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PROGRESS REPORT ON NUCLEAR DATA ACTIVITIES IN INDIA - XI

Compiled by

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I N T R O D U C T I O N

The eleventh progress report on Nuclear Data Activities in India covers the work done during the calender year 1974. A part of the work reported here has been presented at the Nuclear Physics and Solid State Physics Symposium held at Bombay during December 1974 as well as some work done during the current year. Apart from the work done in the field of nuclear fission the major thrust of work in India is directed towards basic Nuclear Physics research both theoretical and experimental. The experiments predominently involve charged particle reactions or level scheme studies. However during the current year a small programme has been started with a view to asses the feasibility for measuring neutron capture data on ^{233}Th between 0.1 and 2 MeV to 5% accuracy. It is hoped to evolve this programme into a more extensively data measuring and evaluation programme for Thorium cycle data which may involve collaboration between a few laboratories in India as well as Bangladesh. A short summary of this preliminary work is given as items number 20, 21 and 22 under section A.

The total number of CINDA entries sent to the Nuclear Data Section of the International Atomic Energy Agency during the period of report is 15. The liason activity with computer programme library (CPL) of the NEA was continued.

Among the new facilities, the installation of the 224 cm Variable Energy Cyclotron has progressed to a stage where beam trials are expected to start during December this year. The design of the 100 MeV thermal research reactor is frozen and the civil works have started.

(M.K. Mehta)
Convener,
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A. BHABHA ATOMIC RESEARCH CENTRE, BOMBAY 400 085

1. Analytic Distorted Waves for DWBA Calculations - N.K. Ganguly and D.K. Srivastava - In the computation of T matrix for reactionchannels the required distorted waves are generated by numerically integrating the scattering equation. In case a finite range interaction is used the requirement on the computer time for T matrix evaluation becomes prohibitive. To circumvent this difficulty some attempts have been made by a number of workers[1].

It is shown that an analytic scattering function can be obtained by expanding it in terms of the product of a plane wave and the value of the ψ -function at the scattering center and its derivatives. Analytic expression for a square-well potential and comparison of the elastic scattering cross-section obtained in this fashion with the results of exact calculation is presented.

The covergence of the series-expansion of the scattering ψ -function and its implication for the general DWBA analysis of reaction mechanism is studied.

1) R.T. Janus and I.E. Mc Carthy, Phys. Rev. C10C(1974)1041 and references therein.

2. Effect of Stripping Channel on Energy Dependence of Deuteron Optical Potential - S. Pal, D.K. Srivastava, N.K. Ganguly and S.N. Mukherjee* - Coupled-channel calculation has been done for

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^{48}Ca, coupling the elastic and p-stripping channel at five energies of the incident deuteron, e.g. 5.0, 7.2, 10.0, 13.0 and 16.0 MeV. The stripping cross-sections are in good agreement with experimental data. The calculated elastic scattering cross-sections fit the experimental values qualitatively.

Coupling of reaction channels is expected to remove energy dependence of the optical potential used in the elastic channel excepting the intrinsic one. In case of ^{48}Ca, the energy gap between 0^+ g.s. and 2^+ first excited state being large (3.83 MeV), the coupling of the most probable stripping channel is expected to remove most of the energy dependence. This was investigated by fitting the coupled-channel prediction for the elastic scattering cross-section with a conventional optical model search code. The nature of the energy dependence of the d-^{48}Ca optical potential is similar mainly for the imaginary part as obtained by other workers in the case of ^{40}Ca both by coupled-channel analysis and analysing elastic scattering data.

3. <u>Consistent Microscopic and Phenomenological Analysis of Composite Particle Optical Potential</u> - Sheela Mukhopadhyay*, D.K. Srivastava, N.K. Ganguly - A microscopic calculation of composite particle optical potential has been done using a realistic nucleon-helion interaction and folding it with the density distribution of the targets. The second order effects were simulated by introducing a scaling factor which was searched

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on to reproduce the experimental scattering results. Composite particle optical potential was also derived from the nucleon-nucleus optical potential. The second order term was explicitly treated as a parameter. Elastic scattering of 20-MeV-3H on targets ranging from ^{40}Ca to ^{208}Pb have also been analysed using phenomenological optical model. Agreement of these results with above calculations verified the consistency of the microscopic theory. But the equivalent sharp radius calculated with n-helion interaction was observed to be smaller than phenomenological value. This was attributed to the absence of saturation effects in the density-independent interaction used. Saturation has been introduced by a density dependent term of the form $(1 - C\rho^{2/3})$, where ρ is the compound density of the target helion system.

4. Assymetry Dependence of Proton Optical Potential - D.K. Srivastava, S. Mukhopadhyay*, S. Pal and N.K. Ganguly - In the optical-model studies the half-value radius of nuclear potential is adopted to vary as $A^{1/3}$. However, it is known from various studies that at least in isotopic sequences, the half-value radius increases less rapidly than $A^{1/3}$. This is easily resolved by considering the concept of equivalent sharp radius[1,2]. The proton elastic scattering data for 64,66,68-Zn at 30 MeV, for 64, 66,68-Zn at 50MeV, for 112,114,116,118,120,122,124-Sn at 30 MeV and 144,148,150,152,154-Sn at 50 MeV have been analysed using simple optical model, with above mentioned modification, with a view to know the isospin dependence of optical potential parameters,

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In addition to finding isospin dependence of parameters, the volume integral of imaginary potential per nucleon is found to vary linearly with the assymmetry parameter (N-Z)/A. This taken along with similar variation for Q value for (p,n) reactions may lead to better understanding of the imaginary potential.

1) W.D. Myers, Nucl. Phys. A204 (1973) 165

2) D.K. Srivastava, N.K. Ganguly and P.E. Hodgson, Phys. Lett. 51B (1974) 439

5. Study of the Reaction $^{55}Mn(p,n)^{55}Fe$ from E_p = 1.35 MeV to 5.4 MeV - S. Kailas, Y.P. Viyogi, S.S. Saini, S.K. Gupta, N.K. Ganguly, M.K. Mehta, A. Banerjee, S.S. Kerekatte - The total (p,n) cross-section for the reaction $^{55}Mn(p,n)^{55}Fe$ was measured in 5keV steps using a ^{55}Mn target ($\sim$ 8 keV thick for E_p = 3 MeV) and a 4π-geometry neutron counter, from E_p = 1.35 MeV to 5.4 MeV. The excitation function exhibits a large number of resonances, some of which can be identified with the isobaric analogue states in the compound nucleus ^{56}Mn. The excitation function averaged over 200 keV energy interval is analysed on the basis of optical model. Hauser Feshbach theory with Moldauer's modification is used to get the fit to the experimental data. The isobaric analogue resonance at E_p = 1.54 MeV is analysed to get the spectroscopic factor.

6. Microscopic Approach to Back-bending Effects in ^{158}Er and ^{162}Er - M.R. Gunye - The recently observed high spin states in the rare earth nuclei are studied in a self-consistent variational approach with the angular momentum projected Hartree-BCS wavefunctions. The nuclear Hamiltonian employed in the present work consists of the pairing plus quadrupole interactions. The nuclear deformation B, the neutron pairing gap Δ_n and the proton pairing gap Δ_p are varied to obtain the minimum energy for each angular momentum state. Our results rule out the suggestion of a phase transition from a superconducting to a normal state at the critical angular momentum $J \approx 12$. On the other hand, our results favour the interpretation of the back-bending effect in terms of a two-band theory. It should, however, be pointed out that the pairing gaps Δ_p and Δ_n decrease with the increase in angular momentum J. The calculated energy spectra in ^{158}Er and ^{162}Er are in good agreement with the recent experimental data.

7. A Note on the Determination of Fragment Mass, Energy and Angular Distributions with a Double Gridded Ionisation Chamber - N.N. Ajitanand and S.S. Kapoor - Data recorded earlier[1] event by event on magnetic tape with a double gridded ionisation chamber for the case of thermal and 2.2 MeV neutron induced fission of ^{235}U has been used to investigate the detailed characteristics of observed fragment distributions at various angles with respect to the electric field direction of the chamber. The relation between the grid and collector pulse heights enabled an event by event

evaluation of the energy and angle of the fission fragments. The energy and mass distributions of the fragments emitted at different angles were then studied and it was found that these distributions are significantly distorted at angles near 90° due to target thickness effects. By considering the data at those angles where energy degradation effects are small, one is able to obtain the mass distributions at various angles in fast and thermal neutron fission. The fast neutron distribution is divided by the thermal neutron distribution at each angle to bring out any possible dependence of the mass asymmetry on the angle in fast neutron fission.

1) N.N. Ajitanand, R.K. Choudhary, S.R.S. Murthy, P.N. Rama Rao and S.S. Kapoor, Nucl. Phys. & Solid State Phys. (India)16B,(1973).

8. Higher Isospin States in ^{36}Ar through α Particle Capture Resonances - D.R. Chakrabarty, M.A. Eswaran, H.H. Oza and N.L. Ragoowansi - With a view to locating and studying the higher isospin states in the self-conjugate nucleus ^{36}Ar, the excitation function in the reaction $^{32}S(\alpha,\gamma)^{36}Ar$ has been obtained in the bombarding energy range, E_α = 4.5 to 4.8 MeV. An isotopically enriched ^{32}S target of 10Kev thickness and a large volume NaI(Tl) scintillation detector for gamma rays were used. Two isolated resonances at $E_\alpha = 4.53 \pm 0.01$ and 4.69 ± 0.01 MeV have been located, corresponding to the excitation energy in ^{36}Ar of E_{ex} = 10.67 and 10.82 MeV respectively. The decay of these resonances have been determined as also the absolute strengths, to

be 0.86 ± 0.13 ev and 2.2 ± 0.2 ev respectively. Angular distribution at the E_α = 4.69MeV resonance has also been measured. Based on these measurements, possible spin and isospin assignments of these resonances are discussed.

9. Resonance Spectroscopy of ^{30}Si Nucleus in the Excitation Energy Range 14.276 MeV to 15.022 MeV.- L.V. Namjoshi*, S.K. Gupta and M.K. Mehta - Excitation functions for the reaction $^{26}Mg(\alpha,\alpha)^{26}Mg$ from 4.185 MeV to 5.145MeV lab. energy measured at angles 81°, 118°, 135° and 165° have been analysed using R-matrix theory of nuclear reactions. The computer program MULTI coding the multi-level-multichannel expression for differential cross section has been used for the purpose. Shape analysis of the observed anomalies have resulted in identification of nine levels in the compound nucleus ^{30}Si. The excitation energies and spins and parities of these levels are $14.320(0^+)$, $14.376(0^+)$, $14.597(0^+)$, $14.647(2^+)$, $14.675(1^-)$, $14.718(3^-)$, $14.874(0^+)$, $14.918(3^-)$ and $15.022(4^+)$ MeV. Tentative determination of total widths and partial widths for (α,α) channel have been made. The average cross section differs from Rutherford cross section by about 30% at all angles except at 81°. The average cross section could be fitted with optical model even though the incident energy is about 2 MeV below the Coulomb barrier.

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10. $^{19}F(\alpha,n)^{22}Na$ Reaction in the Energy Range 2.6 to 5.1 MeV - M. Balakrishnan, S. Kailas, S.S. Kerekatte and M.K. Mehta - Absolute total cross section for the reaction $^{19}F(\alpha,n)^{22}Na$ has been determined for the incident alpha energy range E_α = 2.6 to 5.1 MeV using thin target ($\sim$ 6 keV for 2 MeV alphas) and in fine steps of 5 keV. The excitation function shows some isolated resonances and also some cluster of states in ^{23}Na in the energy of excitation 12.6 to 14.7 MeV. An average strength function is extracted for the alpha-widths in this energy range. The results are compared with existing similar data in this region, obtained from gamma ray information.

11. $^{29}Si(\alpha,n)^{32}S$ Reaction near Threshold - M. Balakrishnan, S. Kailas, S.S. Kerekatte and M.K. Mehta - The low energy neutron cross sections are interesting both from nuclear spectroscopy points and of astrophysical points. We have measured the reactions $^{29}Si(\alpha,n)^{32}S$ just near the threshold in the energy range E_α = 1.8 to 2.5 MeV after reducing back ground effects substantially. The (n,α) cross sections were obtained using reciprocity relations. The reaction shows some interesting structures of width around 80keV wide and the alpha width, neutron width and reduced widths have been extracted for these structures. The possible significances of there structures are discussed. The average alpha strength functions indicates an abnormal behaviour in this region.

12 Alpha Particle Trajectory Calculations in Spontaneous Ternary Fission of ^{252}Cf and Studies of Scission Point Configurations - R.K. Choudury and V.S. Ramamurthy - Three-point-charge model trajectory calculations have been carried out to search for possible scission configurations in spontaneous ternary fission of ^{252}Cf. The distribution of fragment kinetic energies and alpha particle energies for various mass divisions were used as input. Three parameters were used to specify the scission configuration: the interfragment distance D, the distance of the alpha particle from the heavy fragment X, and the distance of the alpha particle from the fission axis Y. As different from similar earlier investigations, for each mass division, not only the most probable values of the parameters D,X and Y but also their variances have been obtained. It is shown that with these parameters as input, it is possible to explain most of the experimentally observed energy and angular correlations. An important conclusion arising out of the present investigations is that the alpha particles originate nearer to either one of the fragments.

13. Alpha Particle Trajectory Calculations in Spontaneous Quaternary Fission of ^{252}Cf.- S.K. Kataria - The trajectory calculations have been performed in an attempt to explain the energy and angular correlations between the two light charged particles (LCP) emitted in the spontaneous fission of ^{252}Cf. Three possible emission mechanisms and scission configurations for LCP have been

tested with trajectory calculations and compared with the observed energy and angular correlations. The first hypothesis is that the two LCP are the result of breakup of ^{8}Be. The second hypothesis is that the two LCP are produced in between the fragments near the axis of separation, simultaneously. The last hypothesis tested is that the two LCP are being emitted from the two fragments independent of each other. Only the last hypothesis predicts angular and energy correlation in agreement with the experimental results. From trajectory calculations for quaternary fission, many important conclusions have been reached regarding the emission mechanism of LCP.

14. <u>Three Dimensional Correlations of Fragment Mass, Fragment Energy and Long Range Alpha Particle (LRA) Energy in the Fission of U-235 by Thermal Neutrons</u> - D.M. Nadkarni, R.K. Chaudhury, S.R.S. Murthy, P.N. Rama Rao and S.S. Kapoor - To investigate in detail the various correlations between the energy and mass of fission fragments and LRA energy we have carried out a 3-parameter investigation in the thermal neutron fission of U-235. A back-to-back gridded ionization chamber was used to measure the energies of correlated fragments and the energy of coincident LRA was measured with semiconductor detectors. This setup ensured that events recorded are not restricted to any particular angle between fragments and LRA but cover all the angles. The data have been analysed to obtain total coulomb energy distributions in binary and

ternary cases. The average LRA energy was seen to decrease with asymmetry in mass division. One other new feature observed was the non-linear anticorrelation between E_k and E_α and the dependence of this anticorrelation on the mass asymmetry, With these data scission parameters in ternary fission are derived by carrying out trajectory calculations.

15. Shape Mixing in ^{184,186}Hg - C.V.K. Baba - Recent potential energy calculations on even Hg isotopes have shown that ^{184,186}Hg are possibly deformed with two energy minima one each for oblate ($\beta_2 = -0.14$) and prolate ($\beta_2 = 0.28$) shapes. The quasi-rotational levels in these nuclei have been studied by heavy ion reactions at Berkeley and Chalk River. The salient features of there studies are (i) a deviation of the energy levels from a totational sequence for $I \lesssim 6$; the levels with higher spins showing a good rotational spectrum and (ii) the deviation of the $4^+ \rightarrow 2^+$ and $2^+ \rightarrow 0^+$, E2 transition rates from the rotational value with $\beta_2 = 0.28$. These features of the spectra are explained on the basis of mixing of bands based on the oblate and prolate shapes. The results of a simple band mixing calculation are presented and they reduce the observed level spacings and B(E2) values.

16. Nuclear Structure Study of ^{50}V by the ^{50}Ti(p,nγ)^{50}V Reaction - S.K. Gupta, S. Saini, L.V. Namjoshi and M.K. Mehta - The information on gamma ray transitions, branching ratios, spins and parities of

low-lying levels of ^{50}V, has been obtained by Ge(Li)-Ge(Li) coincidence measurements. Comparison of the experimental results has been made with the calculations using lowest senority shell model wavefunctions.

18. On the Fundamental Representation of SU(3) Group - S.K. Gupta and I.V.V. Raghavacharyulu - In terms of Biedenharn basis it has been shown that the fundamental representation of SU(3) group is dependent only on one parameter. The expressions for the fundamental representation matrices have been derived in terms of this parameter. Gellmann-Nishijima representation turns to be one of the representations which is obtained by substituting different values for the parameter.

19; Spectra of Doubly Odd-Nuclei - S. Saini and S.K. Gupta - The energy levels of doubly odd nuclei like ^{42}Sc, ^{48}Sc and ^{50}V have been calculated. The two body residual interaction employed has been a schematic one consisting of a short range delta-function plus a long range quadrupole-quadrupole interaction. We have assumed neutron and proton senorities to be good quantum numbers and used the lowest senority wave-functions in all these calculations. The experimental spectra are satisfactorily fitted when the parameters of the interaction are suitably adjusted.

20. Measurement of Neutron Capture Cross Section on ^{232}Th between 0.1 and 2 MeV - H.M. Jain, S.K. Gupta, R.P. Anand, R.N. Jindal and M.K. Mehta - The capture cross sections on ^{232}Th reported in the literature in the above energy range have errors of the order of 20%. There are large discrepancies between different sets of data. The earlier work was generally done by measuring the induced β activity of ^{233}Th. In order to remove the discrepancy and as a check on the previous work it is proposed to measure the cross section with reduced errors. This would be done by measuring the intensity of a few delayed gamma lines emitted following the β decay. With the help of an accurately calibrated Ge(Li) detector this can be done to within less than 10% error. This would require the knowledge of the branching ratios for various gamma rays also to an accuracy better than 10%. Preliminary work to measure this branching ratios and relative photopeak efficiency has been started. A simultaneous irradiation of one thorium and one gold foil, both of 14 mm diameter, was done in a well thermalized neutron flux ($\sim 10^9$ n/cm^2/sec) at the CIRUS reactor at Trombay for 15 minutes. The gamma spectra of the irradiated were measured with a 27 cc Ge(Li) detector with resolution 3.3 keV FWHM at 662 keV. The [redacted] intensities of seven different photopeaks (162, 169,441,448,459,670 and 678 keV) were extracted, and identified to be arising from the decay of ^{233}Th as shown by their half life. The 459 and 670 keV gammas were found to be prominent. The photopeak efficiencies of the seven gammas will be measured relative to the 412 keV gamma from ^{198}Au. The computer

program SAMPO was adapted to BESM-6 for fitting the multiple peaks.

Using the measured relative efficiencies and thermal neutron capture cross-section ^{232}Th and ^{197}Au, the branching ratios for the seven gammas will be calculated. These branching ratios and the known neutron capture cross-section ^{197}Au will be used to measure the capture cross section for ^{232}Th for higher energy neutrons. The capture cross section on gold is known to an accuracy of 3-4%. However absolute measurement is also planned where the neutron flux will be measured utilising a silicon surface barrier sandwich system which is being developed as described below.

21. Neutron Spectrum and Flux Determination using Silicon Surface Barrier Sandwich System - O.P. Joneja, J.C. Coachman and M.P. Navalkar - Among several neutron detectors available, a silicon surface barrier sandwich system enclosing a suitable radiating material can be effectively employed for finding neutron spectrum as well as neutron flux. The radiating material choosen for the puppose could be He^3 or Li^6. The process of detection involves neutron interaction with the radiating material, resulting thereby in two charged particles moving approximately in the opposite direction, which can be easily detected by two separate detectors arranged in a sandwich geometry. In order to establish one to one correspondance between neutron

energy and pulse height, the individual out puts are added up and in addition a coincidence unit is incorporated to avoid sigle particle events. The analyser out put is to be corrected for energy dependent geometry effects, variation of cross-section with respect to energy and finally resolution correction because of finite resolution of the system under consideration. The leakage factors associated with geometry have been simulated by Monte-Carlo method whereas the desired point x-sections are suitably interpolated from the available nuclear data. As regards reolution correction,a special advancing matrix is constructed from the thermal response of the spectrometer which can be suitably operated on the cross-section vector to generate a new cross-section set. The resulting cross-section set would obviously contain the effect of resolution correction.

In order to determine the neutron flux for definite neutron energies produced from an accelerator, the resolution correction can be avoided in case the energy spread due to the finite solid angle is smaller than the resolution of the system. The neutron flux can then be evaluated from the counts under the peak and suitable leakage and cross-section correction. In order to measure neutron fluxes within the error of neutron cross-section for the reaction of interest, a high degree of accuracy is desired for identical properties of detectors as well as for finding the total number of radiating atoms in the system and defining the areas of the detector correctly.

All the electronics has been fabricated for this spectrometer and initial calibration, study of the detector

behaviour etc. are in progress.

22. Summary of the cross section work done in TRPS of Reactor Group - S.B. Garg - Thorium utilization in fast reactors gives rise to Th-233 which is very short lived, its half-life being 22 minutes. Th-233 affects the production of U-233 especially in high flux fast reactors when the capture reaction is taking place at a very rapid rate compared to its β -decay process. The cross-sections of Th-233 are, thus, important and these have not been measured at all.

To fill this void optical model was used to determine the total, elastic and compound nucleus formation cross-sections in the energy 0.1 MeV to 20.0 MeV. Channel theory of fission and dipole radiation theory were then used to estimate the fission and the capture cross-sections.

In addition to the above, following programmes have been pursued:

(1) Evaluation of neutron cross-sections in the resolved and unresolved resonance regions:

(i) A computer code RESEND to evaluate the neutron cross-section, in the resolved and unresolved resonance regions was modified and commissioned on CDC-3600 computer. The code consists of two overlays and is based on single and multilevel Breit Wigner theory and Adler and Adler formalism in the resolved resonance region, and Lan and Lynn theory in the unresolved resonance region.

(ii) Cross-sections for Na, Fe, Cr, Ni, Th-232, Pu-233, U-233, U-234 U-235, U-236, Pu-238, Pu-239, Pu-240, Pu-241, Pu-242, Am-241, Am-243 and Cm-244 were evaluated in resonance regions with the resonance parameters taken from ENDF - data files and the point cross-sections thus generated were combined with the background corrections listed in ENDF-files. These cross-sections can, now, directly be used in generating the unbroadened dilute multigroup cross-sections for reactor physics studies.

(2) Generation of Legendre coefficients and Transformation matrices:

In reactor physics studies the Legendre coefficients are used in the ultrafine group treatment of the neutron propagation in order to calculate correctly the elastic transport and elastic removal cross-sections and therefore these coefficients are generated at thousands of energy points. The transformation matrices are calculated to transform these coefficients from CM to Lab system.

Using the updated scattering cross-section data from ENDF-files the Legendre coefficients have been generated at 1021 energy points in the energy range 0.4 ev to 10 MeV with a constant lethargy width of 1/60 for the nuclides B, C, N, Be, O, Na, Cr, Fe and Ni.

(3) Generation of multigroup cross-sections

To carry out the reactor physics studies multigroup cross-sections for fissile, fertile and structural materials have been generated in the energy range 0.2 ev to 15 Mev using the point cross-section data from ENDF-files. The discrete level, inelastic and (n,2n) scattering matrices have also been evaluated.

B. TATA INSTITUTE OF FUNDAMENTAL RESEARCH BOMBAY 400 005.

1. Internal Conversion Process and Core-Polarization g-Factors - B.N. Subba Rao - Since 1959 there have been reported several measurements of the Nuclear structure (Penetration) effect in M1 Internal Conversion in non-deformed as well as deformed nuclei. Very few of these can be explained with the present day nuclear models. Where such explanations have been attempted, only the numerator of the penetration parameter λ , i.e. the penetration matrix element has been evaluated with the model, resulting in signless (absolute) magnitudes for λ, The ℓ-forbidden M1 transitions are of special concern in (non-deformed) retarded M1 transitions and here an effective operator approach is employed to evaluate not only the core polarization g-factor, g_p, but also the penetration parameters, λ , with their sign. In order to keep track of phase conventions in the definition of nuclear matrix elements, the amplitudes of multipele mixing ratio, δ (E2/M1), are also evaluated. With such simultaneous comparison of λ andδ from both experiment and theory, it is believed that a better picture emerges as to the nuclear structure information emerging from these penetration effect measurements. Odd-proton and odd-neutron ℓ-forbidden M1 transitions in ^{121}Te, ^{123}Te, ^{129}I, ^{133}Cs, ^{141}Pr, ^{143}Pr, ^{147}Pm, ^{149}Pm, (^{175}Lu, ^{181}Ta), ^{197}Au, ^{201}Tl, ^{203}Tl, ^{207}Tl, are considered in this work.

2. g Factor of the 635.4 keV $7/2^+$ Level in ^{171}Tm - S.B. Patel*, P.N. Tandon and K.P. Gopinathan+ - The 635.4 keV level in ^{171}Tm fed in the β decay of the 7.5 h ^{171}Er was recently identified unambiguously to be the $7/2^+(404)$ Nilsson state from directional correlation studies of γ rays through that level[1]. The half-life of this level was measured to be 1.26 ± 0.06 nsec by delayed coincidence technique[1]. Here we report the measurement of the g factor of this level using the perturbed angular correlation technique. The measurement was made using the 277.4 - 210.5 keV γ-γ cascade in an externally applied magnetic field of 10.0kG. The results are: A_2 = 0.124 ± 0.005, R = 0.047 ± 0.007, and $\omega\tau$ = 0.160 ± 0.023. Assuming Tm to be in the 3^+ ionic state after β decay of ^{171}Er, the g factor is obtained to be 0.36 ± 0.06. This value is in good agreement with the Nilsson estimate (g = 0.41) for this level.

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1) K.P. Gopinathan and S.B. Patel, in Proc. Internat. Conf. Nucl. Phys., Munich, 1973, Vol. I, p 300.

3. Potential Energy Curves from the Strutinsky Prescription and from a Microscopic Approach - Y.S.T. Rao, C.S. Warke and S.K. Mukhopadhyay - Strutinsky shell correction method has been quite successful in getting potential energy curves for heavy nuclei. The more microscopic pairing-plus-quadrupole (PPQ) model as used

by Kumar and Baranger has been extremely successful in explaining the properties of medium heavy nuclei. Because of this reason, it is worth extending shell correction methods towards lighter mass region and PPQ model to heavier mass region and compare their results. We present results of both these methods in the neighbourhood of Os, Pt, Hg and W, and compare the deformation energy curves of these two methods. We discuss the significant differences and similarities in the predictions of these two methods and try to reconcile them.

4. Study of Isobaric Analogue States in ^{64}Zn through Proton Capture by ^{63}Cu - A. Roy, K.V.K. Iyengar and M.L. Jhingan - The reaction ^{63}Cu (p,γ)^{64}Zn has been studied in the proton energy range 1650-2750 keV using the Van de Graaff accelerator at B.A.R.C. Trombay. About 100 resonances were observed in the excitation function out of which the prominent ones at E_p = 1731, 1882, 2036, 2099, 2312, 2352, 2421 and 2479 keV have been identified as analogues of the ground and low-lying excited states of ^{64}Cu. The overall energy resolution was 2.5keV. The Coulomb displacement energy for the isobaric pair ^{64}Cu-^{64}Zn has been deduced to be (9.63 $\pm$ 0.01) MeV. The spectra of γ-rays and their angular distributions have been obtained at resonances corresponding to the analogue of the ground and first four excited states of ^{64}Cu. The resonance strengths and the branching ratios for the γ-decay of the resonances will be presented. The M1 width of the γ-decay

from the resonance at 1731 keV to the ground state of ^{64}Zn, (0.20 ± 0.04) eV, is in excellent agreement with the value 0.19 eV deduced from the log ft value of 5.3 of the β -decay of the parent analogue.

5. Measurement of Isotopic Neutron Capture Cross-Section for ^{51}V, ^{63}Cu, $^{74,76}Ge$, ^{75}As, $^{98,100}Mo$, ^{104}Ru, ^{115}In, $^{128,130}Te$, $^{140,142}Ce$, $^{185,187}Re$ at E_n = (25 + 5) keV - R.P. Anand*, D. Bhattacharya, M.L. Thingan and E. Kondaiah - We have measured the isotopic neutron capture cross-sections of a number of nuclei, the majority of which are fission products, at the neutron energy (25 ± 5)keV. The neutron have been obtained from the monoergic filtered neutron beam facility that we have developed at the reactor CIRUS, B.A.R.C. This gives a flux of $\sim 10^5$ n/cm^2/sec. over an area of 3" diameter.

We have employed the gamma-ray activation techniques which enables one to get the isotopic cross-section values directly. For improved accuracy, our measurements have been done relative to the corresponding thermal values. By this procedure we have been able to bring down the errors considerably in most of the cases. The ^{441}keV gamma-ray coming from $^{127}I(n,\gamma)^{128}I$ has been used as a flux monitor.

The data has been analysed within the framework of Lane and Lynn's theory of neutron capture assuming the inelastic

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processes to be negligible at this energy. The analysis yields the p-wave neutron strength functions.

6. An Anomaly in the Neutron Capture Cross-Section of ^{198}Au at 25 keV - R.P. Anand*, D. Bhattacharya and E. Kondaiah - The neutron capture cross-section of ^{198}Au at 25 keV, derived from shell transmission or activation methods, is frequently referred to as a standard. However the divergence between the published values of this cross-section is as much as a factor of two. In both of the above mentioned methods, self-shielding and multiple scattering correctionsplay an important role in the final evaluation of the cross-section. We have made a detailed study of the problem at (25 $\pm$ 5) keV neutron beam facility at the reactor APSARA, B.A.R.C. A stack of gold foils, with thin and thick foils alternately placed, was irradiated. The specific activity of the foils, when plotted against foil thickness, is found to fall sharply upto a thicknessof 150mgms/cm^2 but then remains flat right upto a thickness of 1700mgm/cm^2. The thickness of the thin foils used by us was 50mgm/cm^2. This sharp fall suggests that possibly there is some prominent resonance in the gold cross section at this energy. Recently Schneider has been an intermediate structure in the total cross-section of gold around 23 keV. Using this intermediate structure we are now able to explain the anomaly to a good extent.

7. Level Scheme of ^{74}As. B. Lal, Y.K. Agarwal, S.M. Bharathi and C.V.K. Baba* - The level scheme of ^{74}As has been studied through the ^{74}Ge(p,n)^{74}As reaction. Gamma-ray and internal conversion electron measurements were carried out using Ge(Li) detectors and a six gap electron spectrometer. The level scheme was established by gamma-gamma coincidence measurements. New levels at 372.7, 525.8, 532.8, 632.1, 731.6, 752.7, 758.3, 801.6, 902.9 and 1128.5 keV have been established. Lifetime measurements on some of the levels were also performed by gamma-electron delayed coincidence measurements. As a result, the half-life of 26.8 $\pm$ 0.5 ns observed in the earlier work and attributed to a level at $\sim$ 278 keV has been found in the present work to correspond to a level at 258.9 keV. The half-lives of the 271.3 and 277.5 keV levels were measured to be 1.0 $\pm$ 0.1 ns and $<$ 0.3 ns respectively. The reduced transition probabilities deduced from these measurements are compared with theoretical predictions, and the main configurations of a few levels are determined from this comparison.

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1. Lifetimes of Excited Levels and Electromagnetic Transition Rates in ^{130}Te - V.K. Tikku, H. Singh and B. Sethi - The lifetimes of 2153.0(7^-) and 1819.3(6^+) keV levels in ^{130}Te populated in the decay of isomers of ^{130}Sb have been measured by the delayed coincidence technique using a time to amplitude converter. The results are: $T_{\frac{1}{2}}$(2153.0 keV, ^{130}Te) = 116 ± 6 nsec and $T_{\frac{1}{2}}$(1819.3 keV, ^{130}Te) = 9.0 ± 0.4 n sec. These results along with energy and intensity measurements of γ-transitions in ^{130}Te reported earlier by us [1] have been utilized to deduce the transition probabilities. The large hindrance ($\sim 10^7$), observed for the 333.7 keV (2153.0(7^-) $\longrightarrow$ 1819.3(6^+) transition compared to the s.p. Weisskopf estimate strongly supports the suggestion that the 2153.0 keV level arises due to a coupling between two neutrons of type $(2d_{3/2}^{-1}, 1h_{\frac{11}{2}}^{-1})_{7^-}$. The results of the experimental lifetime of the 1819.3(6^+) keV is compared with those obtained from two proton cluster core coupling model.

1) V.K. Tikku, H. Singh and B. Sethi, Nuclear Physics & Solid State Physics, (India) 16B (1973).

2. K-Capture Probability in the Decay of ^{139}Ce(140 d) - B.K. Dasmahapatra - The K-capture probability (P_K) for the 165.8 keV state of ^{139}La in the decay of ^{139}Ce(140 d) is determined by a method recently developed by us (B.K. Dasmahapatra and P. Mukherjee, J. Phys. A7(1974) 388). In this method P_K is

determined from the analysis of the KX-ray gamma ray sum-peak observed with a high resolution (500 eV) X-ray detector in a close geometry set up. The value of P_K obtained is 0.74±0.06. As the EC feeding to the 165.8 keV state is 100 % and it decays to the ground state through the 165.8 keV transition only, a measurement of the KX-ray intensity together with the use of known conversion coefficients of the 165.8 keV transition yield $P_K = 0.72 \pm 0.04$. Using the weighted average of P_K determined as above the mass difference between ^{139}Ce and ^{139}La is observed to be 269 ± 19 keV in good agreement with the value 275 ± 15 keV obtained from the mass adjustments.

5. Excited states in ^{85}Sr from the Reaction ^{85}Rb(p,nγ)^{85}Sr - S.K. Basu - In-beam γ-ray measurements following the reaction ^{85}Rb(p,nγ)^{85}Sr have been undertaken with a high resolution 32.2c.c. co-axial Ge(Li) detector at a proton energy of 3.8 MeV. Both natural as well as enriched (99.5%) rubidium nitrate targets were used. To identify the γ-rays due to (p,n) reaction, spectra were taken with the proton beam de-graded in energy by mylar absorbers, The following γ-rays with energies (in keV): 193.9, 231.6, 238.7, 409.6, 504.5, 535.7, 546.7, 612.0, 698.2, 767.5, 788.0, 821.2, 914.0, 1030.5, 1262.0, 1323.8 and 1588.5 have been assigned to be from levels below 1.9 MeV excitation in ^{85}Sr. Twelve levels are proposed to accommodate the observed transitions of which the levels at 785.9, 936.9, 1398.0 and 1588.5 keV have not been reported previously. The branching ratios for the

proposed levels are deduced and the level structure is discussed in the light of recent experimental[1] and theoretical investigations[2].

1) S.K. Basu and A.P. Patro, To be published.

2) S.K. Basu and S. Sen, Nucl. Phys. A220 (1974) 580.

4. Decay Schemes of the 9.7 H and 6.2 D Isomers of ^{196}Au - R.K. Chattopadhyay, P. Bhattacharya, B. Sethi and V.K. Tikku - The decay schemes of the 9.7 hour ^{196m}Au and the 6.2 d ^{196g}Au have been investigated with the help of high resolution X-ray Ge(Li) and 32c.c. Ge(Li) detectors, using Laben 4096 channel analyzer. The sources were produced by (n,2n) reaction on specpure gold with 14 MeV neutrons. In the decay of ^{196m}Au γ-rays with energies of 30.6 and 50.5 keV have been detected for the first time. The energies of these γ-rays are in excellent agreement with the conversion electron studies of the transitions in ^{196}Au reported earlier. The γ-rays corresponding to the 84.6 and 174.9 keV transitions in ^{196}Au which were not found by some of the earlier workers, have also been observed. In the decay of ^{196g}Au, it is found that the 1271 keV level in ^{196}Pt is also polulated in addition to the other levels reported in the leterature. A 393 keV γ-ray de-exciting this level has been detected. The existance of 326 keV transition in ^{196}Pt has been confirmed. Revised energies and intensities of all observed transitions in ^{196}Pt, ^{196}Au and ^{196}Hg are given and the decay schemes of $^{196\ m\&g}$Au based on these results are studied.

5. Level Structure of ^{147}Pm.- B.K. Sinha, S. Sen and R. Bhattacharyya - Level properties of ^{147}Pm have been studied from the decay of ^{147}Nd (11.1 d). Experimental set up consists of a pair of XP 1021 photomultiplier tubes coupled to high resolution Bicron 1½ inches x 1 inch NaI(Tl) phosphors and an overlap type of TAC set up using avalanche transitor pulse shaper. For detection of β -rays, 1 inch x 3/8 inch NE 102 plastic phosphors are used. Typical time resolution using NaI(Tl) phosphors for the Co^{60} gamma rays is 600 ps. Mean life of the 91, 410 and 531 keV levels have been determined by measuring the time distribution of the coincidence events between 870 keV β -91 keV gamma rays, 275 - 319 keV gamma rays and (370 keV β -ray - 531 keV gamma ray respectively. Mean lives of these levels deduced from centroid shift method are $\tau(91) = 3.80 \pm 0.04$ ns, $\tau(410) = 201 \pm 20$ ps and $\tau(531) \leq 10$ ps. Angular correlation of the 275-319 keV cascade has been remeasured with a view to clarify some anomalies in the previous results. Differential angular correlation measurement of the 319-91 keV cascade has also been undertaken. Experimental results are compared with theoretical calculations of the level structure of ^{147}Pm using core-particle coupling model.

6. Spectroscopic Study of $^{107,109}Cd$ excited States through $^{107,109}Ag(p,n\gamma)$ Reactions - M.B. Chatterjee, B.B. Baliga and R. Bhattacharyya - (p,n) reactions are known to excite both the

single particle states and collective states. Hence they are ideal to study the low-lying states of several nuclei where the Q-values are not too negative. The excited states of $^{107,109}Cd$ have been observed from the $^{107,109}Ag(p,n\gamma)$ reaction. In beam spectroscopic study of gamma ray singles have been carried out with the Ge(Li) detector varying the proton energy from 3.0 to 5.25 MeV in steps of 250 keV Van-de-Graaff accelerator of BARC. Energies and intensities of gamma rays have been measured. Some of the levels which were weakly populated in decay have been strongly excited in the reaction work. New gamma lines have been observed which were not reported in our decay works earlier. Further support for the existance of these lines have been obtained from the published works on (p,n) and (d,p) reactions. Discussions on various levels of $^{107,109}Cd$ obtained from reaction data will be presented in the light of decay data of our earlier experiments and other published works in the literature.

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1. K-Conversion Coefficients and K/L Ratios of 244 and 344 keV Transitions of Sm-152 & Gd-152 - J. Rama Rao, U.V. Chalpathi Rao, D.S. Reddy, K.L. Narasimham and V. Lakshminarayana - A 35 cc Ge(Li) and a 3 mm Si(Li) detector system has been calibrated for relative efficiency versus energy for gamma rays and conversion electrons in the energy range 100-800 keV. Using the system, the K-conversion coefficients and K/L ratios are measured for the 244 and 344 keV transitions of Sm-152, and Gd-152 respectively occuring in the decay of Eu-152. For the 344 keV transition good agreement is observed between the present results and theory. However, considerable deviation is noticed in the case of 244 keV transition of Sm-152.

2. Shape of the 0→0 Beta Transition of ^{166}110 and the Pseudo-Scalar Interaction - K. Venkata Ramaniah and K. Venkata Reddy - The beta spectrum shape of the $0^- \rightarrow 0^+$ transition of 110-166 is studied after a subtraction of the $0^- \rightarrow 2^+$ inner beta transition in coincidence with the 80 keV gamma ray, corrected for its shape, from the gross spectrum of 110-166. The measured shape factor is $C(W)=k\left[1-(0.131+0.003)/W\right]$ for an end point energy of 1844±2 keV. The present shape is well explained by the Nilsson model. An analysis employing exact formulation of Bhalla and Rose yield $C_p/C_A = -2.5$ and the ratio of the axial vector matrix elements $\lambda = -14$. These results exclude the predictions of partially conserved axial vector current theory due to Tadic. The parameters obtained from the present work disagree with the

theoretical predictions of Rose and Osborn and Pearsson. The deviation of the $0^- \rightarrow 0^+$ beta transition from β -approximation is explained as due to the peculiar combination of nuclear matrix element parameters.

3. Spectral Shapes of the Beta Decay Transitions $1^- - 2^+$ and $1^- - 0^+$ of the Re-188 Nucleus - K. Venkata Ramaniah and K. Venkata Reddy - The beta spectral shapes of the non-unique first forbidden, $1^- - 2^+$ and $1^- - 0^+$ beta transitions in the decay of Re-188 are studied employing an intermediate image beta ray spectrometer, producing the isotope by neutron irradiation of 99.83% enriched Re-187 stable isotope. The shapes of these beta transitions were found to be essentially identical fitting into the shape factor of the form $C(W)=k(1+aW)$ with $a=0.123\pm0.023$ in the case of the $1^- - 2^+$ beta transition for an end point energy of 1962 ± 2 keV and $a=0.110\pm0.0036$ in the case of $1^- - 0^+$ beta transition for an end point energy of 2120 ± 2 keV. The shape factor results are discussed in comparison with the Nilsson model in the single particle description. The Λ values for the two transitions are estimated from the present shape measurements through the Simm's relations using the theoretical and experimental nuclear matrix element parameters.

4. Nuclear Structure Effect in the K-conversion Process of the 223 keV Transition in Cs-133 - K. Venkata Ramaniah and K. Venkata Reddy - The highly retarded 223 keV transition in Cs-133 has been

investigated by determining the K-conversion coefficient of the 223 keV transition using the relative conversion electron intensity measured with an intermediate image beta ray spectrometer and the relative gamma ray intensity using a 35 c.c Ge(Li) detector through the intense 356 keV gamma transition, The K-conversion coefficient is obtained as $\alpha=0.092\pm0.01$. The present K-conversion coefficient is used along with the published gamma-gamma correlation data on the $\gamma_{80}\rightarrow\gamma_{223}$ cascade in a subsequent analysis for the penetration parameter. A value of $+10\pm0.5$ is obtained for the penetration parameter agreeing very well with the theoretical vaue obtained by Church and Weneser for Z-55.

5. Spectral Shape Measurements of the K-forbidden Beta Transitions of Eu-152 and Eu-154 - K. Venkata Ramaniah, Rajan Mathews and K. Venkata Reddy - The K-forbidden beta transitions of Eu-152 and Eu-154 are studied in detail for their beta spectral shapes employing an intermediate image beta ray spectrometer. A detailed analysis in terms of $C(W)/C_B$ vs W where C_B is the modified Hij shape correction factor, for different values of D and W_o is made. The highest energy ($3^-\rightarrow2^+$) beta groups of Eu-152 and Eu-154 exhibit large deviations from statistical shapes and are well fitted into modified Hij shapes with end point energies 1481 ± 2 and 1845 ± 2 keV. The value of D is 6 ± 1 in the case of Eu-152. The present result yields $Y^2=1.25\pm0.25$ in the case of Eu=154. An analysis of the experimental shapes using the

Nilson model configurations for the initial and final states, yielded that K'=1 component is dominating the K-admixure of the initial states. The shape factor results are discussed combining with the beta-gamma angular correlation results due to different authors.

6. First-Forbidden Beta Transitions of ^{42}K - B. Mallikarjuna Rao, C. Narasimha Rao, P. Mallikharjuna Rao and K. Venkata Reddy - The $2^- \rightarrow 2^+$ beta transitions are one of the most interesting and complicated of the first-forbidden non-unique transitions, since all the six nuclear matrix elements operate in this beta transition. There are four earlier shape measurements of this transition. While the two earlier measurements report a shape consistent with ξ -approximation, Daniel and Andre independly report a deviation from the statistical shape. To clarify the situation further, a remeasurement of the shape of this transition employing an Intermediate-image focussing beta ray spectrometer was made in this work. The results are discussed on the basis of the present measurements and the nuclear matrix elements evaluated by other authors.

Small order deviations from the unique shape of the $2^- \rightarrow 0^+$ transition are reported by Daniel et al. Eman et al and Abacasis et al have attempted to interpret these deviations theoretically. To substantiate the observations made by the above authors, a careful analysis of the spectral shape is made in this work.

7. $3^- \rightarrow 4^+$ Beta Decay in ^{140}La - P. Mallikharjuna Rao, C. Narasimha Rao, B. Mallikarjuna Rao and K. Venkata Reddy - A detailed and systematic investigation of the shape of the $3^- \rightarrow 4^+$ beta transition of ^{140}La have been carried out employing an optimised Siegbahn-Slatis coincidence beta ray spectrometer. The experimental shape factor of this transition is weighted least-square fitted to a shape correction factor of the form

$$C(W) = k(1+aW+b/W+cW^2)$$

The applicability of various nuclear models like shell model and quasi-particle model, to describe the nuclear states involved in this transition, has been discussed. For a complete description of the characteristics of this beta transition in terms of ξ - approximation, CVC theory etc..., an evaluation of nuclear matrix elements NHE) combining the present shape measurement with the only other available beta-gamma angular correlation data has also been performed.

8. Beta Decay to the First 2^+ Excited State of ^{42}Ca - B. Vema Reddy, M.L. Narasimha Raju and D.L. Sastry - The directional correlation between non-unique first-forbidden 2 MeV beta and the 1.52 MeV gamma-ray in the decay of K-42 has been measured as a function of beta particle energy in the range 350 to 1850 keV employing a fast-slow scintillation assembly. Nuclear matrix elements governing the 2 MeV beta transition are extracted using the accurate formalism of Buhring that are modified by Simms.

The value of λ , the correction term in the expression of Damgaard and Winther for the vector matrix element ratio, is found to be 1.17 $\pm$ 0,37. Simple shell model configurations for the involved states in the transition could not explain the results on experimental matrix elements.

9. The First Forbidden 358 keV Beta Decay in Yb-175 - D.K. Priyadarsini, M. Srinivasa Rao, B. Vema Reddy and D.L. Sastry - Beta-Gamma directional correlation measurements for the 358 keV beta and the following 114 keV Gamma cascade were carried out using a fast-slow Scintillation assembly. The measured anisotropy is

$$A = 0.1517 \pm 0.0430 \text{ at } E_{\beta} = 300 \text{ keV}.$$

An attempt is made to derive the matrix ϕ elements consistent with the present β-γ angular correlation and the beta spectrum shape of Rao. The Longitudinal polarisation is predicted and finally the results are discussed in the light of the Nilsson model wave functions for the Yb-175 nucleus.

10. Coupled Channel Calculations for Neutron Scattering from U-235 - U. Satyanarayana and S. Ramamurty - A coupled channel calculation has been done for inelastic scattering of neutrons from U-235 and the results are compared with the Hauser-Feschbach theory. The results are discussed.

11. Strong Absorption Model for Neutron Scattering from Th-232, U-235, U-238 and Pu-239 - U. Satyanarayana, S. Ramamurty and N. Lakshmana Das - Elastic and inelastic scattering of neutrons from Th-232, U-235, U-238 and Pu-239 have been calculated using strong absorption model. A computer program has been developed to do these calculations on IBM 1130. The differential cross section for elastic scattering has been calculated with and without the strong absorption condition; and there is a difference of about 0.5 barns per sterdian which may be attributed to the simplifications made when strong absorption condition is included in the calculations. The radius parameter is quite different from that used in optical model calculations.

12. Cross-section for (n,2n) Reactions at 14 MeV - N.Lakshmana Das, C.V. Srinivasa Rao, B.V. Thirumala Rao, J. Rama Rao and V. Lakshminarayana - Activation cross-sections for the reactions Nd-142(n,2n)Nd-141g, Nd-146(n,2n)Nd-147, Gd-160(n,2n)Gd-161 and Er-162(n,2n)Er-163 have been determined at 14 MeV using a 35 c.c. coaxial Ge(Li) detector and the mixed powder technique. The finite size of the target samples and their self-absorption effects for gamma rays have been experimentally taken into account by calibrating the Ge(Li) detector for volume sources using the simulation technique. The measured cross-sections are compared with previous results using scintillation detectors and with various theoretical predictions.

13. Decay of W-187 - K. Subba Rao*, P. Ila, K. Sudhakar, K.L. Narasimhan, K. Premchand and V.Lakshminarayana** - The spectrum of gamma rays accompanying 24 hour decay of W-187 has been investigated with a calibrated 35 cc Ge(Li) detector. From the estimated relative photon intensities and the recent conversion electron intensity data, conversion coefficients of eleven transitions in Re-187 have been deduced. In particular, the internal conversion penetration parameter of the hindered 35 keV transition was deduced from the present value of the conversion coefficient. The experimental results are presented and discussed with respect to spin-parity assignment of levels of Re-187.

14. Gamma-Gamma Angular Correlation Studies in OS-188 - D.K. Priyadarsini, B.R. Sastry, V. Seshagiri Rao and D.L. Sastry - Gamma-Gamma directional correlation measurements between the 931-155, 478-155, (825+829)- 478 keV. cascades involving the states 0^+, 2^+, 2^+, 0^+, 2^+, $(1^+, 2^+)$, 2^- in Os-188 were performed employing a Ge(Li) - NaI(Tl) system available with the NuclearrSpectroscopy group, TIFR, Bombay. The final results are as follows:

A_2 (478, 155) = -0.03534 $\pm$ 0.01399

A_4 (478, 155) = 0.9889 $\pm$ 0.01987

A_2 (931, 155) = 0.2171 $\pm$ 0.0452

A_4 (931, 155) = 1.449 $\pm$ 0.0473

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A_2 (824+829, 478) = 0.0003002 ± 0.03679

A_4 (824+829, 478) = 0.2178 ± 0.4999

The results on (478-155) keV Cascade show a quadrupole content $Q_\gamma \geq 0.99$ for the 478 keV gamma transition. The experimental coefficient for the 931-155 keV Cascade are in accordance with the spin sequence $0^+ - 2^+ - 0^+$.

15. A Note on the Angular Momentum Analysis of the jj coupling Shell Model-III - A. Satyanarayana Rao - In previous notes[1,2] the angular momentum analysis in the $(j)^2$ and $(j)^n$ configurations was given an interpretation in terms of elementary solutions of homogeneous ultrahyperbolic equations of the normal type. In this note the results of (1) are extended by considering solutions of these equations by the method of separation of variables. Polynomial solutions are constructed in an explicit form with a mention of basic sets of homogeneous harmonic polynomials in several variables of related equations useful in a closed jj-coupling shell of identical particles in the j-orbit.

1. 'A note on the Angular Momentum Analysis of the jj-coupling shell model', Nucl. Phys. & Solid State Phys.(India)15B(1972), 229-232.

2. "A note on the Angular Momentum Analysis of the jj-coupling Shell Model-II". Nucl. Phys. & Solid State Phys. (India)16B (1973).

E. BANARAS HINDU UNIVERSITY, VARANASI

1. J-Dependence in (d,p) Reactions at Iow Energy - S.N. Mukherjee - The $^2P_{3/2}$- $^2P_{\frac{1}{2}}$ J-dependence in stripping angular distribution and the vector analyzing power for the (d,p) reaction in calcium isotopes at incident deutron energy around 5.0 MeV has been studied by coupled channel method and DWBA and the results are compared with experiments. It is shown that a large portion of J-dependence is caused by the coupling of the stripping channel to the incident deutron channel. The necessity of including the deutron break-up channel and the deutron-D state is stressed.

2. Sum Rules for γ (d,n)P Reaction - R. Shyam and S.N. Mukherjee - Levinger-Bethe sum rules for γ (d,n)p reaction have been evaluated for realistic nucleon-nucleon forces with soft core. The bremstrahlung weighted and integrated cross sections have been evaluated and the results are compared with experiments and those obtained employing Yale and Hamada-Johnson potentials with hard core. It is seen that the results are insensitive to the nature of the core.

3. Volume Integral of the Absorptive Part of Proton Optical Potential - D.C. Agrawal - More than a decade ago Feshbach(1958) suggested that the volume integral of the potential is a better measure of the strength of the potential because it contains the effect of both the well depth and the geometry. The volume

integral of the real central potentials have been extensively studied recently, however, no such investigation has been reported so far regarding the absorptive part of the nuclear potential. Here we present the results of a detail investigation of volume integrals of the absorptive part of optical potential for protons with energies varying from 9.8 to 61.4 MeV from target nuclei in the mass range from 40 to 208. It is found that the total volume integral (sum of the surface and volume absorption terms) per particle (J/A) of the absorptive part of the proton optical potential is a practically well-defined quantity, and independent of the mass number of the target nucleus. It is well known that the strength of the absorptive part of the optical potential increases with the increase of incident proton energy, since more inelastic channels get opened; however, J/A is found to be practically constant within the above incident proton energy.

4. Back-Bending and Band-Crossing in ^{156}Dy - A.N. Mantri - Experimental study of the ground and β -bands in deformed nuclei has been extended recently to very high spin states. Plots of $\mathcal{J}$ versus ω^2 yield back-bending curves for these states. One of the explanations put forward for back-bending feature is in terms of band-crossing. We have analysed the recent experimental results for ^{156}Dy in terms of a simple-band-crossing model. Assuming the usual form of the rotation-vibration interaction, results for the interband-to-intraband B(E2) ratios from such a calculation are

compared with the available experimental results. The nature of the intersecting bands is also analysed.

5. Physically Consistent Fermi Gas Model for Nuclear Level Densities - A.K. Jain and P.C. Sood - The conventional formulation of the Fermi gas model for calculating nuclear level densities gives correct results only over a limited energy range, defined by the experimental neutron resonance data; its predictions come out far too low at excitations near the ground state and too high for excitations above 15 MeV. A modification of the model known as the back shifted Fermi gas model - yields a better agreement by treating the model parameters 'a' and 'Δ' as free, while keeping the spin cut-off parameter related to the rigid body moment of inertia as before. However, in this formulation one no longer has the straight forward identification of 'a' and 'Δ' with the level density parameter and the gap parameter, derivable both from the conventional approach to experimental data and the Strutinsky type calculations. We suggest that the anomaly is related to the energy dependence of the moment of inertia and proceed as follows. The gap parameter 'Δ' is fixed from the experimental pairing energies, and the level density parameter 'a' is determined from experimental resonance data using the rigid body estimate for the spin out-off parameter σ. Taking 'a' and 'Δ' to be energy independent, the fits to low energy levels of these nuclei are obtained by varying σ. The results so obtained are used to discuss the energy variation of

partial wave can be solved exactly. However separable expansion for the Perey-Buck potential will be in fact an infinite series and difficult to obtain. Similarly the solution of the Schrodinger equation for the local optical potential with Saxon-Wood type radial form can be solved only numerically. In view of this we construct a single rank separable potential which will replace the local potential in optical model. We achieve this by approximating the local potential by a set of square well potentials and then constructing an equivalent one-term nonlocal separable potential for the latter for each partial wave for a given energy. The orbital angular momentum dependence of this potential comes from Bessel function of order ($\ell + \frac{1}{2}$). The usual parameters of the optical potential can be retained in this method to facilitate the least square calculation of the cross-section. Numerical calculations are carried out to illustrate this method.

G. BURDWAN UNIVERSITY, WEST BENGAL

1. Pairing Vibrations in Zirconium Isotopes - M.K. Ghosh* and B.C. Sawanta - The Zirconium isotopes span an interesting region around the mass number A-90. The stable isotope ^{90}Zr has a closed neutron subshell. The modified random phase approximation (MRPA) has been applied to study pairing vibrations in Zirconium isotopes. Pairing correlations in the ground state and the excited states of Zirconium isotopes have been calculated and compared with experimental results. For ground to ground state transitions our results are in good agreement with the experimental ones. The predicted excited '0' pairing-vibrational states of Zirconium isotopes, however, occur at energies somewhat higher than those observed experimentally by Flynn et al[1].

1. E.R. Flynn, J.G. Berry and A.G. Blair, Nucl. Phys. A218, 285 (1974).

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H. DIBRUGARH UNIVERSITY, ASSAM

1. O^{18} Energy Levels from a Realistic N-N Potential - A.K. Deka and P. Mahanta - Nuclear calculations during the last few years have shown that soft core realistic potentials are more suitable than the potentials with ideal hard cores. N-N potential being a basic tool for nuclear structure investigation the search for a good realistic finite N-N potential would continue for some time. In the present work the reference spectrum and separation methods as developed by Kuo and Brown are used to calculate the shell model energy levels of O^{18}. We use a finite N-N realistic potential[1] having good fit to the phase shift data. Calculations show great improvement over those resulting from use of bare matrix elements reported previously and low lying levels are almost the same as obtained from the hard core Hamada-Johnston potential obtained by Kuo and Brown without core polarisation. Moreover, the charge dependancy of the potential seems not to be important in the present work.

I. INDIAN INSTITUTE OF TECHNOLOGY, KANPUR

1. Generalised Ratationally Invariant Core (RIC) Model - A Two Mass-point Approach - V.R. Prakash - A generalised RIC model for rotational-vibrational spectra of deformed even-even nuclei of ellipsoidal shape in the rare-earth region has been proposed by incorporating many important features of various macroscopic models proposed earlier. The two mass-point model[1] and the governor model[2] moments of inertia are obtained on the basis of the proposed model with appropriate limiting values of the radius of the RIC. Also, the model moment of inertia goes to zero for spherical nuclei, thus giving no rotational spectra for such nuclei. A quantum mechanical treatment of the model on the basis of the two mass-point concept, is expected to give results which are in better agreement with experiments.

1) V.R. Prakash, B.M. Bahal and V.K. Deshpande, Can. J. Phys. 51, 2474 (1973).

2) L.E.H. Trainor and R.K. Gupta, Can. J. Phys. 49, 133 (1971).

2. Measurement of Fast Neutron Scattering and Total Cross Sections of ^{141}Pr - R. Singh and H.H. Knitter* - The differential elastic neutron scattering cross sections of ^{141}Pr were measured at incident neutron energies of 1.2, 1.7 and 1.9 MeV in the angular range between 25 to 150 degrees. The 5 MeV Van-de-Graaff

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machine at C.B.N.M., Geel was used to obtain proton pulses of width 1 ns at 1 MHz repetition rate and a 495 $\mu g/cm^2$ TiT target for producing neutrons. The measurements were made with flight paths of 1.43 m at the incident neutron energies of 1.2 and 1.7 MeV and 2.3 m at 1.9 MeV. The over all time resolution was about 2.5 ns. At 1.7 MeV the differential inelastic neutron scattering cross sections corresponding to Q =-1122 keV, and at 1.9 MeV the ones corresponding to Q =-1122, and Q = -1295 keV were also determined. In a transmission experiment, the total cross section was measured between 0.50 and 2.42 MeV. The total and differential cross sections were calculated using the nuclear optical model. The calculated results were compared with the experimental data.

3. Gamma Decay in Proton Capture Reactions in ^{48}Ti - H.R. Prabhakara and G.K. Mehta - In $1f_{7/2}$ nuclei the compound nuclear states reached by proton capture reactions using low energy accelerators are still observable as isolated resonances, some of which can be identified as isobaric analogue resonances having simple structure. In ^{48}Ti at proton energies 1.387 MeV and 1.564 MeV, 8.115 and 8.289 MeV levels are excited respectively in ^{49}V. None of these are known to be analogue resonances. The resonance at 1.564 MeV has a simpler decay scheme as compared to the one at 1.387 MeV. The decay properties of these resonances will be discussed.

4. <u>On the Anticorrelation in LRA Fission</u> - B. Krishnarajulu and G.K. Mehta - The experimentally observed anticorrelation between the average total fragment kinetic energy (E_F) and the alpha energy (E_α) could be of considerable importance in determining the correct set of initial values of, and correlations between, the initial parameters in trajectory calculations on LRA fission.

It is observed that this anticorrelation can be reproduced by fixing the value of the initial interfragment distance, D. However, in doing so it is not possible to explain some asymptotic distributions, e.g. the angular distribution of the alpha particles; unless one assumes a correlation between D and the point of emission of the alpha particle, X_o. The exact nature of this correlation has not been determined as yet.

We have also studied the anticorrelation as a function of the mass ratio, R.

J. KURUKSHETRA UNIVERSITY, KURUKSHETRA

1. Calculated Cross-Sections, Energy and Angular Distributions of Ni-58 Reactions with 14 MeV Neutrons - B.S. Wadhwa and R.K. Mohindra - The direct and compound nucleus cross-sections of the type (n,p), (n,n'), (n,a); (n,n'p), (n,2n), (n,n'a), (n,pn') and (n,an') have been computed using a diffused edge optical model potential at 14.0 and 14.8 MeV (Lab.). Some of our previous cross-sections have been modified and corrected[1]. The spin dependence, shell and pairing energy effects in various level density for mulae have been considered. Newton's shell dependent level density formula with slight modification of effective (2j+1) values gives better agreement for primary and secondary emissions.

Angular distributions in the reactions (n,p), (n,n') and (n,a) have also been computed using Newton's shell dependent level density formula with dependence on spin and spin cut off parameter[2]. The calculated energy and angular distributions of (n,p) and (n,a) show fairly good agreement with the recent experimental data[3,4].

1) Wadhwa and Mohindra, Proc. Nucl. Phys. and Solid State Phys. Symp., India, 15B (1972) 139.

2) Douglas and MacDonald, NuclPhys.13(1959) 382.

3) Alvar, Nucl Phys. A 195 (1972) 289.

4) Khan et al., Nucl. Phys. A 202 (1973) 123.

2. Statistical Analysis of Neutron Reduced Widths - H.C. Sharma and Ram Raj and N. Nath - The χ^2-distribution of neutron reduced widths of a large number of nuclides is studied and the associated degree of freedom (ν) for each nucleus obtained. It is found that ν varies from nucleus to nucleus and could have a value different from unity used in the literature for the estimation of (n,n') reaction yields. It is further noticed that the inclusion of statistical weight factor (g_J) in the analysis affects the χ^2-distribution significantly. The statistical procedure for dealing such a χ^2-distribution with varying degrees of freedom is studied.

3. Neutron Shell Effects and Systematics of (n,2n) cross sections at 14.7 MeV - B.S. Wadhwa and R.K. Mohindra - The existence of shell effects in (n,2n) cross sections around 14 MeV has been controversial[1,2]. With the availability of recent systematized (n,2n) cross section data[3] at 14.7 MeV, it was considered worthwhile to reinvestigate the possible systematics including the existance of shell effects. The systematics have been undertaken with respect to (N-Z)/A, Q-values, $B(n)_{Comp}$ and neutron number, 'N'. It is found that in some of these plots closed shell nuclei with N≅20, 28 and 50 show some evidence of shell effects while N=82 and 126 do not give any indication. The careful analysis of σ (n,2n) vs (N-Z)/A in the vicinity of N=28 and 50 shows that magic nuclei N=28 have a distinctively slower rise than their

non-magic neighbouring nuclei and also at N=50, there is lower trend. The discrepancy in the heavy mass region is evidently due to the overwhelming effect of the neutron excess over the coefficient of magicity.

An empirical relation between $\sigma(n,2n)$ and $(N-Z)^2/A$ has been worked out which predicts results within $\pm$ 15% , for nuclei in the mass region $A \gtrsim 110$.

1) P. Hille, Nucl. Phys, A 107 (1968) 49.

2) S.M. Qaim, Nucl. Phys. A 185 (1972) 614.

3) Z.T. Body, Atom. En. Rev. 11(1973).

K. MARATHWADA UNIVERSITY, AURANGABAD

1. Levels of ^{29}P from the $^{28}Si(p,p'\gamma)^{28}Si$ Reaction - R.G. Kulkarni - The gamma rays were produced by inelastic scattering of protons by the first excited state of ^{28}Si at 1.78 MeV. A 3 in. x 3 in. NaI(Tl) crystal was used to detect the gamma rays. Excitation cruves for the 1.78 MeV gamma rays have been measured in the proton energy range from 4.6 to 5.0 MeV. Resonances were observed at E_p= 4.69, 4.89 and 4.95 MeV. At 4.69 and 4.89 MeV, the angular distributions of the 1.78 MeV gamma rays were measured. By comparison with theory, the corresponding compound levels of ^{29}P at 7.26 and 7.45 MeV were assigned spins and parities to be $5/2^+$ and $5/2^-$, respectively.

2. Coulomb Excitation of Levels in ^{53}Cr - R.G. Kulkarni and P.N. Patarwale - The excited states of ^{53}Cr were investigated by means of Coulomb excitation using 5.5 to 7.2 MeV α-particle projectiles. The de-excitation gamma rays were studied with the aid of a 25 cm^3 high-resolution Ge(Li) detector. Six excited states in ^{53}Cr were populated by direct E2 excitation up to an excitation energy of 2322 keV. Energy level measurement with an accuracy of $\pm$ 2 keV and B(E2) values obtained (in units of e^2f^4) are as follows: 564 keV, 100.0$\pm$0.5; 1006 keV, 115.6$\pm$0.8; 1287 keV, 253.7$\pm$1.8; 1539keV, 28$\pm$2; 1970 keV, 195.4$\pm$5.2; 2322 keV, 147.8$\pm$5.3. The measured B(E2) values are compared with the predictions of a Core-excitation model of de-Shalit.

L. PHYSICAL RESEARCH LABORATORY, AHMEDABAD

1. Spontenous Fission Spectrum of Curium - 248 M.N. Rao - The mass-yield distributions in the spontaneous fission of $Cm^{242,244}$, Pu^{244}, Cf^{252} and in the neutron induced fission of Cm^{245} and Cf^{249}, determined by radiochemical, mass-spectrometric and other methods in different laboratories are studied in detail to deduce the spontaneous fission spectrum of Cm^{248} with particular reference to the fine structure in the heavy fragment mass-peak. The yields are normalized to mass number 132. The fission xenon (and krypton) spectra determined mass-spectrometrically in a special group of extra-terrestrial samples, known as carbonaceous chondrites (whose composition is similar to that of our Sun) are compared with the laboratory-deduced spontaneous fission spectrum for Cm^{248}. This study points out that lighter actinides show fine structure effects in their mass-yield spectra whereas it is not so with the heavier ones. The significance of the difference in the mass-spectra of now-extinct nuclides, Pu^{244} and Cm^{248} for understanding the nucleosynthesis-processes which contributed to our solar system materials are briefly discussed.

2. Structure of ^{8}B with Projected Multi-Major Shell Hartree-Fock Calculations - V.B. Kamble, S.B. Khadkikar and D.R. Kulkarni - Major shell-mixing calculations are carried out in the configuration space of first four major shells within the framework of Hartree-Fock (H-F) theory for the ^{8}B nucleus incorporating centre

of mass motion and Coulomb corrections Axial symmetry is assumed. The interaction used is the realistic interaction obtained by Sussex group directly from the experimental phase-shifts. Good angular momentum states have been projected from the H-F solution to explain some of the properties of this nucleus, viz. the energy levels, magnetic dipole omoment and the electric quadrupole moment. Preliminary band-mixing calculations for the bands k=1 and k=2 are also carried out. Energy levels and the magnetic dipole moment are compared with the experimental data and the agreement is found to be fair. The electric quadrupole moment has been theoretically predicted. The results are also compared with other theoretical calculations.

3. A Shell-Model Calculation of Ga^{74} - D.P. Ahalpara and K.H. Bhatt-The low-lying energy levels of Ga^{74} are studied by simple shell-model calculation in which it is assumed that a proton hole in orbit $2p_{3/2}$ is coupled with neutrons in $2p_{\frac{1}{2}}$ and $1g_{7/2}$ orbits. The negative-parity states are assumed to arise from the configuration $\pi(2p^{-1}_{3/2})\ \nu\left[(2p_{\frac{1}{2}})^2(1g_{\frac{9}{2}})^3\right]$ while the positive parity states are assumed to arise from the configuration $\pi(2p^{-1}_{3/2})\ \nu\left[(2p_{\frac{1}{2}})^1 (1g_{9/2})^+\right]$ The neutron-neutron effective interaction needed for the calculation was taken from the experimentally observed[1] $(1g^{-1}_{7/2}\ 1g_{9/2})$ multiplet in Nb^{90}. To get the proton-neutron interaction, surface-delta interaction was used where the strength of the interaction was adjusted to fit the $(1g_{9/2})^2$ multiplet obtained through the particle-hole to particle-particle

transform of $(1g_{9/2}^{-1}\ 1g_{9/2})$ multiplet in Nb^{90}. The recently observed[2] low lying states of Ga^{74} are $4^-, 3^-, 1^+$. The model described above gives 4^- as the ground state and 3^- as the first excited state.

1) Nucl. Phys. A187, 161 (1972), Y. Yoshida, M. Ogawa, T. Hattori, H. Taketani, H. Ogata and I. Kumabe.

2) Phys. Rev. C9, 2252 (1974), J. Van Klinken and L.M. Taff.

4. Intermediate Coupling Model Description of Zinc Isotopes - J.J. Dikshit and B.P. Singh* - The properties of the negative parity states of ^{65}Zn and ^{69}Zn are investigated in the frame work of the intermediate coupling in the unified vibrational model. In the model, a quasineutron is coupled to an anharmonically vibrating core. The neighbouring even-even (A-1) isotope is considered as a core. Observed properties of the core nucleus is used to describe its anharmonicities. The model as applied involves only few free parameters. Energy levels, electromagnetic transition rates, life times, static moments etc. have been calculated. The results of present calculations have been compared with experimental results. Drastic changes in electromagnetic properties of the isotopes are very well accounted for. Also, the model predicts the quadrupole moments of first 2^+ states of ^{64}Zn and ^{66}Zn. The experimental values should be close to -0.08 barn and -0.09 barn respectively. Further comments on the results for ^{69}Zn will be made.

* Indian Institute of Geomagnetism, Bombay.

5. Spectral Distribution Study of Nuclei in fp-Shell - R. Haq and J.C. Parikh - Systematics of nuclei in the beginning of fp-shell are investigated using the spectral distribution method of French. The centroid energies and widths for various distributions are avaluated using the interaction of Kuo with the modification suggested by McGrory et al. The two moment distributions are used to determine ground state energies fractional occupancy of the single particle orbits for ground states and low lying spectra of various nuclei in this shell. The results are compared with the deformed configuration mixing calculations of Dhar et al. Bearing in mind the accuracy and limitations of the method, the binding energies of nuclei are given well despite the large variations in the dimensionalities of the spaces that we are working with. We observe however that as the spaces encountered become larger one needs to do a finer averaging. We have also investigated the goodness of Wigner SU(4) symmetry in these nuclei. The mixing of various SU(4) representations near the ground state provide a measure of symmetry mixing and the substantial admixture in most of the cases show that it is badly broken, largely due to the single particle spin orbit coupling.

6. On a New Explanation of the Coriolis Kinking Effect in Deformed Odd-Even Nuclei - S.K. Sharma and K.H. Bhatt - Experimental spectra of deformed odd-A nuclei do not exhibit a purely rotational spectrum. According to the collective

rotational model of Bohr and Mottelson, a large part of the deviation of the spectrum from a rotational sequence comes from the coriolis coupling between the odd particle and the core. This coupling gives rise to the socalled kinking effect in which the energy levels of odd-A nuclei can be separated into two groups of states with opposite (J+1/2) parity, say 3/2, 7/2, 11/2 ... and 5/2,9/2, 13/2..... In the present paper we show explicitly, in the framework of a schematic model in which a collective set of levels for the proton group are coupled to a similar set of levels for the neutron group, that such a feature in the spectra of even-odd deformed nuclei results from the higher multipoles ($Q^4.Q^4$, $Q^6.Q^6$ etc.) of the effective interactions operative in these nuclei.

7. A Microscopic Study of the Even-Even Nickel Isotopes in the 2p-1f Shell - S.K. Sharma - The even-even Ni isotopes have earlier been extensively studied within the theoretical framework provided by the various approximate methods such as those involving quasi-particles, as well as in the (exact) shell-model scheme, in the configuration space consisting of only the $2p_{3/2}$, $1f_{5/2}$ and $2p_{\frac{1}{2}}$ orbits, with the nucleus Ni56 as an inert core. Though the problem of core-excitations (with respect to the Ni56 core) has also been tackled by including some of the np-nh (with $n \leq 4$) excitations in the diagonalization space, it has still not been possible to account for the spectra of the low-lying states in a completely microscopic and parameter-free manner. In this paper,

the Nickel, isotopes are studied in the framework of the Projected HFB method within the complete 2p-1f shell space. The effective interaction employed is a slightly modified version of the Kuo-Brown effective interaction for the 2p-1f shell. This interaction has earlier been shown to reproduce qualitatively the observed B(E2)(0→2) systematics for Cr and Fe isotopes. The present calculation yields quite satisfactory results for the low-lying J=0,2,4 and 6 states in Ni isotopes, The electric quadrupole transition probabilities for the states in the ground state band are also computed.

8. On the Structure of Low-lying Levels in Ni^{56} - S.K. Sharma - A traditional shell-model calculation for the nucleus Ni^{56} in the configuration space of the complete 2p-1f shell is impossible for various reasons. It is necessary to resort to some kind of truncation or approximation while making a choice of the shell-model basis. Various theoretical schemes, often contradictory, have been proposed, in a number of calculations carried out recently, depending on the approximations employed as well as owing to rather arbitrary choices of the (unknown) parameters as, for example, the spherical single-particle energies and the two-body effective interaction. In the present work it is shown that it is possible to describe the low-lying states in Ni^{56} in a simple way in terms of the two HF states obtained by carrying out calculations with a slightly modified version of the Kuo-Brown

interaction for the 2p-1f shell. The theoretical spectrum consisting of the spherical HF state, the two 1particle-1hole states with J=2 and J=4 and the states obtained by angular momentum projection from the deformed, excited HF solution, is in quite good qualitative agreement with the observed spectrum upto about 6 MeV.

9. On the Low-lying Levels in Fe-52 - S.K. Sharma - An attempt is made to provide a microscopic description of the low-lying excited levels in the nucleus Fe-52, within the frame-work of the projected HF and projected HF-BCS prescriptions in the configuration space consisting of the 2p-1f shell orbits. Deformed HF calculations, carried out by employing an effective interaction obtained by a small modification of the Kuo-Brown effective interaction for the 2p-1f shell,are seen to give rise to two HF minima for Fe-52. The excited HF solution is found to occur at 3.3 MeV relative to the lowest-energy solution. Whereas the excited HF solution is unstable towards the onset of pairing correlations, the one pertaining to the ground state is seen to be quite stable. An improved escription of the excited states in Fe-52 is thus obtained by carrying out an HF-BCS calculation. States with good angular momentum are projected from the lowest-energy HF as well as the excited HF-BCS intrinsic states. The theoretical (positive parity) spectrum thus obtained compares very well with the experiments upto about 6 MeV excitation. Static quadrupole moments 0_7 + and the reduced transition

probabilities B(E2) ($J \rightarrow J'$) for the low-lying states are computed.

10. On the Structure of the Low-lying 0^+ states in Ni-56 in a Three-Dimensional Caricature Space - S.K. Sharma - The purpose of this paper is to demonstrate that the ground as well as the first excited 0^+ states in the nucleus Ni-56 are predominantly of Zero-particle Zero-hole (op-oh) and 4p-4h nature with respect to the $|(1f_{7/2})^{16}\ J=0\rangle$ core. First we carry out the deformed HF calculations in the complete 2p-1f space. A slightly modified version of the Kuo-Brown two-body interaction is used and the single-particle energies are taken from Ca-41 spectrum. It is noted that the excited HF solution is almost 4p-4h with respect to the ground state. The energy variances $\sigma^2 (= \langle H^2 \rangle - \langle H \rangle^2)$ for the two HF states is then computed. Next, a 3x3 Hamiltonian matrix is constructed in the "caricature" space consisting of the basis states with op-oh, 2p-2h and 4p-4h configurations. The HF energies and the variances provide information about the two diagonal and the two off-diagonal matrix-elements. A set of values ranging from several MeV above it are taken for the average position of all the (2p-2h) J=0, T=0 states. The results show that ground state in Ni-56 is dominantly a op-oh state and the first excited state is mostly of 4p-4h nature.

11. Binding Energy Systematics in 1f-2p Shell Nuclei - A.K. Dhar

D.R. Kulkarni and K.H. Bhatt - Binding energy (B.E.) systematics has been studied in the framework of deformed configuration mixing formalism for the isotopes of Ti(A=44-52), V(A=47,51), Cr(A=48,52), Fe(52,54) and Ni(56), using the modified Kuo-Brown interaction and ^{42}Ca single particle energies. Contribution to B.E. arising from two particle-two hole excitation within fp shell have been estimated through second order perturbation calculation. The experimental and theoretical values, in general are in good agreement. Deviations in B.E. for higher mass nuclei indicate the modification in T=0 part of the choosen effective interaction.

12. Shape Indeterminacy and Spectrum of ^{51}V - A.K. Dhar, S.B. Khadkikar, D.R. Kulkarni and K.H. Bhatt - The deformed configuration mixing calculations performed in the framework of projected Hartree Fock (HF) formalism lead to the indeterminancy of ground state shape for the nucleus ^{51}V. Multiple HF solutions of almost-equal deformation ($\beta_2 \sim 0.10/b^2$) have been obtained within about 0.5 MeV of each other. This indicates lack of collectivity at shell closure. Because of the dominance of (f7/2) configuration in the low-lying states of ^{51}V, except for the lowest J=3/2 and 9/2 states, large overlaps are obtained for the states projected from the above intrinsic states. The observed low-lying J=3/2 and 9/2 states of ^{51}V are found to belong dominantly to the oblate and prolate K=3/2

intrinsic states respectively. The calculated spectra and B(E2) values are in good agreement. As in other N=28 nuclei, besides the low-lying states of small intrinsic deformation, a band of states belonging to a highly deformed prolate intrinsic state is likely to exist quite low in the spectrum of ^{51}V. B(E2) values for transitions between these highly deformed states have been calculated.

13. Collective States in ^{48}V - A.K. Dhar, D.R. Kulkarni and K.H. Bhatt - The structure of the low-lying collective states in ^{48}V has been studied in the framework of deformed configuration mixing formalism. For the ground state band of states, the reduced electric quadrupole transition probabilities have been calculated. The structure of the negative parity band of states observed recently in (^{16}O, pn) reaction is shown to be consistent with the description of a proton excitation from the $d_{3/2}$ state to the fp shell space. The observed values of the moment of inertia parameter S=57.3 keV and the intrinsic electric quadrupole moment of 0.79b of the negative parity band of states are in very good agreement with the corresponding estimated values of 56.9 keV and 0.82b respectively.

M. PUNJAB UNIVERSITY, CHANDIGARH

1. Conversion Coefficient Measurements in ^{144}Pr, ^{192}Pt and ^{192}Os.- Nirmal Singh, S.S. Bhati, Punjar Dass and P.N. Trehan - K- and L-conversion lines' intensities have been measured in ^{144}Pr, ^{192}Pt and ^{192}Os using a double focusing beta ray spectrometer of TIFR, Bombay. In addition, gamma ray intensities have been measured in ^{144}Pr using a Ge(Li) detector. From these studies, K- and L-shell conversion coefficients of various transitions in ^{144}Pr, ^{192}Pt and ^{192}Os have been calculated. The existance of 1055keV level in ^{192}Pt has been confirmed and a spin 2^+ has been confirmed for the 1090 keV level in ^{192}Pt. The multipolarities of 196, 308 and 604 keV transitions in ^{192}Pt and 488 keV transition in ^{192}Os were found to be M1+(99.0±0.5)%E2, M1+(96.5±0.5)%E2, M1+(79^{+5}_{-7})%E2 and M1+(94±2)%E2 respectively. The multipolarities and 'δ' values of these transitions agree well with the theoretical estimates from Kumar and Barangar model. A new level at 804(0^{+1}) keV has been proposed on the basis of this model to account for the existence of 314.8 keV transition (multipolarity M1(87±3)%E2) which can be fitted between 804 and 489 keV levels.

2. Magnetic Moments via Single-Particle Transfer Reactions - Ashwani Kumar and R.K. Bansal - Non energy weighted multipole sum rules have been used to derive explicit relationship between the magnetic moment of the target state and the one-particle transfer strengths. One version of the relationship demands, from a single

transfer reaction experiment, complete spectroscopic information about both the isospin-bands of states of the residual nucleus, which the experimentalist usually finds very difficult to obtain. Another version requires a single experiment to furnish information only about one isospin-band of states but one has to do now two experiments-one pickup and one stripping - on a given target state, to be able to calculate its magnetic moment. This latter version has been used to calculate ground state magnetic moments of F^{19}, Ti^{47}, V^{51}, Y^{89}, Nb^{93}, Pb^{207} and Bi^{209} from the available experimental data. The calculated values compare reasonably well with the known magnetic moments. It has been emphasized how the calculation of magnetic moment serves as a check on the accuracy of the measured strengths, especially the distribution of total strength to the various J-states populated via particle transfer to a particular orbit.

3. Two-particles and Two-holes-core excitation Effects - S. Shelly and R.K. Bansal - The formalism for calculating the effects of two-particles and two-holes excitations accompanied by the isospin excitations of the target nucleus on the structure of the final nucleus states obtained via single proton transfer has been presented. The target considered has a neutron filled orbit outside a doubly closed shell.inert core and the proton is added to one of the empty orbits. The energies, wave functions and spectroscopic factor have been

calculated for 3/2 excited states of ^{49}Se nucleus and 5/2 excited states of ^{61}Cu nucleus using some standard two body interactions.

A comparison of the present results with those obtained by taking into account only the already known isospin excitations of the core indicates that the two-particles two-holes excitation of the target results in many more, $\ell=1$ and $\ell=3$ states in the ^{49}Sc and ^{61}Cu spectra respectively than allowed otherwise. Experiments seem to confirm such a trend.

4. Level Structure Studies in ^{160}Dy - S.S. Bhati, Nirmal Singh, Punjar Dass and PN. Trehan - Energy and intensity measurements of various gamma rays in ^{160}Dy have been done using a Ge(Li) detector. In addition gamma-gamma angular correlation studies of ten cascades were done in ^{160}Dy using a Ge(Li) - NaI(Tl) fast coincidence set-up. These cascades are 299-966, 299-879, 197-87, 962-87, 879-87, 215-962, 296-(879)-87, 215-(962)-87, 299-(682)-197 and 215-(765)- 197 keV. Out of these 215-(962)-87 and 215-(765)-87 keV cascades have been attempted for the first time. The multipolarities of 197, 215, 299, 879 and 962 keV gamma rays were found to be E2+(2±2)%M3, E1+(2±2)%M2, E1+(0.5±0.5)%M2, M1+(99.5±0.5)%E2 and M1+(98±1)%E2 respectively. The reduced E1 and E2 transition probabilities of various transitions in ^{160}Dy have been compared with unified model calculations. This comparison shows that 1264 keV state belongs to K=2 gamma

vibrational band, while 1286 and 1399 keV states are either K=0 or K=2 states and 1358 keV state is either K=0 or K=1 state.

5. Level structure studies in ^{99}Tc, ^{140}Ce and ^{147}Pm. S.S. Bhati, Nirmal Singh, Punjar Dass and P.N. Trehan - Energy and intensity measurements with considerable precision have been done in ^{99}Tc, ^{140}Ce and ^{147}Pm using a 8 c.c. Ge(Li) detector in conjuction with ND-1100 multichannel analyser. The technique of Gehrke et al[1] was used for energy and efficiency claibration. The accuracy obtained in energy and intensity measurements were of the order of 0.05 keV and 3-5% respectively. With this accuracy, it was possible to improve upon the previous values of energies and intensities. In addition, gamma ray coincidence spectra were taken in ^{140}Ce and ^{147}Pm using a Ge(Li)-NaI(Tl) fast-coincidence set-up. On the basis of single's as well as coincidence studies, the existence of 312 keV gamma ray in ^{147}Pm has been confirmed. Also, the existence of 722 keV level in ^{147}Pm has been confirmed. The 298 keV gamma ray proposed by H. Singh et. al has not been observed in the present study.

1) R.J. Gehrke, R.L. Heath and J.E. Cline, Nucl. Inst. and Methods 91 (1971) 349.

N. PUNJABI UNIVERSITY, PATIALA

1. Some Internal Conversion Puzzles - H.S. Sahota - Despite large number of attempts to explain the nature of the 279, 191 and 192 keV transitions in ^{203}Tl, ^{197}Au and ^{114}In respectively they have remained puzzles. In the case of 279 keV transitions in ^{203}Tl nuclear penetration effects were involved so that an agreement for mixing ratios obtained from L-subshell ratios, electron gamma directional correlations and coulomb excitation measurements could be found. Later measurements of gamma linear polarisation-gamma directional correlations gave a much smaller value for δ. The resonance fluorescence results for δ were also in favour of a smaller value. For the 191 keV transition in ^{197}Au the K-conversion coefficient and subshell ratio measurements yield a penetration parameter of $\lambda = 5 \pm 2$. The sign of λ obtained from the theoretical calculations is negative while the numerical value is 4, in agreement with above. For the 192 keV E4 transition in ^{114}In the k as well as the L subshell conversion coefficients are smaller by nearly 30%. Although the nuclear penetration effects are usually associated with the lower multiple order transitions yet it becomes necessary in this case to consider their presence to explain the internal conversion process of this transition.

2. Spin Assignment to 42ms. state of In^{114} from the Isomeric cross section Ratios - K.G. Garg and C.S. Khurana - The isomeric

cross-section ratio measurements are a very useful method of investigating the angular momentum effects in nuclear reactions. The isomeric ratio may yield information of spin dependence of nuclear level densities in the final nucleus which is characterized by a spin cut-off parameter σ. In this paper firstly the analysis has been carried out for $Sc^{45}(n,2n)Sc^{44}$ reaction where a value of 0.483 has been obtained for the theoretical value of isomeric cross-section ratio which is in agreement with experimental ones existing in the literature[1,2,3,4]. Also a value of σ =3.5 is obtained which is same as that of given in reference[1]. Secondly, we have employed this technique of comparison of the experimental cross-sectional ratios with the theoretical ones performed for σ=3 to assign a value of spin =8 to the 42ms state of In^{114} nucleus. Weisskopf estimates' for the photon transition probabilities also strongly support this spin value.

1) J. Karolyi and J. Csikai, Nucl. Phys. A112 (1968) 234.
2) S.K. Mukherjee et. al., Proc. Phys. Soc. London,77A(1967)508.
3) J.R.Preswood and B.P.Bayhurst, Phys.Rev.121(1961)1438.
4) L.A. Rayburn, Phys. Rev. 122(1961)168.

3. <u>Double Coriolis Coupling in Odd-Odd Deformed Nuclei</u>- S.D. Sharma and V.P. Garg - Double Coriolis coupling is expected to play an important role in the study of spectra, static moments and transition probabilities of odd-odd nuclei in bands with $k=0^{\pm}$ and $1^{\pm}$. Odd-even shift observed in case of these bands is

expected to be useful to understand the nature of nuclear forces as only the tensorial forces are likely to explain the odd-even shift. As the first step, the effect of double coriolis coupling on the moments of inertia of deformed odd-odd nuclei is studied. The computed results are compared with the experimental reports.

4. Coriolis Coupling Effects on the Magnetic Moments of Odd-A and Odd-odd Nuclei - V.P. Garg and S.D. Sharma - Bohr and Mottelson's symmetric core model was extended to the case of odd-A nuclei by Chi & Davidson and further to odd-odd nuclei by Sharma and Davidson. The model consists of rotating core inert to vibrations and odd nucleon (s) moving in deformed harmonic oscillator potential well (s) with L.s and l.l. terms. The odd-nucleon (s) is (are) taken according to single particle Nilsson orbitals. The total Hamiltonian consists of rotational part, Nilsson's Hamiltonian (s) for odd nucleon (s), (and the residual particle interaction for odd-odd nuclei). Jagdev and Sharma reported coriolis coupling effect on Moments of Inertia of odd-A and odd-odd nuclei. They also reported magnetic moment of these nuclei without configuration mixing. In the present study, coriolis coupling (which accounts for $k=\pm 1$ mixing) has been used to calculate magnetic moments of some of deformed odd-A and odd-odd nuclei. (The effect of double Coriolis coupling is used for the states with $K=0^{\pm}, 1^{\pm}$). The results are found in better agreement with experimental reports.

O. REACTOR RESEARCH CENTRE, KALPAKKAM

1. Evaluation of Fission Width of 1 + Spin State and Updating of Intermediate Resonance Parameters Based on Double Humped Fission Barrier Model for PU-239 - S. Ganesan - An accurate knowledge of fission width of J=1+ spin state is important and attractive for many reasons. After reviewing the theoretical and experimental work done earlier, on the analysis of intermediate structure in the fission cross section of PU-239 and specially the generation of intermediate resonance parameters based on Weigmann's formulation of Strutinsky's need for updating the intermediate resonance parameters as any other basic neutron nuclear data is updated. Starting from the latest recommended values of the ratio of capture to fission cross section for PU-239, we evaluate by adjustment, a set of fission width values for 1+ spin state corresponding to the observed variations in alpha values. Using these values of fission widths we obtain a set of 37 intermediate resonance parameters using which one can generate reliable widths of 1+ spin state for any energy region below 10 keV.

P. UNIVERSITY OF DELHI

1. Is $_{\Lambda}C^{12*}$ a Strangeness Analogue State?-Swapna Banerjee and N. Panchapakesan - Strangeness analogue states are coherent superposition of particle-hole states where the particle and neutron hole occupy identical orbits. We discuss the possibility of $_{\Lambda}C^{12*}$ state being a strangeness analogue state in the frame-work of alpha particle model. We first discuss C^{12*} in this model using equilateral triangle configuration. This is done with three different N-N potentials; those of Volkov, Gillet and Brink-Boeker. The radius and separation of the alpha clusters are determined knowing the binding energy of C^{12}. The same wavefunction is taken to describe $_{\Lambda}C^{12*}$ in which one cluster has a Λ -particle in it instead of a nucleion. With this wavefunction the Λ -N potential which gives the observed binding energy is calculated. This Λ-N potential is expressed in terms of an equivalent soft potential which has a volume integral about 30% to 50% more than that obtained from the study of light hypernuclei. The idea of strangeness analogue state is thus seen to be consistent with the alpha particle model.

2. Pion Condensation and the Presence of Nucleon Resonances in Nuclear Matter - N. Panchapakesan - The presence of mesons like pions inside the nucleus has been a matter of study for a long time. Recently it has been suggested that the pion could be in a resonant state with the nucleon and be present as a nucleon resonance Δ of mass 1236 MeV. The attractive interaction of the pion and nucleion in p-wave has also led to the suggestion that a

condensate of coherent pions of same momenta may be formed in dense systems. We study the interaction of pions in nuclear matter with the static model. Following Bethe, we use the theory of refractive index and the requirement of unitarity. We conclude that the pions, if condensed, must be necessarily in a resonant state with the nucleon forming a Δ resonance. The critical density for appearance of the resonance is shown to be $\sim$ 0.074 baryons F^{-3} much lower than the nuclear matter density of $\sim$ 0.16 baryons F^{-3}. The presence of resonances in nuclei should, therefore, play a significant role in nuclear physics.

3. Magnetic Moment of the Deuteron in the Presence of Nucleon Resonances - N. Panchapakesan and R. Venkataraman - Magnetic moment of the Deuteron M_d , includes the intrinsic magnetic moment of Nucleons and the orbital magnetic moment. The amount of ^3D state present is fixed by the Quadrupole moment and is taken to be about 7%. M_d is calculated to be 0.8400nm, below the experimental value of 0.8573nm and the difference is attributed to mesonic effects. One way of taking mesonic effects into account is to consider the Physical Neucleon to be a superposition of Nucleon and a Δ resonance. Δ has a mass of 1236 MeV and Spin 3/2 and Isospin 3/2. Bethe has shown that the width of Δ increases with Nuclear density. We calculate the probability of the presence of Δ and calculate the

contribution of Δ to the magnetic moment. We take the Δ_s to be also in the ^3S or ^3D states. We obtain a value of 0.8644nm which is more than the experimental value. The result depends on the Nuclear density and hence on the Deuteron wavefunction. We present values for two possible models.

4. Nuclear Structure Studies through Proton-Hole State Formation - R.S. Kaushal and S.K. Monga - In order to understand the nuclear structure properties, we consider the formation of a real proton-hole state in nuclear matter by doorway mechanism and investigate the spreading widths of the hole states thus formed in relation to the particle-hole energy gap parameter (Δ) and the saturation nuclear density (k_F). Our calculations with rank two N-N separable potential of Mongan's type show that the ^1So free two-body force when inserted in the Bethe-Goldstone equation is strongly over repulsive in producing the widths of the expected magnitude. Our results, which are in agreement with others' investigations too, are further confirmed by detailed analysis using different values of the parameters Δ and k_F for the nuclear matter.

Q. UNIVERSITY OF MADRAS

1. Asymmetry and Polarization of the Recoil Nucleus in the Reaction $\mu^- + {}^{12}C \rightarrow {}^{12}B + \nu_\mu$ - V. Devanathan and P.R. Subramanian - Expressions for the resultant polarization of ^{12}B nuclei recoiling in the experimental arrangement of Louvain-Saclay Collaboration[1] are derived. How these polarizations are related to the average polarization P_N, the longitudinal polarization P_L and the asymmetry parameter α is investigated. The experiment consists of two parts. In the first (second) part, the polarization of the nuclei recoiling into the forward(backward) hemisphere is preserved whereas it is destroyed in the backward (forward) hemisphere. Of the three quantities α , P_N and P_L only P_N and P_L can be found directly. It is proved that $\alpha - 2 P_L = 1$ and this relation is independent of nuclear models and coupling constants of the muon capture interaction[2]. Using this relation, α can be found. It is found that α , P_N and P_L are sensitive to the g_P/g_A ratio but insensitive to the nuclear model used.

1) For measurements on average polarization, see A.Possoz et al, Phys. Lett. 50B (1974) 438.

2) P.R. Subramanian and V. Devanathan, Phys. Rev.C. to be published.

2. Cascade Process in Muon Capture: Gamma-Neutrino Angular Correlations - V. Devanathan and P.R. Subramanian - A nuclear

cascade process resulting from muon capture and subsequent de-excitation by gamma emission is considered. The gamma ray yield is expressed in terms of certain observable correlations involving the three vectors - the gamma ray momentum k, the neutrino momentum $\vec{\nu}$, and the muon polarization $\vec{P}$. We have investigated the process $^{16}O(0^+, g.s.) \xrightarrow{\mu^-} {}^{16}N(1^-, 392keV) \xrightarrow{\gamma} {}^{16}N(0^-, 120\ keV)$. The angular correlation coefficients are independent of g_P/g_A but sensitive to g_A/g_V and nuclear structure. We have used the single particle j-j coupling shell-model and the Gillet and Vinh Mau wave functions. Simple relations independent of nuclear models and coupling constant of the muon capture interaction are obtained between nuclear recoil asymmetry α and the angular correlation coefficients. Measurements of correlationcoefficients, therefore, give one a handle to find α and hence present an alternative to other efforts in the field[1].

1) A. Possoz et al., Phys. Lett. 50B (1974) 438.

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