22.6 m	1.2±0.3 mb		
	Xe^{124}	(n,2n)	Xe^{123}	2.08 h	1130±110 mb		
	Xe^{126}	(n,2n)	$Xe^{125(m+g)}$	16.8 h	1355±165 mb		
			Xe^{125m}	55 s	700±200 mb		
	Xe^{128}	(n,2n)	$Xe^{127(m+g)}$	36.41 d	1530±170 mb		
			Xe^{127m}	75 s	840±65 mb		
	Xe^{130}	(n,2n)	Xe^{129m}	8 d	1435±130 mb		
		(n,p)	I^{130}	12.3 h	6.7±0.8 mb		
	Xe^{131}	(n,p)	I^{131}	8.05 d	5.3±0.6 mb		
	Xe^{132}	(n,2n)	Xe^{131m}	11.8 d	775±65 mb		
		(n,p)	I^{132}	2.26 h	2.5±0.3 mb		
	Xe^{134}	(n,2n)	$Xe^{133(m+g)}$	5.27 d	2360±240 mb		

Energy of the Neutron	Target	Reaction	Residual Nucleus	Half-life of Activity	Measured cross-section	Neutron source & Method	Authors
			Xe^{133m}	2.26 d	665±80 mb		
		(n,P)	I^{134}	52 m	2.2±0.5 mb		
	Xe^{136}	(n,2n)	$Xe^{135(m+g)}$	9.14 h	1700±100 mb		
			Xe^{135m}	15.6 m	750±50 mb		

Note: A : Reactor (thermal n): Mixed Powder method;Ge(Li)Y-detection (Atlanta)

B :T(d,n) Source; Well-type Nai(Tl); Y-detection,(India)

C :T(d,n) Source; Mixed Powder Method; Ge(Li)Y-detection(Atlanta)

EK : E. Kondaiah, NRK : N. Rana Kumar, RWF : R.W. Fink, PRP : P. Rama Prasad, JRR : J Rama Rao.

E. PUNJAB UNIVERSITY, CHANDIGARH

1. The Decay of ^{144}Ce* - P.C. Mangal and P.N. Trehan - Gamma ray in decay of ^{144}Ce have been investigated with scintillation spectrometers using gamma-gamma coincidence method, sum-peak coincidence method and gamma-gamma angular correlation technique. The study with high efficiency sum-peak coincidence spectrometer suggests the highest excited states in ^{144}Pr and ^{144}Nd at 166 and 2860 keV respectively. These levels are found to de-excite by 33-133 and 2180-696 keV cascades respedtively. The gamma-gamma coincidence study confirms the results of sum-peak study and also yields the relative intensity of some weak gamma rays. From the k-x ray-gamma ray coincidence work the k-conversion coefficients of 80 and 53 keV transition in ^{144}Pr have been found to be 2.8 ± 0.4 and 7.8 ± 0.8 respectively. The k-conversion coefficient of 53 keV transition agrees well with the theoretical results but the higher value of k-conversion coefficient of 80 keV transition as compared to its theoretical values suggests some dynamic nuclear structure effect in the conversion process of this transition. The gamma-gamma angular correlation study on 33-41 and 53-80 keV cascades support spin 2^- and 1^- for the 100 keV state and ground state of ^{144}Pr. From this study the branching ratios for the decay of 133 and 100 keV levels in ^{144}Pr are found to be $I_{133}/I_{53}/I_{33} = 0.73/0.17/0.10$. and $I_{100}/I_{41} = 0.59/0.41$.

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F. ALIGARH MUSLIM UNIVERSITY, ALIGARH

1. Energy Dependence of Spin Fall-Off Parameter (σ)* - A.K. Chaubey and M.L. Sehgal - Isomeric cross-section ratios are measured for 76-Ge, 108-Pd, 130-Te and 164-Dy at 24 keV neutron energy using Sb-Be photoneutron source. Using the spin distribution form due to Bethe and Block, the isomeric cross-section ratios were calculated for the above cases in addition to 68-Zn, 80-Se, 79-Br and 103-Rh. The theoretically calculated ratios were compared with experimentally measured ratios to study the spin-fall-off parameter σ. In the case of 79-Br, 103-Rh and 115-In value of σ has been calculated at different energies of study the energy dependence of σ. The even and odd Z effect in the cross-section value is also seen. It is found that $\sigma_{odd}/\sigma_{even} = 4.5 \pm 0.5$ at 24 keV neutron energy.

2. Study of the average level spacing from neutron capture Cross-section** - S.S. Hasan, A.K. Chaubey and M.L. Sehgal - Neutron activation cross-sections have been measured for 19 cases at 24 keV. A Sb-Be photoneutron source was used for these measurements. The value of the average level spacing 'D' has been estimated for these cases using statistical theory of nuclear reactions. These estimated values of average level spacing have been compared with the experimental values wherever they are known from low energy resonance parameter data. An agreement between these two set of values is found.

* Under publication in Nuclear Physics
** Under publication in Nuove Cimento

Finally the comparison of the deduced transition rates with Weisskopfs single particle estimates suggest many particle character for 133 and 80 keV levels where as 100 keV level seems to arise from collective excitations.

Previous reports published by the Indian Nuclear Data Group (INDG):

1.	A.E.E.T./NP/10	Progress report on nuclear data activities in India-I	1964
2.	A.E.E.T./227	Nuclear data measuring facilities in India	1965
3.	A.E.E.T.-228	Progress report on nuclear data activities in India-II	1965
4.	A.E.E.T.-267	Progress report on nuclear data activities in India-III	1966
5.	B.A.R.C.-305	Progress report on Nuclear Data activities in India-IV	1967