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# GOVERNMENT OF INDIA ATOMIC ENERGY COMMISSION 

PROGRESS REPORT ON NUCLEAR DATA ACTIVITIES<br>IN INDIA -II<br>Compiled by<br>Indian Nuclear Data Group<br>Nuclear Physics Division

## ATOMIC ENERGY ESTABLISHMENT TROMBAY <br> BOMBAY, INDIA

# GOVERNMENT OF INDIA ATOMIC ENERGY COMMISSION 

## INDIAN NUCLEAR DATA GROUP

## Members

| C. Badrinathan | T.I.F.R. |
| :--- | :--- |
| H.G.Devare * | T.I.F.R. |
| A.S.Divatia | A.E.E.T. (Convener) |
| D.N.Kundu | S.I.N.P. |
| B.P.Rastogi. | A.E.E.T. |
| M. Srinivasan | A.E.E.T. |
| G. Venkataraman | A.E.E.T. |

* In place of M.C. Joshi, Tata Institute of Fundamental Research, Colaba, Bombay-5
T.I.F.R. : Tata Institute of Fundamental Research, Bombay 5
A.E.E.T. : Atomic Energy Establishment Trombay, Bombay 74
S.I.N.P. : Saha Institute of Nuclear Physics, Calcutta 9


## PREFACE

The second Progress Report on Nuclear Data Activities in India is being published about ten months after the publication of the first report; it incorporates work done upto June 1965. The definition for 'nuclear data', adopted earlier has been adhered to; however, the scope has been somewhat expanded by including theoretical papers, which deal with quantitative calculations or determination of specific parameters. The response to our request for material has been better this year and we hope it will improve further. We wish to thank all those who have co-operated in the preparation of this report and to acknowledge the assistance rendered by Shri T. Ramanujam in assembling the report.

July 1965.

## A. ATOMIC ENERGY ESTABLISHDENT TROMBAY

1. Study of $C^{13}(\alpha, n) 0^{16}$ and $F^{19}(\alpha, n) \mathrm{Na}^{22}$ reaction K.K.Sekharan, A.S.Divatia and M.K. Mehta - The absolute cross sections of these two reactions have been measured using a $4 \pi$ neutron counter. In the case of the $C^{13}(\mathcal{C}, \mathrm{n}) 0^{16}$ reaction the energy range studied is 1.95 MeV to 5.5 MeV . Twenty resonances were observed. The energies at which the resonances appear agree with earlier measurements by Bonner et al. (1).

The peak absolute cross sections of these resonances agree for broad resonances with those evaluated by Walton et al. from angular distribution measurements upto 3.5 MeV whereas for sharp resonances there is some discrepancy. The values are tabulated below:

## Absolute peak cross section,mb.

| $\mathrm{E}_{\boldsymbol{\alpha}}$ | Present work $( \pm 15 \%)$ | Previous work |
| :---: | :---: | :---: |
| 2.10 | 46 | 56 |
| 2.27 | 75 | 98 |
| 2.43 | 69 | 85 |
| 2.63 | 44 | 76 |
| 2.70 | 45 | 83 |
| 2.79 | 38 | 68 |
| 2.83 | 82 | 175 |
| 3.08 | 53 | 44 |
| 3.34 | 105 | 108 |
| 3.43 | 93 | 88 |

E
3.67
3.73
4.13
4.44
(4.5)
4.63
4.78
5.06
5.3
5.42

## Present work

7
24
17
76
Not well separated
67
23
113
148
197

The Breit Wigner single level formula has been applied to evaluate the partial width $\Gamma_{\alpha}$ and $\Gamma_{\boldsymbol{n}}$ for some of the isolated resonances. $F^{19}(\alpha \quad n) N^{22}$ reaction cross section shows more than thirty resonances in the energy range 2.4 MeV to 5.5 MeV .

1. Bonner, Kraus, Marion and Schiffer, Phys. Rev. 102 (1956) 1348.
2. R.B.Walton, J.D.Clement and F.Boreli, Phys. Rev. 107 (1957) 1065.
3. Reactions Induced by Proton Bombardment of Aluminium - M.K.

Mehta, Joseph John and S.S. Kerekatte - - The reactions $A I^{27}\left(\mathrm{p}, \mathrm{p}_{\mathrm{o}}\right) \mathrm{Al} \mathrm{I}^{27}, \mathrm{Al}^{27}\left(\mathrm{p}, \mathrm{p}_{3}\right) \mathrm{Al} \mathrm{I}^{27}$ and $\mathrm{Al}^{27}\left(\mathrm{p}, \alpha_{0}\right) \mathrm{Mg}^{24}$ are studied in the proton energy range from 3.5 to 5.5 MeV with energy steps of about 5 KeV using thin (~ $\sim \mathrm{KeV}$ ) natural aluminium targets. The differential cross sections are


#### Abstract

measured as a function of bombarding energy to $\pm 15 \%$ accuracy at laboratory angles of $90^{\circ}$ and $150^{\circ}$. Seven angular distributions are measured for the reaction $\mathrm{Al}^{27}\left(\mathrm{p}, \alpha_{0}\right) \mathrm{Mg}^{24}$ at selected energies. The excitation curves exhibit sharp maxima of 10 to 50 KeV widths superimposed on broad 150 to 200 KeV wide structure. The ratio of the average observed width to the average observed separation is estimated to be $\approx 1$ from the inspection of the excitation curves. A very strong energy correlation is exhibited by the structure in all the five excitation curves indicating a probable resonance interpretation as against a fluctuation interpretation based on a statistical model assumption of $\Gamma / D \gg 1$.


3. Analysis of the Reaction Type ( $\alpha, d$ ) - B.K. Jain and N.Sarma - The angular distribution of the nuclear reaction of the type ( $\alpha d$ ) has been calculated on the plane-wave Born-approximation theory assuming that both light-particle and heavy-particle stripping processes occur. The interference between the two processes have also been taken into account. The angular distribution has been computed for the reaction $B^{10}(\alpha d) c^{12}$ and the results compared with the available experimental data.
4. A Study of the Levels of Ti-44 - M.G. Betigeri and N. Sarma The energy levels of the nucleus $\mathrm{Ti}^{44}$ has been studied using the reaction $\mathrm{Ca}^{40}(\alpha, \alpha) \mathrm{Ca}^{40}$, as part of a program for the detailed theoretical and experimental investigation of this nucleus. The
excitation function for the reaction was measured from incident energies 3.5 to 5.5 MeV , and several levels in nucleus of $\mathrm{Ti}^{44}$ were determined.
5. A Distorted Wave Born Approximation Calculation for ( $\mathrm{He}^{3}, p$ ) Reactions - B.K. Jain and N. Sarma - A theoretical expression for the differential cross section of the ( $\mathrm{He}^{3}, \mathrm{p}$ ) reaction has been developed for a direct interaction two nucleon transfer process. Distorted wave Born approximation theory has been used with a Gaussian form of the direct interaction potential. The calculations have been programed for the CDC -3600 computer and the results compared with available experimental data on the $\mathrm{Ca}^{40}\left(\mathrm{He}^{3}, \mathrm{p}\right) \mathrm{Sc}^{42}$ reaction.
6. Emission of Long Range Alpha Particles in 3 MeV Neutron Induced Fission of $\mathrm{U}^{235}$ - V.A.Hattangadi; T.Methasiri* D.M.Nadkarni, R. Ramanna and P.N. Rama Rao - The energy spectrum and anisotropy $\left(N\left(0^{\circ}\right) / \mathbb{N}\left(90^{\circ}\right)\right.$ ) of the angular distribution of long range alpha particles emitted in 3 MeV neutron induced fission of $\mathrm{U}^{235}$ were measured. The ratio of binary fission cross section and ternary fission cross sections for fission of $\mathrm{U}^{235}$ induced by thermal and 3 MeV neutrons has also been measured. The al pha particles were detected by solid state detectors and the fission fragments by a gas scintillation counter. 3 MeV neutrons were produced by the $\mathbb{T}(p, n) \mathrm{He}^{3}$ reaction using a 5.5 MeV Van de Graaff Accelerator
and thermal neutron measurements were made at the thermal column of 'Apsara' Reactor. The energy spectrum of $\alpha$ - particles in 3 MeV neutron fission of $\mathrm{U}^{235}$ has a peak around 15-17 MeV and a full width at half maximum of about 8.5 MeV . The alpha particle angular distribution is forward-peaked with anisotropy of ( $32 \pm 12$ ) \% The ratio of binary to ternary fission cross sections was found to be $(650 \pm 10): 1$ and $(780 \pm 15): 1$ in thermal and 3 MeV neutron fission of $\mathrm{U}^{235}$ respectively. Implications of these results on the mechanism of alpha emission in fission are discussed.

* I.A.E.A. Fellow on leave of absence from the Office of Thai Atomic Energy, Bangkok.

7. Fission of $\mathrm{Th}^{229}$ - R. Zaghioul* - With a view to study the characteristics of fission of $\operatorname{Th}^{229}$ a thin foil of this element on a VYNS foil backing has been prepared. $\operatorname{Th}^{229}$ was chemically separated from all other impurities and a very pure sample of $T h^{229}$ in a form suitable for coating on a VYNS foil was prepared. Fission cross section measurements for thermal neutron induced fission of $\mathrm{Th}^{229}$ are in progress.

* I.A.E.A. Fellow from the Atomic Energy Establishment, Cairo, U.A.R.

8. Measurements of Correlated Kinetic Energy of Fission Fragments in Thermal Neutron Fission of $U^{235}$ - S.R.S. Murthy - Using a back-to-back solid state counter assembly and a thin foil of $U^{235}$ on a VYNS backing, reasurements of mass distribution and kinetic
energy distributions of fission fragments in the thermal neutron induced fission of $U^{235}$ were made. Analysis of this data shows that for the symmetric fragment mass region ( $A=112$ - 124) the decrease in the total kinetic energy of the fission fragments compared to that of most probable fragments is not as pronounced as that observed in time of flight measurements. This implies that the number of neutrons emitted from symmetric fragments is probably smaller than that indi cated by the so called "Universal Curve" of neutron yields from individual fragments.
9. Study of Phonon Dispersion Relations in Beryllium - P.K. Iyengar, P.R.Vijayaraghavan, S.K. Sinha and A.P. Roy - A multiple arm spectrometer has been designed and built for use at one of the beam holes at the CIR. The spectrometer is similar to the conventional triple axis spectrometer except for the number of detector channels. There are four detector channels each having its own analyser. The spectrometer is now operational and is capable of measuring slow neutron inelastic scattering cross sections simultaneously for various selected values of the momentum transfer. The instrument is at present being used to measure the phonon dispersion curves in beryllium. A technique has been developed for choosing the incident wave vector in such a way that the single -phonon peaks for any two predetermined values of momentum transfer could be scanned simultaneously using two arms. The remaining arms are then programmed to scan phonons along any of the directions in the crystal lattice.

A beryllium detector spectrometer has also been used to study the phonon dispersion curves in a beryllium single crystal. Two methods have been employed:
a) Using a four inch length of cintered beryllium block in front of the detector, the spectrometer was programmed for the Constant $\underline{Q}$ mode of operation with the scattered wave vector corresponding to the cut off wave length of the beryllium filter. A sharp edge was observed in the spectrum of the neutrons scattered from the sample and this was taken to determine the phonon frequency.
b) The widow filter consisting of a beryllium filter followed by a BeO filter to back scatter the neutrons of wave length between 3.96 and $4.7 \AA$ into the detectors was also used. As before the spectrometer is used in the Constant $Q$ mode of operation. Further measurements on the beryllium single crystal sample are in progress.

The three acoustic branches of dispersion relations along the [0110] direction in Be have been closely measured using the multiarm spectrometer. The results differ by $10 \%$ from previous reported measurements ${ }^{(1)}$ for low phonon wave vector values. The window filter technique has been mainly used to measure the optical branches along the same direction.
(1) R.E.Schurik et al.,.Phys. Rev. 128, 562 (1962)
10. Neutron Diffraction Study of the Crystal Structure of Beryllium Sulphate Tetrahydrate - S.K. Sikka - The structure of tetragonal $\mathrm{BeSO}_{4} 4 \mathrm{H}_{2} \mathrm{O}$ has been determined $\mathrm{b}_{y}$ a single crystal neutron diffraction study. The CsCl type of arrangement of $\mathrm{SO}_{4}$ and $\mathrm{Be}\left(\mathrm{O}_{\mathrm{w}}\right)_{4}$ tetrahedra, as suggested by an earlier X-ray investigation is confirmed, the two being linked by hydrogen bonds between the water oxygen and the sulphate oxygens. Least squares refinement of the co-ordinates using isotropic temperature factors indicate that the hydrogen bonds are bent and the $\mathrm{H}-\mathrm{O}_{\mathrm{W}}-\mathrm{H}$ angle is more than the $0-0_{w}-0$ angle. Least squares refinement using anisotropic temperature factors is now in progress.
11. Cold Neutron Scattering by Gaseous Methane and Ammonia - G Venkataraman, B.A. Dasannacharya and P.K. Dayanidhi - Calculations have been performed on the CDC-3600 for cold neutrons scattering by gaseous methane at $300^{\circ} \mathrm{K}$ based on the theory given by Griffing. The calculations shown a good agreement with the experimental results of Webb ${ }^{(1)}$.

Formulae for the scattering of neutrons by gaseous Ammonia have been derived using symmetric top wave functions to describe the rotations. Calculations used on these are now in progress. When completed, they will be compared with Webb's ${ }^{\text {(1) }}$ experimental-results.
(1) F.J. Webb, Proc. International Symposium on Inelastic Scattering of Neutrons, 1963 (I.A.E.A., Vienna 1963)
12. Magnetic Structures in the Iron Germanium System - H.S. Satya Murthy, R.J. Begum, C.S. Somanathan and M.R.L.N. Murthy - Three phases in the iron germanium system have been studied. Of the se $\mathrm{FeGe}_{2}$ is antiferromagnetic with a Neel temperature of $315^{\circ} \mathrm{K}$. It has a tetragonal, $14 / \mathrm{mm}$ structure, the lattice constants being $a_{0}=5.899 \AA$ and $C o=4.941 \AA$. The $x$ parameter of the germanium positions was determined to be $1 / 6$. The magnetic moment per iron atom is $1 / 2 \pm 0.1 u B$ and the moments lie within the basel planes. The moments within a (200) plane are parallel, but alternate (200) planes are arranged antiferromagnetically.
$\mathrm{Fe}_{1.67^{\mathrm{Ge}}}$ is ferromagnetic. Its curie temperature is $510^{\circ} \mathrm{K}$. It has been reported to have the ideal 'filled' NiAs structure. But the systematic absence of intensities like (112), (004) and (114) in the neutron diffraction pattern rules out this possibility. The observed intensities suggest distortion in $x$ as well as $z$ parameters which are being determined. The neutron diffraction patterns of FeGe showed no magnetic Bragg reflections between $140^{\circ} \mathrm{K}$ and $410^{\circ} \mathrm{K}$. The paramagnetic scattering doe not indicate a large magnetic moment of $3.1 \mathrm{uB} / \mathrm{Fe}$ atom as reported by others. The moment is rather of the order of $1.0 \mathrm{uB} / \mathrm{Fe}$ atom. Also the suggested space group p6/mmm seems to be wrong. P6 mm is the most probable space group. Further investigations at - lower temperatures are being carried out.
13. Atomic and Magnetic Structure of $\mathrm{Mn}_{1.74} \mathrm{Sn}$ - N.S. Satya Murthy, R.J. Begum, B.S.Srinivasan and M.R.I.N. Murthy - The neutron diffraction patterns $\mathrm{Mn}_{1.74} \mathrm{Sn}$ were taken at room temperature and at lower temperature down to $92^{\circ} \mathrm{K}$. The observed reflections show the structure to be hexagonal with the lattice constants of $a_{0}=4.370 \AA$ and $C O=5.475 \AA$. Least squares analysis of the results shows the structure to be the ideal 'filled' NiAs type and gives an effective Debye temperature of $187.7^{\circ} \mathrm{K}$ which is very close to the theoretically estimated value.

The low temperature patterns show that $\mathrm{Mn}_{1.74} \mathrm{Sn}$ is ferrimagnetic with a Neel temperature at $260^{\circ} \mathrm{K}$. The magnetic moment of $\mathrm{Mn}_{\mathrm{I}}$ atoms of $2(\mathrm{a})$ sites is $0.8 \pm 0.2 \mathrm{uB}$ each while $\mathrm{Mn}_{\mathrm{II}}$ atoms of $2(d)$ sites have a much larger moment of $3.8 \pm 0.2$ uB. This leads to a net moment of $0.9 \mathrm{uB} / \mathrm{Mn}$ atom which is very good agreement with the saturation magnetisation data. The interatomic distances in $\mathbb{M n}_{1.74} \mathrm{Sn}$ are such that any direct antiferromagnetic interaction between any pair of Mn atoms or strong indirect exchange via a Sn atom seems unlikely. However, the structure can be visualised as alternate layer of $M n_{I}$ and $M n_{I I}$ atoms stacked at intervals of 1.37 A a distance short enough to permit the overlap of $d$ orbitals of adjacent layers and this results in antiferromagnetic interaction. $\mathrm{Mn}_{\mathrm{I}}$ layers have only Mn atoms while $\mathrm{Mn}_{\text {II }}$ layers have both Mn Sn atoms. The low moment of $\mathrm{Mn}_{\mathrm{I}}$ atoms may possibly be due to the participation of a larger number of their 3d electrons in bonding within the layers. Published in Physics Letters 15, 225 (1965)
14. Single Crystal Neutron Diffraction Study - V.M. Padmanabhan, S. Srikantha and So. Medhi Ali - (1) Ammonium Oxalate, monohydrate: Neutron diffraction study of this compound which was reported earlier has been completed. The hydrogen atom positions of $\mathrm{NH}_{4}$ and water molecules have been determined fram Fourier projection and least squares method. The study confirmed the non-planarity of the oxalate radical and linking of the oxalate ions by means of 0---H...O hydrogen bonds into linear chains parallel to X-axis. The $\mathrm{NH}_{4}$ group was distorted and the distortion is suggested as due to presence of linear $\mathrm{N}--\mathrm{H} . . \mathrm{O}$ bonding in the crystal. (2)Lithium hydrazine sulphate - R. Balasubramanian and V.M.Padmanabhan - Intensity data for about 250 (HkO) (okl) and (hol) reflections were collected and they were analysed to determine the positions of hydrogen atoms. The refinement upto present stage indicates that $\mathrm{NH}_{3}$ of the $\mathrm{N}_{2} \mathrm{H}_{5}$ group is rotating about the $\mathrm{N}--\mathrm{N}$ axis. Whether the protons of the $\mathrm{NH}_{2}$ group are pointing up the C-axis or down the C-axis or whether they are tunnelling through is not yet clear. Further refinement is in progress.

This crystal is ferroelectric at room temperature and so to understand the mechanism, intensity data for some (hk0) reflections were collected at $223^{\circ} \mathrm{K}$. The results are being analysed.
(3) Ammonium Sulphate : Intensity data for 120 (hol) and 52 (okl) reflections were collected. The nuclear density map is being plotted to locate the proton positions of the ammonia group.
(4) Single Crystals of ammonium stannic bromide, ammonium copper chloride, and Thiamine hydrocloride (Vitamin $B_{1}$ ) have been grown for neutron diffraction studies.
15. Neutron Scattering from Liquid Carbon Tetrachloride - K.R.Rao - A triple axis neutron spectrometer for studies of solids and liquids using thermal neutrons is installed at the E17 beam hole of the CIR. the spectrometer is designed to be versatile incorporating the features of variable incoming neutron monochromatisation and variable but fixed outgoing neutron energy. The spectrometer is driven automatically using linear or nonlinear motor-drive-instruction data from a paper tape input.

The spectrometer is being used in the study of inelastic scattering of thermal neutrons from liquid carbon tetrachloride. Liquid carbon tetrachloride consists of spherically symmetrical molecules like those in liquid methane. The molecules in the lịquid may be freely rotating. However, there is no evidence for any distinct inelastic peak in the scattered neutron spectrum in the range of momentum transfers of $1 \AA^{-1}$ and above. This is quite likely since the rotational energy levels are fairly low lying and they can be masked under the quasi-elastic peak due to diffusion broadening and the finite resolution of the spectrometer. More data is being collected for further analysis.

A diffraction spectrum of liquid carbon tetrachloride has been measured using a diffraction spectrometer. Five distinct peaks have been observed in the range of momentum transfer of
$0.5 \AA^{-1}$ to $8 A^{-1}$ corresponding to the values of $1.25,2.3,3.15$, 4.8 and $7.2 \AA^{-1}$. The one at $3: 15 \AA^{-1}$ is barely discernable. The peak positions and intensities compare well with the X-ray diffraction peaks obtained by Gingrich et al. The data is being fourier analysed to obtain the radial distribution function.
16. Slow Neutron Scattering from Liquia Methane - B.A.Dasannacharya, and G. Venkataraman - Scatteri ng of 4.1 A neutrons from liquid methane at $\sim 100^{\circ} \mathrm{K}$ has been measured at various angles of scattering between 15 and 90 degrees. The aim of the experiment was to (a) learn about the mechanism of diffusion and (b) see whether rotations in liquid methane are free or not. If the rotations are free, then peaks corresponding the rotational levels should be seen in the scattered neutron distribution at equal intervals of 1.3 mev in energy. The se peaks will be diffusion broadened, the broadening increasing roughly as the square of angle of scattering for small angles. Hence, the experiment is done best with a high resolution at a small scattering angle. Our measurement at $15^{\circ}$ with an energy resolution of 2 meV did not show any discreet peaks suggesting that rotations are not completely free in liquid methane. The study of the width of the quasielastic scattering show that upto about 50 degrees the width varies linearly with square of the wave vector transfer, QO, of the neutrons. The slope of the width gives a value of the diffusion constant (if a simple diffusion model is assumed)
which is about $15 \%$ less than the diffusion constant measured using tracers. Further, a detailed examination of the inelastic scattering confirms the result, earlier shown by Janik et al. (1), that the shape of the inelastic spectrum is independent of the scattering angle. Calculations based on a model described earlier ${ }^{(2)}$ give too low a inelastic scattering when the quasielastic scattering is normalised for zero energy transfer. Howver, the model shows the general behaviour of inelastic scattering in that it gives a maximum in the inelastic spectrum which is independent of angle, and at the correct energy transfer.
(1) J.A. Janik et al., J. Phys. Chem. Solids 25, 1091 (1964)
(2) B.A. Dasannacharya, G.Venkataraman and K. Usha, INDG Report No. 1.
17. Neutron Standardization - Neutron Standardization Group, Electronics Div.- A new primary national standard is being established by the manganese bath pumping technique using an $\mathrm{Am}-\mathcal{K}-\mathrm{Be}$ neutron source. The accuracy of standardization is expected to be better than $\pm 1 \%$. This experiment is in progress and the results will be communicated in due course.

A standrad thermal neutron flux facility consisting of six $A m-\mathcal{C}-B e$ neutron sources in a large graphite moderator is being set up. This facility would also be ready within a year's duration.
18. Measurements on the branching ratio in the decay of $\mathrm{Rb}-86$ and Cr-51 - Neutron Standardization Group, Electronics Division The number of $\gamma$-rays per distintegration in the decay of $\mathrm{Rb}^{86}$ has been measured by $N a I(T l)$ scintillation spectrometer and a $4 \pi \beta-\gamma$ coincidence counting set up. The 1.08 MeV gamma rays were found to be $3.91^{\prime} \pm 0.028 \%$ of the total disintegration rate. In the case of Cr. ${ }^{51}$ the total disintegration rate has been measured by $x-\gamma$ coincidence method and the disintegration leading to 0.328 MeV state in $\mathrm{V}^{51}$ has been measured with a $\gamma$-spectrometer. A value of $10.20 \pm 0.63 \%$ was obtained. The results have been sent for publication.

## B. TATA INSTITUTE OF FUNDAMENTAL RESEARCH

1. Study of Cl ${ }^{37}(\mathrm{p}, \mathrm{n}) \mathrm{Ar}^{37}$ Reaction - K.V.K. Iyengar, S.K.Gupta B. Lal and E. Kondaiah - The yield of the 1.42 MeV gamma rays from $\mathrm{Ar}^{37}$ in the $\mathrm{Cl}^{37}(\mathrm{p}, \mathrm{n}) \mathrm{Ar}^{37}$ reaction was measured in the proton energy region 3.2 to 4.8 MeV which shows two broad peaks at $E_{p}=3.7$ and 4.3 MeV . The angular correlation between the neutrons to the 1.42 MeV level and the gamma from the same level to ground state in $A_{r}{ }^{37}$ was studied at $E_{p}=4.3 \mathrm{MeV}$ as a function of the gamma emission angle in the ( $\mathrm{p}, \mathrm{n}$ ) reaction plane keeping the neutron detector angle fixed at zero degree. The measured angular correlation is essentially isotropic and is consistent with an assignment of $\frac{1}{2}$ for the spin of the $1.42 \stackrel{\rightharpoonup}{\mathrm{M}} \mathrm{mV}$ level of $\mathrm{Ar}^{37}$. The angular distributions of the neutrons to ground state of $\mathrm{Ar}^{3.7}$ in the same reaction were measured at proton energies of $5.1,5.3$ and 5.5 MeV. These distributions are neither isotropic nor symmetric around $90^{\circ}$ in the centre of mass system and appear to change with proton energy. Comparison of these experimental results with theory indicates that the random phase approximation is not fully valid for this reaction at the se energies under the experimental conditions employed.
2. $\mathrm{Ne}(\mathrm{n}, \mathrm{p})$ F Reaction - E. Kondalah and Ro. Patell - $\mathrm{Ne}(\mathrm{n}, \mathrm{p}) \mathrm{F}$ reaction is studied at $14.1 \pm 0.1 \mathrm{MeV}$ neutron energy using natural Neon gas as target and nuclear emulsion as detector. Hydrogen gas is used as standard and the cross-section for $\mathrm{Ne}(\mathrm{n}, \mathrm{p}) \mathrm{F}$
reaction is determined by comparison as $142 \pm 28 \mathrm{mb}$. The angular distributions of protons from Hydrogen as well as Neon gas targets are given. The angular distribution in the case of Hydrogen agrees with known results; in the case of Neon, the angular distribution is symmetric around $90^{\circ} \mathrm{com}$. Neon angular distribution fits well with a second order Legendre Polynomial, $1+a_{2} P_{2}$ (Cos) with $a_{2}=$ $1.35 \pm 0.2$. Assuming the energy distribution to be Naxwellian, the temperature of the residual nucleus is determined as $1.43 \pm 0.15$ MeV from the observed proton energy distribution in the case of Neon. From these it is concluded that $\mathrm{Ne}(\mathrm{n}, \mathrm{p})$ F reaction is essentially a compound nucleus reaction at this energy.

Reported at the International Conference on 'The Study of Nuclear Structure with Neutrons' held at Antwerp, in July 1965.
3. Fermi to Gamow-Teller Matrix Element Ratios in Allowed Beta Transitions in Eu ${ }^{152}, \mathrm{Sb}^{124}$ and $\mathrm{Ga}^{72}$-S.K. Bhattacharjee, S.K. Mitra and H.C. Padhi - The beta-circularly polarised gamma correlation following allowed beta decays in three complex nuclei of the type $3^{-} \underset{\longrightarrow}{ } 3^{-}$have been measured. The polarimeter employed the forward Compton scattering of gamma rays. The performance of the polarimeter has been checked by measuring the known beta circularly polarised gamma correlation in $\mathrm{Co}^{60}$ and $\mathrm{Na}^{22}$. The measured asymmetry parameter $A$ and the isotopic spin impurity coefficient $\mathcal{\alpha}$ which account for the Fermi component in the mixed decays are as follows:

|  | A | $\propto .10^{3}$ |
| :---: | :---: | :---: |
| $\mathrm{Eu}^{152}$ | $0.15 \pm 0.02$ | $(3.2 \pm 3.2) \times 10^{-3}$ |
| $\mathrm{Sb}^{124}$ | $0.30 \pm 0.03$ | $(0.53 \pm 0.13)$ |
| $\mathrm{Ga}^{72}$ | $-0.13 \pm 0.04$ | $6.3 \pm 0.9$ |

The full paper will be published shortly in Nuclear Physics.
4. Life Time and Angular Correlation Measurements in Au ${ }^{199}$ - K.G. Prasad, R.P. Sharma and B.V. Thosar - In order to ascertain the nature of the levels in $A u^{199}$, the following measurements have been carried out. The life-time of the 75 keV level has been measured to be $1.46 \pm 0.6 \mathrm{~ns}$. The analysis of the gamma-gamma angular correlation data yields the results (a) for the 475-320 keV cascade $\mathrm{A}_{2}=0.082 \pm 0.01, \mathrm{~A}_{4}=0.042 \pm 0.031$ and (b) for the $197-540 \mathrm{keV}$ cascade $\mathrm{A}_{2}=0.064 \pm 0.013, \mathrm{~A}_{4}=-0.051 \pm 0.04$ 。 Based on these results and in anology with the level structure in $A u^{197}$, a possibility of core multiplet is indicated in $A u^{199}$.
5. Decay of $\mathrm{Pd}^{111}$ and $\mathrm{Pd}^{111 \mathrm{~m}}-\mathrm{V} \cdot \mathrm{R}$. Pandharipande, R.M.Singru and R.P. Sharma - The decay of $22-m i n ~ P d^{111 m}$ was studied using scintillation spectrometer and coincidence techniques. The 22-min activity was studied in equilibrium with $\mathrm{Pd}^{111 \mathrm{~m}}$ and also independently and it was observed to emit gamma rays of energies 70,
$160,280,385,400,500,560,630,750,830,960,1130,1380$ and 1440 keV . Gamma rays of energies $1080,1250,1640,1690$ and 1900 keV were observed only in the decay of 5.5 hr activity. The beta spectrum of both the activities extends upto 2110 keV . From the beta-gamma and gamma-gamma cascade relationships, a decay scheme with levels in $\mathrm{Ag}^{111}$ at $70,120,280,385,470,560,1015,1220$, 1515, 1640, 1760, 1810, 1850 and 1970 kev has been proposed. Possible spins and parities for these levels have been discussed.
6. X-ray Yields from $K$-Shell Ionisation by $\mathcal{\alpha}$-particles - R.P. Sharma, B.V. Thosar and K.G. Prasad - The characteristic K-X-ray yields are measured in $\mathrm{Sn}, \mathrm{Te}, \mathrm{Ce}, \mathrm{Sin}^{144}, \mathrm{Sm}^{152}, \mathrm{Sm}^{154}, \mathrm{Gd}^{160}$, $W^{186}$ and Pb , by bombarding them with $\alpha$-particles of energy 4 MeV and 3 MeV . No excess of X-ray yield has been observed in the atoms of deformed even even nuclei, when the observed data were corrected for the X-ray contribution due to internal conversion by using the theoretical values of K-shell internal conversion coefficients. The observed variation of the number of $K$-shell vacancies per microcoulomb with the atomic number indicates that the $E 2$ internal conversion coefficients and also the probability for K-shell ionisation are unaffected by nuclear deformation. The details of this work will appear in the Physical

Review.
7. Low Lying Excited States in In ${ }^{115}$ and In ${ }^{117}$ - V.R.Pandharipande K.G.Prasad, R.M. Singru and R.P. Sharma - The low lying levels in In ${ }^{115}$ and In $^{117}$ have been studied by gamma-gamma and beta-gamma directional correlation measurements and life time measurements. The gamma-gamma directional correlation of the 1306 - 274 keV cascade in In $^{117}$ was found to be $W(\theta)=1+(0.271 \pm 0.013) P_{2}(\cos \theta)+$. $(0.026 \pm 0.042) P_{4}(\cos \theta)$. The measurement of the beta-gamma directional correlation between the beta transition from Cd ${ }^{115}$ to the 598 keV level in $\mathrm{In}^{115}$ and the following gamma ray of energy 261 keV gave $\mathrm{A}_{2}(w)=-0.16 \pm 0.02$. Based on these measurements it is shown that the levels at 598 and 588 keV in $\mathrm{In}^{115}$ and $\mathrm{In}^{117}$ respectively have spin and parity $3 / 2^{-}$. The half life of the 750 keV in $\mathrm{In}^{117}$ was found to be $4.9 \pm 0.2 \mathrm{~ns}$ 。
8. The Level Structure of $I^{131}$ - S.H.Devare, R.M. Singru and H.G. Devare - The levels of $I^{131}$ excited in the decay of the $30-h r$ àctivity of $\mathrm{Pe}{ }^{131 \mathrm{~m}}$ have been studied. Scintillation spectrometers were used for recording the gamma spectrum and gamma-gamma coincidences. The internal conversion spectrum with a double focussing spectrometer showed $K$ and $L$ lines corresponding to gamma rays of energies 81,102 and 150 keV and K lines corresponding to 200-, 241-, 336-, 452-, 775-, and $854-\mathrm{keV}$ gamma rays. K conversion lines of 775-, 786-, 797-, 830-, 854-, 869-, 1127-, and 1206-keV gamma rays were observed in the external conversion spectrum. The relative intensity of the gamma rays was found by analysing the
gamma spectrum and also from the external conversion spectrum. Using these relative intensities and the intensities of the internal conversion lines, the conversion coefficients and the possible multipolarities of the gamma transitions were ascertained. In particular, the 200- and $241-\mathrm{keV}$ transitions were found to be of E1 type indicating presence of od parity states in $I^{131}$. These two transitions were also found to be highly retarted and the 1829keV -level from which they arise was fo und to have a half life of $5.9 \pm 0.2 \mathrm{~m}$ sec. from delayed coincidence measurements using time to amplitude conversion technique. From these measurements it is concluded that $T e^{131 m}$ decays by beta transitions mainly to the 2112-, 1981-, 1965-, 1931- and 1902-keV levels of $I^{131}$. These levels de-excite by transitions to the levels at 1829-, 1629-, 1583-, 1340-, 1140-, 1065-, 797-, 775-, 602- and 150-keV. From the beta spectrum studied with an intermediate image spectrometer it was concluded that the beta transition to the ground state has an end-point energy of $2460 \pm 15 \mathrm{keV}$ and a relative intensity of $6 \%$ while the isomeric transition takes place with a relative intensity of $18 \%$ 。

The details of these measurements will be published in Physics Review.
9. The Magnetic Moments of the First Excited States of $I^{127}, I^{131}$ and Pm ${ }^{149}-$ PoN. Tandon and HoG. Devare - The nuclear $g$ factors for the excited states of $I^{127}$ at $59 \mathrm{keV}\left(7 / 2^{+}\right), I^{131}$ at 150 keV
$\left(5 / 2^{+}\right)$and $\mathrm{Pm}^{149}$ at $114 \mathrm{keV}\left(5 / 2^{+}\right)$have been measured by observing the rotation of the $\gamma-\gamma$ angular correlation pattern in a magnetic field using the integral method. The half lives of these excited states were measured by the technique of time to amplitude conversion. The angular correlation of gamma ray cascades passing through these excited states was measured and fitted to $W(\theta)=1+c_{2} \cos ^{2}(\theta)$. The results obtained were as follows:

| Nucleus | $\begin{gathered} -\mathrm{ray} \\ \text { Cascade } \\ (\mathrm{keV}) \end{gathered}$ | C2 | 1/2 | $\begin{gathered} \text { H } \\ \text { kilogauss } \end{gathered}$ | g |
| :---: | :---: | :---: | :---: | :---: | :---: |
| $I^{127}$ | 365-59 | $0.206 \pm 0.009$ | $1.2 \pm 0.1$ | $12.8 \pm 0.1$ | $0.77 \pm 0.15$ |
| $I^{13}$ | 452-150 | $0.043 \pm 0.006$ | $0.95 \pm 0.05$ | $13.3 \pm 0.1$ | $1.04 \pm 0.24$ |
| Pm ${ }^{149}$ | 538-114 | $0.028 \pm 0.003$ | $2.52 \pm 0.1$ | $13.3 \pm 0.1$ | $0.78 \pm 0.11$ |

These $g$ factors correspond to a value of the magnetic moment $\mu=2.71 \pm 0.52 \mathrm{~nm}$ for $I^{127}, \mu=2.6 \pm 0.6 \mathrm{~nm}$ for $I^{131}$ and $\mu=1.94 \pm 0.28 \mathrm{~nm}$ for $\mathrm{Pm}^{149}$.
10. Gamma-Gamma Directional Correlation in Pr ${ }^{143}$ - K.P.Gopinathan - The directional correlation four duty $\gamma-\gamma$ cascades in $\operatorname{Pr}^{143}$. fed from the decay of $\mathrm{Ce}^{143}$ have been studied. The correlation functions for the 293-57, 232-493, 591-293, and the $668-57 \mathrm{keV}$ cascades are found to be:

$$
\begin{aligned}
W\left(\theta_{293-57}\right)= & 1+(0.112 \pm 0.009) P_{2}(\cos \theta) \\
& +(0.000 \pm 0.014) P_{4}(\cos \theta) \\
W\left(\theta_{232-493}\right)= & 1-(0.176 \pm 0.008) P_{2}(\cos \theta) \\
& -(0.001 \pm 0.012) P_{2}(\cos \theta) \\
W\left(\theta_{591-293}\right)= & 1+(0.146 \pm 0.015) P_{2}(\cos \theta) \\
& +(0.003 \pm 0.026) P_{4}(\cos \theta)
\end{aligned}
$$

and
 Knowing the spin of the ground state of $\operatorname{Pr}^{143}$ as $7 / 2^{+}$and the recently measured spin of the ground state of Ce ${ }^{143}$ as $3 / 2^{-}$, the angular correlation results have been analysed. From this and the $\log \mathrm{ft}$ values of $\beta$ transitions from $\mathrm{Ce}^{143}$, the levels of $\operatorname{Pr}^{143}$ have been assigned spins and parities as follows: ground state: $7 / 2^{+} ; 57 \mathrm{keV}: 5 / 2^{+} ; 351 \mathrm{keV}: 3 / 2^{+} ; 493 \mathrm{keV}: 7 / 2^{+} ; 725 \mathrm{keV}: 5 / 2^{+}$; $942 \mathrm{keV}: 3 / 2^{+}$or $5 / 2^{+} ; 1160 \mathrm{keV}: 1 / 2^{+}, 3 / 2^{+}$or $5 / 2^{+}$and $1395 \mathrm{keV}:$ $3 / 2^{-}$or $5 / 2^{-}$.

The details of this work will be published in the Physical Review.
11. Gamma-Gamma Directional Correlations in Pm ${ }^{149}$ - K.P.Goninathan

- The directional correlations of six $\gamma-\gamma$ cascades in $\operatorname{Pm}^{149}$ from the decay of $\mathrm{Nd}^{149}$ have been studied. The results are as follows:
$W\left(\theta_{440-210}\right)=1-(0.026 \pm 0.011) P_{2}(\cos \theta)+(0.033 \pm 0.018) P_{4}(\cos \theta)$
$W\left(\theta_{536-114}\right)=1+(0.042 \pm 0.006) P_{2}(\cos \theta)-(0.009 \pm 0.010) P_{4}(\cos \theta)$
$W\left(\theta_{328-210}\right)=1+(0.109 \pm 0.006) P_{2}(\cos \theta)-(0.020 \pm 0.010) P_{4}(\cos \theta)$
$W\left(\theta_{424-114}\right)=1-(0.102 \pm 0.006) P_{2}(\cos \theta)-(0.027 \pm 0.010) P_{4}(\cos \theta)$
$W\left(\theta_{266-272}\right)=1-(0.227 \pm 0.008) P_{2}(\cos \theta)+(0.013 \pm 0.013) P_{4}(\cos \theta)$
and.W $\left(\theta_{158-114}\right)=1+(0.074 \pm 0.026) P_{2}(\operatorname{Cos} \theta)+(0.026 \pm 0.040) P_{4}(\cos \theta)$

From the measured spin of the ground state of $\operatorname{Pn}^{149}$ as $7 / 2$ the excited states of $\mathrm{Pm}^{149}$ are assigned spins as follows: $114 \mathrm{keV}-5 / 2,210 \mathrm{keV}$ $-5 / 2(7 / 2), 272 \mathrm{keV}-7 / 2$ or $5 / 2,538 \mathrm{keV}-5 / 2$, and $650 \mathrm{keV}-3 / 2$ (7/2). The half lives of the 114-and 272-keV levels are found to be $2.4 \pm 0.2 \mathrm{~ns}$ and $2.6 \pm 0.2 \mathrm{~ns}$ respectively.

The details of the work have been communicated to the Physical Review for publication.

## C. SAHA IN STITUTE OF NUCLEAR PHYSICS, CALCUTTA 9

1. Calculation of Exchange Stripping Amplitude - Anand Kumar - In view of the small contribution due to the knock-out process we have concentrated only on heavy particle-stripping (h.p.s.) and its interference with the light-particle-stripping amplitude. Calculation of these terms is straightforward in P.W.B.A.; but it is a poor approximation in view of discrepancy in cross section magnitudes and the spectroscopic factors. D.W.B.A. is a necessary refinement in the light of its encouraging success on elastic scattering. However, they had to confine to the zero-range-force alone. In the latter attempts, as a refinement, they, although, considered finite-rangeforce but made asymptotic approximations for the bound states. This seems apparently to be an improvement but we have shown exactly that the approximation of the above type is as poor as the one with a zero-range-force.

It was only in early 1964 that a complete treatment with a finite-range-force in D.W.B.A. due to N.Austern and collaborators was anrounced. Basing on this we have analysed the $0^{16}(n, d) N^{15}$ experiment. The spectroscopic factor thus extracted has been compared with the one obtained on shell-model.
2. Configuration Mixing and Single Particle Motion - S.N. Tewari A shell model calculation on $\mathrm{Na}^{22}$ with configurations mixing has been done in the Elliot's SU 3 classification scheme. For the two particle interaction the Yukawa shape including its spin dependence
and with an exchange character of the Serber type has been used. It is found that there is an extremely good intrinsic wave-function from which the good J wave function can be projected. The intrinsic wave-function is primarily a linear combination of two orthogonal bands. The density matrix set up for the dominant bands shows them to be single determinant to the order of $98 \%$ to $99 \%$. The comparison of the single particle wave-functions thus obtained with the corresponding Hartree-Fock wave function is under investigation.
3. Analysis of the Angular Distribution for $0^{16}(n, \alpha) C^{13}$ Reaction at $14 \mathrm{MeV}-\mathrm{M} . \mathrm{I}_{\text {。 }}$. Chatterjee - The $0^{16}(\mathrm{n}, \alpha) \mathrm{C}^{13}$ reaction leading to about 4 MeV excitation of $\mathrm{C}^{13}$ has been studied by bombarding a thin mylar film and using nuclear emulsion plate as detector. The angular distribution of the emitted alpha particles is found to be asymmetric about $90^{\circ} \mathrm{cm} . \mathrm{m}$. and is prominently peaked in the backward direction indicating the presence of exchange effect like heavyparticle stripping. Theoretical fits to the angular distribution have been attempted in terims of heavy-particle stripping process.
4. On the 1.86 and 3.32 MeV States of $\mathrm{Sr}^{88}$ - S. Shastry - The 1.86 and 3.22 MeV states of $\mathrm{Sr}^{88}$ arising from one-hole and one-particle shell model configurations have been calculated theoretically taking finite range forces. The various relevant transitions probabilities are also calculated. The results are in agreement with the experiments.
5. Angular Correlation in $W^{187}$ - A.K. Nigam - Beta spectrum and gamma-gamma angular correlation have been measured in the decay of one-day $W^{187}$ activity. Beta-gamma coincidence spectra have also been measured. The level scheme for $\operatorname{Re}^{197}$ has been drawn on the basis of these findings.
6. Decay of Hf ${ }^{183}$ and Nuclear Levels of $\mathrm{Ta}^{183}$ - H. Bakhru and S.K. Mukherjee - The decay of Hf ${ }^{183}$ produced by ( $n, \mathcal{\alpha}$ ) reaction on $W^{186}$ has been studied by scintillation spectrometery. A new isomer of $\mathrm{Hf}^{183}$ decaying with a half life of 91 days, is suggested. Spectrometric measurements show: (1) three beta groups, two of them decaying with a half life of 91 days and the third with a half life of 64 mins and (2) ten gamma rays ranging from 95 keV to 930 keV . A tentative level scheme based on coincidence spectrometry is given.
7. The isotope $T^{162}$ and its Decay Characteristics - H. Bakhru and S.K. Mukherjee - The decay of $\mathrm{Tb}^{162}$ is studied after bombarding Ho and Dy with 14 MeV neutrons and using standard Sceintillation Counter Techniques. A half-1ife of 7.5 min is assigned to $\mathrm{Tb}^{162}$. Three beta grouṕs are observed to decay with abo ve half life. Gamma measurements show six gamma rays. Gamma-gamma and beta-gamma coincidence experiments are performed and based on those results a decay scheme of $\mathrm{Tb}^{162}$ is proposed. The results are discussed in the light of the Unified model.
8. Life times of First Few Excited States of Au ${ }^{196}$ - Bo Sethi and S.K. Mukherjee - The half lives of first few excited states of Au ${ }^{196}$ have been measured with the help of fast slow coincidence circuit, using a time to pulse height converter. The source used was $\mathrm{Au}^{196 m}$ $\left(T \frac{1}{2}=9.7 \mathrm{hr}\right.$ ) which was produced by ( $n, 2 n$ ) reaction in $A u^{197 .}$.
9. Decay of $\mathrm{Nb}^{98}$ - S.C.Gujarathi and S.K. Mukher jee - The decay of $\mathrm{Nb}^{98}$ is studied after bombarding Mo with 14 MeV neutrons, using standard scintillation counter techniques. The half life of $\mathrm{Nb}^{98}$ is found to be 52 min . with an isomer having the half ife of 1.5 min . Depending upon various measurements of gamma and beta energies and their sum and coincidence studies, a decay scheme is proposed.
10. Alpha decay of Americium-241 - M. Rama Rao - Most of the available information on the excitation levels of $\mathrm{Np}^{237}$ has been derived through experiments based on: (i) $\beta_{\text {-decay of } U^{237}}$ (ii) Electron capture in $\mathrm{Pu}^{237}$, and (iii) Coulomb excitation of $N p^{237}$ 。

However, relatively much less was known about the excitation levels of $\mathrm{Np}^{237}$ from direct measurements on alpha transitions in $\mathrm{Am}^{241}$. Our knowledge of the alpha decay of $\mathrm{Am}^{241}$ was limited to only six or seven fine structure alpha groups until 1963 when working with a high resolution magnetic spectrograph, Baranov et al. showed the existence at least 18 fine structure alpha-ray groups.
:29:

A study of the alpha decay of $\operatorname{Am}^{241}$ would hence be of considerable interest both from the view point of excited levels of $\mathrm{Np}^{23.7}$ as well as of the alpha decay characteristics of $\mathrm{Am}^{241}$.

The study has been undertaken with the help of a low pressure expansion cloud chamber. The alpha-tracks are photographed in a stereo set-up. Range and energy measurements are made after sterio projection of the photographs containing over 40,000 tracks. The alpha groups identified with the above equipments are presented.

## D. IABORATORIES FOR NUCIEAR RESEARCH, ANDHRA UNIV ERSITY WALTAIR .

1. The Elastic Scattering of 662 keV Gamma rays - V.A.Narasimhamurthy, V. Lakshiminarayana and Swami Jnanananda - Employing a 2.5 curie Cs ${ }^{137}$ source total elastic scattering cross sections in $\mathrm{Pb}, \mathrm{Pt}, \mathrm{Ta}, \mathrm{Sn}$ and Zr are determined using a collimator geometry at angles $20^{\circ}, 30^{\circ}, 45^{\circ}, 60^{\circ}, 75^{\circ}$ and $90^{\circ}$. The experiment results are compared with theoretical values obtained from the form-factor formula of Bethe and exact calculations of Brown et al. The experimental values in $\mathrm{Pb}, \mathrm{Pt}$ and Ta are in agreement with the theoretical values obtained from Brown et al data. The experimental values in Sn and Zr show good agreement with form-factor values.

The paper will appear in the Proceedings of Physical Society, London.
2. Inelastic Scattering of Low Energy Photons - P.V. Ramana Rao, J. Raraarao and V. Lakshminarayana - The total atomic cross-sections are determined in C, Al and Cu at photon energies 145, 129, 100 and 84 keV by the transmission method in a good geometry set up. The values of bound electron inelastic scattering cross-sections

To are extracted by subtracting the theoretical sum of photoelectric and coherent scattering cross-sections from the total cross-sections. The values of $\sqrt{b}$ are also calculated theoretically using their $S(q, Z)$ values based on Thomas-Fermi atomic charge distribution. The free electron incoherent scattering
cross-sections are computed from the Kiein-Nishina formula. Good agreement is noticed between theoretical and experimental ratios of $\sigma_{B} / \sigma_{f}$ for $C$ and $A l$ at 145 keV and $C$ at 129 keV . Systematic deviations outside the experimental errors increasing with atomic number and decreasing energy are observed in all other cases and are ascribed to the systematic errors inherent in $T-F$ atomic charge distribution. This paper will appear in the Proceedings of the Physical Society, London.
3. Absolute Photoelectric Cross Sections of 320 keV Gamma-rays K. Parthasaradhi, V. Lakshminarayana and Swami Jnanananda Absolute photoelectric cross sections of 320 keV gamma rays in $\mathrm{Pb}, \mathrm{Pt}$ and Ta have been determined experimentally using a well type plastic crystal scintillation spectrometer. It.is found that the agreement between the experimental results and the values computed from the Nagel's theoretical expressions as well as with the interpolated values from the Grodstein's tables is satisfactory within the range of experimental errors. Similar work has been carried out with a source of 145 keV gamma-rays. The oretical values of cross-sections were computed on BESK service, Sweden.
4. The Life-time of the 75 keV Level of $\mathrm{Dy}-161$ - K.M.M.S.Ayyangar,
V. Lakshminarayana and Swami Jnanananda - The Iife time of the 75 keV level of Dy ${ }^{161}$ was measured with a time-to-amplitude
converter and found to have a half-life of $2.95 \pm 0.15 \mathrm{nsec}$. A retardation factor of the experimental transition probabilities with Nilsson's estinates, the retardation factors are found to be 6.8 and 7.6 for the 49 keV and 75 keV transitions respectively. This paper will appear in Nuclear Physics journal.
5. The Life-time of the 114 keV level of Lu ${ }^{175}-$ K.M.M.S.Ayyangar, V. Lakshminarayana and Bwami Jnanananda - The measurement of the life-time of the 114 keV level of $\mathrm{Lu}{ }^{175}$ is carried out employing a time-to-amplitude converter and the half-life is found to be $(10.6 \pm 1.1) \times 10^{-11} \mathrm{sec}$. For the 114 keV transition, an enhancement factor of 351 for E 2 and a retardation factor of 26 for M1 are observed. The rotational parameters $Q_{0}, B(m 1), g_{R}$ and $g_{K}$ are calculated and compared with the previous work.

This paper will appear in the Journal of Pure and Applied Physics.
6. Life-times of $2^{+}$and $4^{+}$States of Dy ${ }^{160}-$ K.M.M.S.Ayyangar, V. Lakshminarayana and Swami Jnanananda - The half-lives of the first and second excited states of Dy ${ }^{160}$ are measured by the delayed coincidence method. For this measurement, a time-to-amplitude converter arrangement with an intrinsic time resolution of 0.27 nsec down to 200 keV is employed. The life-times of $2^{+}$and $4^{+}$levels of Dy ${ }^{160}$ are obtained as $\mathbb{T}_{\frac{1}{2}}\left(2^{+}\right)=1.94 \pm 0.097 \mathrm{~ns}$ and $\mathbb{T}_{\frac{1}{2}}\left(4^{+}\right)=$ $(11.25 \pm 1.13) \times 10^{-11}$ sec. These values confirm the previous
results and the predictions of the unified nuclear model.
7. Life-times of the 321 and 113 keV levels of Hf 177 - B. V. Naras imha Rao and Swami Jnanananda - Life times of the 113 and 321 keV levels of $\mathrm{Hf}^{177}$ are measured with a fast time-to-amplitude converter. The values obtained are $5.23 \pm 0.16 \times 10^{-10}$ and $6.47 \pm 0.19 \times 10^{-10}$ secs. The experimental transition probabilities are compared with the single particle estimates. A good agreement with the Nilsson's estimate, based on the strong coupling model, is observed for the 72 and 208 keV transitions. The rotational parameters are calculated.
8. Half-lives of the First Excited $2^{+}$States in $W^{182}$ and Yb ${ }^{170}$ B.V. Narasimha Rao and Swami Jnanananda - The half lives of the first excited $2^{+}$states are measured and found to be $1.43 \pm 0.05 \mathrm{~ns}$ for the $100 \mathrm{keV} \cdot l e v e l$ of $W^{182}$ and $1.6 \pm 0.05 \mathrm{~ns}$ for the 84 keV level of $\mathrm{Yb}^{170}$. Experimental internal conversion coefficients are calculated using the present values of life-time measurements and the published data of the Coulomb excitation $B(E 2)$ !values. Agreement with the theoretical values of internal conversion coefficients is found satisfactory.
9. Internal Conversion Coefficients employing Internal External

Conversion Technique using a Scintillation Spectrometer - M. Rajarao and Swami Jnanananda - A beta scintillation spectrometer with a well
type of plastic phosphor is assembled for the measurement of total internal conversion coefficients employing the internal-external conversion technique. With foils of elements ranging from lead to copper as external converters, measurements were made and the values obtained for the total internal conversion coefficients are 0.112 and $0.21 \pm 0.03$ for the 661 keV and 279 keV transitions of $\mathrm{Ba}^{137}$ and $T I^{203}$ isotopes respectively. The deduced $\mathcal{C}_{k}$ values are in satisfactory agreement with the theoretical values.
10. Gamma-Gamma Directional Correlations in the Decay of $\mathrm{Tb}^{160}$ -
K. Venkata Reddy, BoB. Venkatapathi Raju, R.V. Ramamohan and Swami Jnanananda - Gamma-gamma directional correlation measurements have been made in the decay of $\mathrm{Tb}^{160}$ - Dy ${ }^{160}$ for the cascades, $87-197 \mathrm{keV}$, $87-877 \mathrm{keV}, 87-960 \mathrm{keV}, 37-1175 \mathrm{keV}, 197-1250 \mathrm{keV}$ and $298-877 \mathrm{keV}$. The corresponding angular correlation functions obtained are as follows:

$$
\begin{aligned}
& W(\theta)_{87-197 \mathrm{kev}}=1+(0.100 \pm 0.001) P_{2}(\cos \theta)+(0.0087 \pm 0.001) P_{4}(\cos \theta) \\
& W(\theta)_{87-877 \mathrm{kev}}=1-(0.092 \pm 0.001) P_{2}(\cos \theta)+(0.300 \pm 0.01) P_{4}(\cos \theta) \\
& W(\theta)_{87-960 \mathrm{kev}}=1-(0.07 \pm 0.003) P_{2}(\cos \theta)+(0.0009 \pm 0.001) P_{4}(\cos \theta) \\
& \dot{W}(\theta)_{87-1175 \mathrm{kev}}=1+(0.133 \pm 0.04) P_{2}(\cos \theta)+(0.0700 \pm 0.012) P_{4}(\cos \theta) \\
& W(\theta)_{197-680 \mathrm{kev}}=1+(0.200 \pm 0.002) P_{2}(\cos \theta)+(0.089 \pm 0.001) P_{4}(\cos \theta) \\
& W(\theta)_{197-1250 \mathrm{kev}}=1+(0.09 \pm 0.001) P_{2}(\cos \theta)-(0.152 \pm 0.002) P_{4}(\cos \theta) \\
& W(\theta)_{298-877 \mathrm{kev}}=1-(0.126 \pm 0.02) P_{2}(\cos \theta)-(0.008 \pm 0.01) P_{4}(\cos \theta)
\end{aligned}
$$

## E. KARNATAK UNIVERSITY, DHARWAR 3

1. On an Empirical regularity in the Energy Spectra of some Oddmass Nuclei - S.M. Brahmavar and M.K. Ramaswamy - Analysis of data on low-lying excited states of odd-mass nuclei shows a regularity in the energy spectra of nuclei with 51,53 and 55 protons. The energy level sequence is observed to obey a relation of the type:

$$
\text { where } \quad \begin{aligned}
\mathrm{E} & =\mathrm{n}^{2} \mathrm{Eo} \\
\mathrm{n} & =\text { is an integer } \\
E o & =\text { some basic energy value. }
\end{aligned}
$$

## F. DEPARTMENT OF PHYSICS, LUCKNOW UNIVERSITY LUCKNOW

1. The Li + d reaction at 500 keV - M.K. Saxena and J.P. Sah The neutron spectrum of the $\mathrm{Li}+\mathrm{d}$ reaction has been studied at seven angles using nuclear emulsion technique (Preliminary data has been reported previously) (1)

Evidence has been found only for the 2.9 meV level besides the ground state of $\mathrm{Be}^{8}$.

The angular distribution of the emitted group of neutrons corresponding to the formation of $\mathrm{Be}^{8}$ in the ground state is found to be asymmetric about $90^{\circ} \mathrm{com}$. - The distribution shows a prominent peak in the forward direction. The theoretical fits to the experimental angular distribution are being worked out.

The full report on the work will appear shortly.
(1) Indian J. Applied Physics 2, 364 (1964).

