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भारत सरकार
GOVERNMENT OF INDIA
परमाणु ऊर्जा आयोग
ATOMIC ENERGY COMMISSION

PROGRESS REPORT ON NUCLEAR DATA ACTIVITIES IN INDIA - XIII

by

M. Balakrishnan
Nuclear Physics Division

भाभा परमाणु अनुसंधान केन्द्र
BHABHA ATOMIC RESEARCH CENTRE
बंबई, भारत
BOMBAY, INDIA
1978

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INIS Subject Category : A34

Descriptors:

CROSS SECTIONS

RESEARCH PROGRAMS

FISSION

NEUTRON REACTIONS

DATA

ENERGY-LEVEL TRANSITIONS

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

The thirteenth progress report on Nuclear Data Activities in India covers the work done during the calender year 1977. Following our earlier practice all the work done in the area of nuclear physics in the country has been included, the major portion consisting of the papers presented at the annual Nuclear Physics and Solid State Physics Symposium held at the University of Poona at Poona, in December 1977. However unlike previous years the activity in the field of neutron cross sections and nuclear data related to fission and fussion reactors is on the increase. Institution wise items numbered 22,23,26-41 (B.A.R.C.), 1-4 (R.R.C.), 2 (T.I.F.R.), 2 (A.M.U.), 1 (D.A.V.) and 1-4 (K.U.) come under this category. The fission work is covered by items numbered 6-15 (B.A.R.C.), 9-10 (S.I.N.P.), 2 (IIT-K) and 4 (P.R.L.).

The total number of CINDA entries sent to the Nuclear Data Section of IAEA during this period is 91. The liason activity with CPL and NEA was continued. The Variable Energy Cyclotron at Calcutta has operated with a 50 MeV alpha particle internal beam in June 1977. The deflector and extractor assemblies were under installation during the later half of 1977.

(M.K. Mehta)
Convener,
Indian Nuclear Data Group

INSTITUTION	Page

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13.	M. Srinivasan	:	Neutron Physics Division BARC.

A. BHABHA ATOMIC RESEARCH CENTRE, BOMBAY 400 085

1. High Spin States In ^{45}Sc - S. Saini and M.R. Gunye - The high spin negative parity states upto $23^-/2$ in ^{45}Sc have been recently observed in heavy ion fusion reactions. Since the high spin states provide a significant insight into the intrinsic nuclear structure, it is worthwhile to investigate these states to test the validity of different nuclear models. The available structure calculations for this nucleus in the framework of restricted $(f_{7/2})^5$ shell model and phenomenological rotation model yield only a qualitative account of the observed energy states. It is thus desirable to perform microscopic calculations with realistic nuclear interaction in a large configuration space. The calculations are carried out in the framework of Hartree-Fock projection formalism. All the nucleons outside ^{40}Ca core are explicitly treated in pf-shell configuration space by employing a modified Kuo-Brown interaction. The nuclear properties are extracted frommthe band-mixed wavefunctions obtained from the lowest four intrinsic states of ^{45}Sc. The results of the present realistic calculations are in good agreement with the experimental data.

2. Scrutiny of the Impulse Approximation for (p,2p) Reaction - B.K. Jain - Impulse approximation for the co-planar (p,2p) reaction has been examined for 60 to 100 and 300 MeV incident energy for various average intermediate excitations. It has been found that the correction term changes shape as well as magnitude of the recoil momentum distribution at 100 MeV.

At 300 MeV it only changes the magnitude. The corrected cross-section is more then the 'impulse' cross-section. The correction is not sensitive to the intermediate excitation energy.

3. Off-shell Effects in (π^+,π^+p) Reaction on ^{12}C - S.C. Phatak and B.K. Jain - The dependence of (π^+,π^+p) cross-sections on the off-shell pion nucleon (πN) interaction has been studied by using one stop knock-out mechanism. The out-going proton distortion has been neglected in this calculation and the distortion of in-coming and out-going pions has been approximately included by (1) computing pion wave-number in nuclear medium (dispersive effect) and (2) excluding the central region of the nucleus where the real pion-absorption is dominant (absorption effect). Harmonic oscillator wavefunctions are used for nucleon wavefunctions in ^{12}C and different off-shell extrapolations for πN scattering matrix are used in the computation. The magnitude of the cross-sections seems to be sensitive to the type of off-shell extrapolation; their shapes, however, are similar. The theoretical results are compared with experimental data. The agreement between the theoretical results for separable off-shell calculation and the data is good.

4. Microscopic Calculation of D-α Scattering Including Exchange Effects - Kiran Kumar, and A.K. Jain - The description of d-α scattering in terms of N-α potential of the Saxon-Woods form does not reproduce the experimental angular distributions at

medium energies. A microscopic calculation using a N-N interaction of Yukawa form and wave functions including all the exchange terms has been performed to investigate the reasons for the failure of the description of d-α scattering in terms of N-α interactions. In order to simplify the computations the Yukawa form has been expanded in terms of a series of Gaussians. The calculated angular distribution has been compared with experiment, as well as with calculation using N-α interaction. The influence of the deuteron size on the d-α angular distribution has also been investigated.

5. Microscopic Model of Low Energy Heavy Ion Collisions - V.S. Ramamurthy and S.K. Kataria - A microscopic model of low energy heavy-ion collisions has been studied in an attempt to relate the dynamics of the collision process directly to the nucleon-nucleon interaction rather than through the microscopic properties of nuclei. The model basically involves a description of the colliding ions as two bound particle clusters, with a suitably chosen particle-particle potential. The collision process is then studied by simultaneously solving the classical equations of motion for all the constituent particles. The distributions of particle positions and velocities as a function of time are suitably averaged to yield the time dependence of the most relevant macroscopic variables. In the first instance, in analogy with the classical liquids, a Lennard-Jones form was chosen for the

particle-particle interaction potential with the constants suitably chosen to ensure that the particle clusters in their ground state have macroscopic properties close to those of nuclei. It is found that the present model can bring out qualitatively all the essential features of heavy ion collisions, such as complete fusion, deep inelastic scattering and nucleon transfer. Since the above model being a fully classical description, neglects the effect of the Pauli principle and the possible presence of coherence effects, we have also investigated a model where each of the wave packets are studied as a function of time in the semiclassical limit.

6. Effect of Friction on Fragment Motion near Scission Point and Fission Fragment Kinetic Energies - M. Prakash, V.S. Ramamurthy, S.K. Kataria and S.S. Kapoor - Potential energy calculations of fissioning nuclei near the scission point based on the assumption that the nascent fragments have coaxial spheroidal shapes with diffuse surfaces have been reported earlier[1] It was found that a considerable amount of nuclear interaction energy is present upto a few form is of the separation between the two equivalent sharp surfaces of the fragments. This also leads to a stationary point in the potential energy. In the past, this stationary point has been identified as the rapture point[1,2], beyond which the relative motion of the fragments was treated as a simple conservative motion and the final

fragment kinetic energy was identified with the total potential energy at the rupture point. In the present work, we have studied the post rupture dynamics with the inclusion of the effect of friction in relative motion arising from the finite overlap of nuclear matter. It was found that with values of friction in the neighbourhood of those obtained from heavy-ion reaction data, the dissipation beyond the repture point amount to about 5 to 15 MeV from light to heavy nuclei. It was also found that good fits to the experimental kinetic energy data can be obtained for a wide range of nuclei with reasonable values of k and there was no need to involve any appreciable precission kinetic energy.

1. M. Prakash, S.K. Kataria and V.S. Ramamurthy, Nucl. & Solid State Phys. (India) 19B, 127 (1976).
2. K.T.R. Davies, R.A. Managan, J.R. Nix and A.J. Siesk (Preprint).

7. Transmission through Biharmonic Oscillator Potentials: Application to Fission - M. Prakash - A recent addition to the collection of exactly solvable models in one dimension is the biharmonic oscillator (oscillator frequencies about the position of the extremm are penetrability through an inverted barrier have been obtained[1]. The availability of exact solutions for both the bound state and the scattering problem has facilitated the incorporation of biharmonic oscillator wells and barriers in describing the many humped potential landscape of a fissioning nucleus. The exact calculation of penetrability througha double humped barrier where the second well or saddle has been taken to be of a biharmonic nature has been performed. The application of the present

model to obtain the fission probabilities of charged particle and neutron induced fission of actinide nuclei are studied.

1. M. Prakash, J. Phys. A: Math.Gen., 9, 1847 (1976).

8. A Quantitative Resolution of Thorium-234 Anomaly -

M. Prakash and B.S. Bhandari - For thorium isotopes the calculated first saddle and second minima of the double humped potential barrier are about 3 MeV lower than the experimental values commonly attributed to them. This discrepancy constitutes the well known "thorium anomaly" in the fission literature. However, Moller and Nix have suggested a possible resolution of this anomaly in terms of a third asymmetric minimum in the fission barriers of thorium isotopes. A recent exact calculation of penetrability has been reported by Sharma and Leboeuf[1)] where a comparison of the fission penetrabilities for ^{234}Th calculated in two-hump and three-hump models with those experimentally observed has been made. The authors conclude that although the ppenetrability calculated in the three hump model does help in reproducing the observed sub-barrier fission resonance structure, its magnitude is considerably lower than that calculated in the two hump model. In the present work we point out that the low values of the penetrability parameters, which are not consistent with the anomaly mentioned above. It is shown that one can obtain the correct penetrability by assuming that Back et al actually determined the parameters of the second saddle, third minimum and third saddle for ^{234}Th from an analysis of their

model to obtain the fission probabilities of charged particle and neutron induced fission of actinide nuclei are studied.

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(t,pf) data. The height of the first barrier is assumed to be that given by microscopic calculations for this nucleus. Results of calculations for penetrability through the proposed three humped barrier for ^{234}Th in both exact and the WKB approximation methods are analysed.

1. R.C. Sharma and J.N. Leboeuf., Phys. Rev. C14, 2340 (1976).

9. Emission of Individual Light Charged Particles (Z=1,2) in 120-500 keV Neutron Induced Fission of ^{235}U - D.M. Nadkarni, R.K. Choudhury, S.S. Kapoor and B. Krishnamurthulu and G.K. Mehta - As a part of our programme to study the emission probability and the energy spectrum of individual light charged particles (Z-1,2) emitted in fast neutron fission of ^{235}U, measurements have been carried out at incident neutron energies of 120,235 and 500 keV. The light charged particles were identified with a Δ E-E semi-conductor detector telescope in coincidence with fission fragments detected in a 2π gemmetry by means of a gas ionization chamber. The ΔE and E detector outputs were recorded event by event by means of a 3-parameter data acquision system for detailed off-line computer analysis. The outputs of ΔE and E were also fed to a particle identifier unit whose output was recorded in a multichannel analyser. Neutrons were generated with the reactions Li^7 (p,p) and T(p,n) using the 2 MeV Van de Graaff accelerator at IIT, Kanpur.

10. <u>TFSD Response to Fragments from Light Charged Particle Accompanied Fission of ^{238}U</u> - N.N. Ajitanand, K.N. Iyengar and S.R.S. Murthy - The relative response of a thin film scintillation detector (TFSD) to fragments from binary and light charged particle accompanied (LCPA) fission has been studied. The TFSD was prepared by a technique reported earlier[1] and the E/M and Z dependence of the TFSD response was calculated on the basis of an expression developed for the specific luminescence[2]. The pulse height calibration was done by assigning the most probable values of E/M and Z of the light and heavy fragments in binary fission to the corresponding peaks in the observed TFSD pulse height distribution. Using the published information on the energies of binary and LCPA fission fragments, the TFSD data was analysed to obtain the E/M and Z of the most probable light and heavy fragments in LCPA fission. The present data indicate that the light charged particles (i.e. alpha particles) are formed more often at the expense of nucleons from the light fragments.

1. N.N. Ajitanand and K.N. Iyengar, Nucl. Instr. and Meth. 133 (1976) 71.
2. N.N. Ajitanand, Nucl. Instr. & Meth. (1977) 345.

11. <u>Multiparameter studies of Mass, Energy Correlations in Ternary Fission of ^{235}U induced by Thermal Neutrons</u> - R.K. Choudhury, D.M. Nadkarni, P.N. Rama Rao and S.S. Kapoor - Measurements of various distributions and correlations of fission fragment mass, energy and light charged particle (LCP) energy were carried out in ternary fission of ^{235}U induced by thermal

neutrons. Fission fragment and LCP energies were measured by a back-to-back gridded ionisation chamber and semiconductor detectors respectively. Two LCP detectors were placed in line with the electric field direction of the chamber, and information about the angle of the fission fragments with the electric field direction was obtained from the coincident pulse heights at the grid and collector. The pulse hight information of the two collectors, two grids and the LCP detectors in ternary fission were recorded event by event by means of a multiparameter recording system. Computer analysis of the recorded data is being carried out to obtained multidimensional correlations between mass, energy, angle of fragments.

12. <u>Multiplicity Distribution of Prompt Gamma Rays in Spontaneous Ternary Fission of ^{252}cf</u> - R.K. Choudhury, V.S. Ramamurthy and J.C. Mohana Krishna - Measurement of characteristics of gamma ray emission in fission gives information about the properties of the excited states of the highly excited fission fragments. In the present work the first and the second moments of the multiplicity distribution of gamma rays in spontaneous ternary fission of ^{252}cf were measured by multiple coincidence technique. The average value, $\bar{n}$ and width σ of the multiplicity distribution were obtained from these two moments assuming the distribution to be of Gaussian form. The variations of $\bar{n}$ and σ with the energy of the light charged particle (LCP) were also obtained. It was seen that that both $\bar{n}$ and σ are nearly independent of the energy of the LCP. However, the width

in ternary fission was found to be larger than that in normal binary fission by about 20%. The results have been analysed on the basis of the mechanism of LCP emission in fission.

13. Nuclear Charge Distribution in Fission: Fractional Cumulative Yields of ^{99}Mo and ^{135}I in Thermal Neutron Fission of ^{245}Cm - Tarun Datta, S.P. Dange, S.B. Manohar, Satya Prakash and M.V. Ramaniah - Nuclear charge distribution in $^{245}Cm(n_{th},f)$ has been studied for mass chains 99 and 135. The fractional cumulative yield (FCY) of ^{99}Mo and ^{135}I have been determined following the growth and decay of respective daughter products ^{99m}To and ^{135g}Xe activities on a 60 cc Ge(Li) detector. The widths of the distributions were calculated from measured FCY assuming Gaussian distributions and most probable charges. The values of the widths thus obtained were correlated to the fragments shell effect.

14. Nuclear Charge Distribution in Fission: Determination of Fractional Cumulative Yields of ^{99}Mo, ^{112}Pd, ^{132}Te in the Spontaneous Fission of ^{252}Cf.- S.S. Rattan, P.P. Venkatesan, R. Trehan, S.B. Manohar, Satya Prakash, Tarun Datta, A.G.C. Nair and M.V. Ramaniah - The fractional cumulative yield (FCY) of ^{99}Mo, ^{112}Pd and ^{132}Te in the spontaneous fission of ^{252}Cf have been determined using gamma spectrometric and radiochemical techniques. These FCY values are used to calculate the most probable charge for these mass chains. The results of these studies have been

analysed together with our earlier work to investigates the shell effects in charge distribution.

15. Low-Yield, Short-Lived Products in the very Asymmetric Fission of Uranium: Additional Evidence for the Influence of the 28-Proton Shell in Fission Mass Distribution - V.K. Bhargava, V.K. Rao, S.G. Marathe, S.M. Sahakundu and R.H. Iyer - New experimental data have been obtained on the yields of some short-lived very asymmetric products in the reactor neutron induced fission of ^{238}U. Cumulative yields for the mass chains 73, 167, 171, 173 and 179 have been determined. The present data together with the earlier yield data[1] for mass chains 66, 67, 72, 77, 161, 172, 183 and 199 lend additional support to the possible influence of 28-proton shell in low energy fission resulting in 'bumps' or 'shoulders' in the highly asymmetric mass region. Recent theoretical predictions by Gupta[2] and Sharma et al[3] corroborate our experimental observations. The present data along with the earlier data have been used to construct the experimental mass yield curve in the fast neutron fission of ^{238}U.

1. S.G. Marathe, S.M. Sahakundu, V.K. Bhargava, V.K. Rao and R.H. Iyer, Proc. Of Nucl. Phys. & Solid State Phys. Symp. Bangalore, Vol. 16 B, Nuclear Physics, p.21 (1974)
2. R.K. Gupta, A review article to be published in a book entitled "Particles and Nuclei" (Private Communication)
3. D.N. Sharma, M.R. Iyer and A.K. Ganguly, BARC/I-408 (1976).

16. <u>Microscopic Calculation of Nucleus-Nucleus Complex Optical Potentials</u> - S.K. Gupta and S. Kailas - The Brueckner energy density formalism is extended into the complex domain to calculate both the real and imaginary parts of the ion-ion potential. Recent nucleon-nucleus potentials calculated by Jekeunne, Lejeune and Mahaux using Reid's hard core nucleon-nucleon potential are employed to generate the complex potential energy densities required in the calculation. The computed potentials are in good agreement with the phenomenological values. The computation of cross-sections using these potentials is in progress.

17. <u>Heavy Ion Interaction Potential</u> - D.K. Srivastava and N.K. Ganguly - Optical potential for heavy-ions (HI) scattered from a target has been calculated in terms of the optical potential for its constituent nucleons- known a priori. For this purpose, an extension of Feshbach's projection operator formalism is utilized in which the propagator for the HI is approximated by the propagator for one of the nucleons in the projectile evaluated at an effective energy $\{E/A_p + 0.3\hbar^2 k_f^2/m + (A_p-1)V_1\}$ where E is the c.m.energy, k_f is local Fermi momentum, V_1 is nucleon-nucleus optical potential and A_p is projectile mass. In doing this, we make use of the fact that in energy density formalism the interaction potential at separation R is the difference in the binding energy when the two system have moved from infinite separation to the distance R. Calculations have been done for number of ion-ion combinations and results compare with other available results.

18. Exchange Effects in Alpha-Potential for $N=Z\neq A/2$ Nuclei - S. Pal, D.K. Srivastava and N.K. Ganguly - Various approximate procedures are in vogue which give exchange effects for composite particles. We discuss a method of including exchange terms for interaction of alpha-particle with nuclei having $N = Z = A/2$. The alpha-potential is obtained by folding alpha-alpha interaction of Ali and Bodmer with the alpha matter distribution of these nuclei. The alpha matter distribution was calculated by unfolding the alpha-particle density, from the known nuclear matter distribution of the target.

We emphasize that the repulsion at short distances in the alpha-alpha interaction empirically includes the effect of exchange of nucleons whereas the exchange of alpha-clusters themselves is made less probable due to this. Good fits to elastic scattering data have been obtained. The method can be extended for ion-ion potentials using double folding procedure. Results comparing well in the tail region with the findings of Stancu and Brink are obtained.

19. The Imaginary Part of Nucleus-Nucleus Potential - S.C. Phatak and B.C. Sinha - The imaginary part of the nucleus-nucleus optical potential has been computed by evaluating the imaginary part of second order term in the optical potential series. Fermi-gas model is used for intermediate nuclear excited states. For distances greater than the touching distance of two nuclei, the form of the imaginary potential is very close to square of Woods-Saxon form and it compares favourably with phenomenological potential. We

intend to use this potential along with the real part to investigate elastic and inelastic heavy-ion scattering and various other reactions.

20. Application of Thomas-Fermi Gas Model to strongly Damped Collisions of Heavy Ions - A.K. Jain and N. Sarma - The large transfer of energy from the relative motion of colliding heavy ions to their internal excitation energies is derived by considering the two nuclei as Thomas-Fermi gas clouds. The density distributions of these nucleon clouds are dtermined from data on elastic scattering and on μ-mesic atoms. The diffusion of nucleons across the boundary between the two nuclei leads to a transfer of momentum and so of energy to the internal degrees of freedom of the nuclei. The trajectory on which this nucleon exchange occurs is determined from the Coulomb+Optical potentials. The final spins of the nuclei and the ratio of the radial and tangential friction coefficients are in reasonable agreement with the measured values.

21. Nuclear Friction and the Imaginary part of the Nucleus-Nulceus Interaction Potential - Bikash Sinha - Using semi-classical approximations, the phenomenological form-factor of nuclear friction is derived from the imaginary part of the nucleus-nucleus interaction potential. The results obtained are compared with the prediction of the frictional co-efficient using the linear response theory. The two models are used to predict the experimental data on damped collision for two nuclei.

22. Calculation of (n,2n) Cross-sections around 14.5 MeV using an Integrated Preequilibrium-cum-Statistical Model - Ambar Chatterjee and Santosh K. Gupta - An integrated preequilibrium-cum-statistical model approach is used to calculate the absolute values of the (n,2n) reaction cross sections around 14.5 MeV for nuclei throughout the periodic table. In this approach the absolute preequilibrium fraction is calculated using the Griffin-Williams exciton model as used by Braga-Marcazzan et al[1] in the analysis of (n,p) cross sections around 14 MeV. The reduction of flux for the statistical component due to the preequilibrium process has been accounted for by including both proton and neutron emission. The calculation is global and free from any new parameter. There is considerable improvement over the pure statistical model for nuclei in the mass range $60 < A < 209$ but not much improvement for $A < 60$.

1. G.M. Braga-Marcazzan et al. Phys. Rev. C6, 1398 (1972).

23. Direct and Collective Nucleon-Capture using Microscopic Optical Potential - D.R. Chakraberty and S.K. Gupta - In nucleon-capture when the excitation of the compound system is in giant resonance (GR) region, the direct and collective process[1] contributes strongly to the cross section. The incident nucleon excites the target nucleus to its GR state through particle-vibration coupling, depending on the isovector part of the optical potential. Potokar[2] has found this coupling to be complex to explain the experimental results using a phenomenological approach. A recent calculation of optical potential by Jeukenne, Lejeune and Mahaux[3],

starting from Reid's hard core nucleon-nucleon interaction has a complex isovector part. Using the results of this calculation, (n,γ) cross sections have been computed for various partial transitions in $^{208}Pb(n,\gamma)^{209}Pb$. These calculations along with the experimental data are compared.

1. C.F. Element, A.M. Lana and J.R. Rook, Nucl. Phys. 66, (1965) 273.
2. M. Potoker, Phys. Lett. 46B (1973) 346.
3. J.P. Jeukenne, A. Lejeune and C. Mahaux, Phys. Rev. C16 (1977) 80.

24. Fluctuation Analysis of $Ca^{48}(p,n)^{48}Sc$ Total Excitation Function from 1.900-5.100 MeV. Gulzar Singh*, S. Kailas, A. Chatterjee, S. Saini, M. Balakrishnan and M.K. Mehta - The total excitation function (E.F.) was measured with fine resolution ($\Delta E \sim 2$ keV and energy step ~ 5 keV)[1]. This Ex. Fun has been subjected to fluctuation analysis. Application of peak counting, Fourier analysis, and the autocorrelation methods resulted in $\Gamma = 6\pm1$, 7 ± 1, and 6 ± 1 keV respectively, at about 13 MeV excitation energy. The value $\langle\Gamma\rangle = 6$ keV, for the compound nucleus ^{49}Sc, was employed to deduce the level density parameter $a = 5.48$ MeV^{-1}. The Exn. Fun. variance ($C(0)$) as well as cross-section probability distribution indicated an insignificant direct reaction contribution ($\leq 0.2\%$ even at the highest energy of measurement range).

1. Gulzar Singh et al. N.P. & S.S.P. Symposium 19B, 29(19760.

* D.A.E. Research Fellow. Physics Department, P.U. Chandigarh 160014.

25. <u>Resonance Spectroscopy of the Nucleus ^{44}Ti</u> - S. Saini, S. Kailas, N. Anantaraman, M. Balakrishnan and M.K. Mehta - We have studied the levels in the ^{44}Ti nucleus in the excitation energy range of 7.8 to 9.5 MeV by means of the $^{40}Ca(\alpha,\alpha)^{40}Ca$ reaction. The excitation function for this reaction has been measured at the four laboratory angles: 84°, 120°, 137° and 165° for 3 MeV $< E_{\alpha} <$ 4.75 MeV. Many anomalies are observed in the excitation function and some of these correlate well with resonances which have been seen[1,2] in the $^{40}Ca(\alpha,\gamma)^{44}Ti$ reaction. An interesting feature of the data is that the anomalies are weaker at the most backward angle (165°) compared to the forward angle (84°) which is contrary to general expectation. A multi-level and multi-channel R-matrix analysis is used to fit the data and extract the spins and parities of the populated levels.

1. W.R. Dixon et al. Phys. Rev. <u>C15</u>, 1896 (1977).
2. J.J. Simpson et al. Phys. Rev. <u>C4</u>, 443 (1971).

26. Analysis of ^{232}Th cross-sections using Deformed Optical Model - S.B. Garg - A study of total, elastic, inelastic and level exfication cross-sections has been carried out for ^{232}Th using the deformed optical model with adiabatic approximation in the energy range 2.0 MeV to 20.0 MeV. In this study first three levels (2^+, 4^+, 6^+) of the ground state rotational band have been coupled to each other and the deformed optical model parameters of Fasoli et al[1] have been extended upto 20 MeV. The calculated values of total cross-section have been found to agree well with those given in ENDF/B-IV library.

1. U. Fasoli et al; Nucl. Phys. A151, 369 (1970).

27. Compilation of Measured cross-section Data for ^{232}Th - S.B. Garg, V.K. Shukla and Amar Sinha - An up-to-date compilation of the measured total, elastic, inelastic, and differential elastic cross-section data has been made for ^{232}Th with a view to evaluating these cross-sections to meet the requirements of the IAEA-- Research Contract. The different sets of the measured total cross-section data in the energy range 100 keV to 20 MeV have been intercompared and their discrepancies have been brought out in a write-up.

An independent evaluation of the above mentioned cross-section data is in progress.

28. Multigroup Resonance Self-shielding Factors and Cross-Sections of Main Reactor Elements - S.B. Garg - Multigroup resonance self-shielding factors and cross-sections have been generated for Be, ^{10}B, ^{11}B, C, N, O, Na, Cr, Fe, Ni, Th, ^{233}Pa, ^{233}U, ^{234}U, ^{235}U, ^{238}U, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu using their basic cross-section and resonance parameter data from the ENDF/B library. These cross-sections and self-shielding factors can be directly used in fast reactor codes 1 DX and FCC-IV to study the physics of any dilute or dense fast system representing soft or hard neutron spectrum. The Doppler coefficient of reactivity, vital for safety considerations, can also be estimated using these data.

29. Multigroup P_8-Elastic Scattering Matrices for Main Reactor Elements - S.B. Garg and V.K. Shukla - To study the effect of anisotropic scattering phenomenon on shielding and neutronics of nuclear reactors multigroup P_8-elastic scattering matrices have been generated for H, D, He, ^{6}Li, ^{7}Li, ^{10}B, C, N, O, Na, Cr, Fe, Ni, ^{233}U, ^{235}U, ^{238}U, ^{239}Pu, ^{240}Pu, ^{241}Pu and ^{242}Pu using their angular distribution, Legendre coefficient and elastic scattering cross-section data from the basic ENDF/B library. These scattering matrices can be directly used as input to the transport theory codes ANISN and DOT.

30. Basic and Multigroup Cross-sections for Safety Research Studies - S.B. Garg - The basic total, capture and elastic scattering cross-sections in the resolved and unresolved resonance regions have been generated for Sm, Gd, ^{151}Eu and ^{153}Eu using their resonance parameters from ENDF/B library. These cross-sections have also been corrected for the background corrections listed in ENDF/B file.

27-group reaction cross-sections and down scattering matrices for the inelastic and (n,2n) reactions have been obtained for use in safety research studies.

31. Multigroup Anisotropic Scattering Matrices and Transport Cross-sections for H and D in the Thermal Energy Range - Amar Sinha and S.B. Garg - Ten group P_3-upscattering and downscattering matrices have been evaluated for H bound in water and D bound in heavy water using the anisotropic model of Koppel and Young in the energy range .001 ev to 1.5 ev. Scattering and transport cross-sections and the Maxwellian averaged energy loss moments have also been evaluated in the above mentioned energy range. These data can be used in the physics studies of thermal reactor systems using water or heavy water as moderator.

32. <u>A Test of 27-Group cross-sections and Self-Shielding Factors in the Criticality Predictions of Fast Critical Assemblies</u> - V.K. Shukla and S.B. Garg - An improved criticality analysis has been carried out of several fast critical assemblies using their self-shielded multigroup cross-sections. These assemblies are JEZEBEL, ZEBRA-3, ZPR-3-48, ZPR-3-50, ZPR-3-53, ZPR-6-7, GODIVA, TOPSY, ZEBRA-2 and ZPR-6-6A and they are fuelled with metals, oxides and carbides of uranium and plutonium. They represent very soft to very hard neutron spectra and therefore are the good testing grounds of the multigroup data generated from ENDF/B library.

The K_{eff}-values obtained in all these cases have shown marked improvement over those obtained with the unshielded cross-sections. In several cases the calculated K_{eff}-values agree well with the measured ones.

33. <u>Improved Measured of Neutron Capture Cross-Section of ^{232}Th by the Activation Method</u> - H.M. Jain, R.P. Anand, M.L. Jhingan, R.N. Jindal, S.K. Gupta, V.C. Deniz, M.K. Mehta - A set of improved measurements of ^{232}Th (n,γ) capture cross-section relative to ^{197}Au were performed at Van-de-Graaff in the 400-600 keV neutron energy region using a liquid nitrogen cooled lithium metal target. For eliminating the branching ratio for the measured gammas and the photopeak efficiency of the Ge(Li) detector, similar measurements were performed in a thermal flux. The

improvements include the increase in proton current and the purification of thorium to reduce background. Data processing is in progress.

34. <u>An Assessment of the cross-sections used in Thermal Reactor Lattice Studies</u> - (H.C. Huria, P. Mohanakrishnan, K.R. Srinivasan and B.P. Rastogi - In order to assess the adequacy and reliability of the cross-sections used in predicting the nuclear characteristics of thermal reactors, a wide spectrum of experimental evidence is a must. Measurements on clean uniform lattices with simple geometry and composition provide a very good base for this purpose. With this in the background we have analysed a wide variety of experimental information covering not only uranium (natural/enriched) systems but plutonium enriched criticals and thorium bearing lattices as well using the cross sections developed by us and those from the WIMS library. This paper presents a resume of the results for predicting integral reactor physics properties like reactivity and reaction rates and their comparison with relevent measurements. This evaluation brings out ample evidence of the adequacy of the cross sections.

35. <u>An Analysis of Enriched Uranium Lattices</u> - P. Mohamkrishnan, H.C. Huria, K.R. Srinivasan and B.P. Rastogi- Adequacy of a

reactor physical calculational model and itss associated cross-sections could be established through the analysis of experimental information on representative lattices. A number of critical and exponential the cross-sections (and the physical formulation) used in our design methods. The good reactivity predictions for all the lattices and satisfactory agreement between calculated and measured reaction rates indicates that there are no serious discrepancies in the ctoss-sections of uranium isotopes and also the efficacy of the model.

36. <u>Reactivity Prediction of Uniform PuO_2-UO_2 fuelled Lattices and $Pu(NO_3)_4$ Solutions in Light Water</u> - P. Mohanakrishnan and H.C. Huria - A theoretical analysis of the reactivities of the experimentally measured uniform light water moderated and reflected PuO_2 in UO_2 lattices and $Pu(NO_3)_4$ solutions is presented here. The mixed oxide single rod lattices are homogenised by the use of multigroup integral transport theory and diffusion theory is used for the cylindrical core calculations. The cross-sections are derived from the WIMS library. The homogeneous spherical $Pu(NO_3)_4$ solutions are analysed by discrete ordinate transport theory. Due to the small size of these criticals, it is necessary that one dimensional core calculations also be performed with a cross-section energy group structure which can

represent neutron slowing down and thermalisation at the core reflector interface accurately. Due to the absence of such core calculations in the BNWL analyses of the mixed oxide lattices, the agreement of our predictions for these lattices with measurement is considered to be more satisfactory. Our reactivity predictions agree generally within ±0.6% of measurements for the mixed oxide lattices and within 1% for the solution systems.

37. Program Grace: To Generate Multi-group cross sections using Basic Data in the ENDF/B Format - Ashok Kumar - The multigroup technique is the most accepted tool for all type of reactor physics analysis now a days. The accuracy undoubtedly will depend upon the accuracy of the derived multigroup cross-sections. These are derived from the basic point data which can be either measured experimentally or evaluated theoretically. Besides these point data one needs an energy spectrum over which these data are to be averaged. The effective cross-sections for a group are derived from the conservation of reaction rates within the group.

This analysis posses a problem as the spectrum itself depends upon the cross-sections and vice-versa. This difficulty is alleviated to some extent by choosing a spectrum which is a typical of that existing in the system under study.

The code GRACE has been written on BESM-6 to generate multi-group cross-sections using the recently available data in the form of Evaluated Nuclear Data File. The weighting spectrum can be chosen as one or a combination of (i) 1/E, (ii) Maxwellian, (iii) Fission spectrum and (iv) Any given spectrum in the form (E_i, ϕ_i).

These spectra cover the entire range of the neutron energy in all types of reactors thereby making the code most general. It reads the point data for the reactions (n,n), (n,n'), (n,f), (n,γ), (n,2n), (n,p), (n,α) and μ as a function of incident energy and generates the group averaged elastic scattering, inelastic scattering, fission, absorption, transport $\nu\sigma_f$ (n,2n), (n,p) and (n,α) cross-sections.

38. <u>Multigroup Cross-sections for Thermal Reactors</u> - H.C. Huria and Ashok Kumar - Multigroup cross-sections in the 69 groups WIMS structure were generated for the isotopes of uranium and plutonium using the basic data of ENDF/B-IV and the program GRACE developed here. These were then used to analyse experimental information on clean uniform lattices using enriched uranium and mixed oxide fuel rods in light water moderator. The satisfactory prediction of reactivity over a range of enrichments and plutonium compositions showed that there are no serious discrepancies in the data being used by us.

39. Generation on Multigroup Cross-sections of Hafnium - Ashok Kumar - Hafnium is used as a control material in pressurised light water reactors. In order to determine its worth in a reactor system the multigroup cross-sections for hafnium are required.

Natural hafnium has five isotopes viz. H_f^{176}, H_f^{177}, H_f^{178}, H_f^{179} and H_f^{180} and all of them exhibit resonances in their energy variation of cross-sections. The resonance parameters of all the resonances with their natural abundance were used to generate 27-group cross-sections in the MINI WIMS energy structure. The $1/v$ contribution was then added to these cross-sections to obtain the required set.

40. Resonance Group Cross-sections for ^{232}Th - H.C. Huria Composition and temperature dependent resonance parameters from ENDF/B-IV and the program RESONX- a homogeneous medium version of EPITHET. The group resonance integrals were derived from the detailed reactions and fluxes given by RESONX which solves slowing down equations in an infinite homogeneous medium consisting of a resonance absorber and a moderator. The cross-sections so prepared have been used to analyse experiments with ^{232}Th-^{233}U fuel in light/heavy water moderator. The results give an under-prediction of epithermal to thermal captures in ^{232}Th to the

extent of around 10% but the reactivity estimates are quite satisfactory in all the lattices. Similar results have been reported by other workers also.

41. Generation of Thermalization Scattering Matrix for Hydrogen

V.K. Jain and Vinod Kumar - 27-group MINIWIMS and 69-group WIMS libraries contain thermalisation scattering matrices tabulated only at 5 temperatures ranging from 20°C to 200°C for hydrogen. The normal temperature in light water reactors is of the order of 250°C to 300°C. At present the parameters at these temperatures are obtained by extrapolation of the matrices. It is proposed to extend the matrices to these temperatures. The first step in this direction was to check the existing codes with the data available. The code COSMOS was used for this purpose. This code can generate scattering matrices under a variety of models. During the comparison it was found that there is some disagreement. But when the groups are further subdivided into finer subgroups and an appropriate spectrum is used for collapsing the resulting matrices, there is satisfactory agreement below 1 ev. The procedure is being used to generate scattering data at all temperatures.

REACTOR RESEARCH CENTRE, KALPAKKAM

1. RAMBHA - A Computer Code to Generate Multigroup Cross Sections from a Nuclear Data File - P. Bhaskar Rao, M.L. Sharma and S. Ganesan - The first phase of developing a computer code to generate a complete set of temperature and composition dependent multigroup cross sections was completed with the development of code DOPSEL[1] for the resonance region. In the next phase a code XSAVG[2] was developed to process the data from the continuum region. In the third phase a unified code RAMBHA has been developed in which models for the calculations of cross sections for inelastic scattering, inelastic transfer, transport, total, fission, capture and elastic scattering are also included along with the above two codes to cover the entire energy range. The code is designed to process the RRC data file which has basic data in both the ENDF/B and KEDAK formats. In the final phase the models for the calculations of $\nu\sigma_f$ and elastic removal cross sections are being implemented in this code.

1. S. Ganesan, P. Bhaskar Rao and R. Shankar Singh, "DOPSEL - A program fro Evaluation of Self Shielding Factors in Resolved and Unresolved Resonance Region", RRC-6 (1975).
2. M.L. Sharma and P. Bhaskar Rao, "XSAVG- A Code to Generate Multigroup Cross Sections", RRC-FRG/RP-32 (1974).

2. <u>Generation of Multigroup Cross Sections for Dosimetry Materials</u> - M.L. Sharma, R. Venkatesan and R. Shankar Singh - Multigroup cross sections of isotopes of Fe, Co, Ni, Al, Cu, Au, S. In, Na have been generated[1] for (n,p) and (n,γ) reactions from the point data available in the ENDF/B-IV Dosimetry File[2] and 175 group ENDL library of Lawrence Livermore Laboratory[3] for checking the consistency and spread in the generated sets.

The cross sections were evaluated in 1,12,25, and 100 group structures using the codes AVCROSS[4] and DOPSEL[5]. These cross sections are required for the study of activation and heat generation in FBTR, and for the analysis of transmission experiments in sodium and iron.

1. M.L. Sharma et al., "Generation of Multigroup Capture Cross-sections for dosimetry materials", RRC-FRG/RP-145 (1977)
2. B.A. Magurno (Ed.), "ENDF/B-IV Dosimetry File", BNL-NCS-50446
3. E.F. Plechaly et al., "Tabular and Graphical Presentation of 175 Neutron Group Constants Derived from the LLL Evaluated Neutron Data Library (ENDL)", UCRL-50400, Vol-16 (1976)
4. M.L. Sharma and P. Bhaskar Rao, "AVCROSS-A Code to Generate Multigroup Cross-sections", RRC-FRG/RP-32 (1974)
5. S. Ganesan et al., "DOPSEL, A program for Evaluation of self Shielding Factors in Resolved & Unresolved Resonance Region", RRC-6 (1975).

3. Updating and Testing of Ni and U^{233} Cross Sections - M.L. Sharma, S. Ganesan and R. Shankar Singh - Comprehensive evaluation of Ni cross section data was taken-up in view of atleast two evident deficiencies in the Cadarache Cross section library[1,2]. Firstly the infinite dilution cross. sections were found to be out dated, secondly in the existing data, set all the shielding factors are unity i.e. there is no self shielding.

The following three groups of cross section data sets were employed: cross sections in the Cadarache library, Ni cross sections generated here[3], a combination of the two sets such that higher capture cross sections of each were taken in the new set. Both the options available in the code EFFCROSS[4] for treatment of elastic scattering resonances were utilized. Testing of these data sets was done against the homogeneous 1-D spherical model of bench-mark assembly ZPR-6-6A[5] and the reactor RAPSODIE (Fortissimo) as both of them had reflectors made up of Ni. Multiplication eigenvalues and Doppler effect was calculated using the old and new data sets and their variants.

The results of these studies were not definitive and it is considered necessary to repeat these calculations with

certain changes in the light element scattering matrices and with a few more assemblies. However, one important fact which came to light was that the effect of changes in the capture cross sections is negligible compared to the influence of different options for the treatment of the effect of elastic scattering resonances.

To update the data available presently in the Cadarache Cross section library[1,2], evaluation of the mean resonance parameters for U^{233} has been taken up in view of its importence in Th-U fuel cycle. Compilation of the resonance parameters in both the resolved and the unresolved resonance region has been completed from the available literature.

Calculations of the central reactivity worths using the existing cross section library has been completed for ZPR-677 assembly.

The new set of cross sections is being prepared using the latest available and adjusted data for the unresolved resonance region for repeating the calculations to evaluate its suitability

1. J. Ravier, "Sections Efficaces Multigroupes et Jan SEFR a 25 groupes", PNR/SEPR 66.050 (1966)
2. J.Y. Barre et al., "Lessons drawn from Integral Experiments on a set of Multigroup cross sections", Paper 1.15, Int. Conf. on the Physics of Fast Reactor Operation and Design,

London (1969)

3. R. Venkatesan et al., "Generation of Self shielded Multi-group Cross sections for the isotopes of Ni", RRC-FRG/RP-102 (1976)

4. M.L. Sharma et al., "EFFCROSS-A code for Generating Effective Cross sections from Cadarache Cross-section library", RRC-FRG Note (Under preparation)

5. R.W. Hardie et al., "An analysis of Selected Fast Critical Assemblies Using ENDF/B-IV Neutron Cross Sections", Nucl. Sci. Engg. 57, 222-238 (1975).

4. Analysis of Delayed Neutron Yield Data - S. Krishnan, M.L. Sharma and S.M. Lee - It has been reported in many laboratories[1] that a discrepancy of around 20% exists between the measured and calculated central reactivity worths of the major fissile and fertile nuclides in fast critical uncertainties in the delayed neutron data.

In the past, the delayed neutron data of Keepin[2] have been employed in the central worth calculations. Recently, based upon fresh measurements new delayed neutron yield evaluations have been proposed by Tomlinson[3], Cox[4] and Tuttle[5].

Calculation of the central worths of several nuclides in selected critical assemblies was undertaken[6] using the different delayed neutron yield data to study their effect on the calculated/experimental (C/E) discrepancy. It was found that the later evaluations lead to a higher value of effective delayed neutron fraction and hence the central owrth C/E ratio gets reduced by about 7%.

Keepin's evaluations indicate that the absolute delayed neutron yield ($\bar{a}$) increases with neutron energy approximately at the same rate as the total neutron yield ($\bar{\nu}$) so that the delayed neutron fraction ($\bar{\beta} = \bar{a}/\bar{\nu}$) is approximately independent of energy. On the other hand the later evaluations show that $\bar{a}$ is approximately constant (upto 4 MeV) so that $\bar{\beta}$ decreases with energy. The effect of using constant $\bar{\beta}$ or constant $\bar{a}$ was also studied for Keepins data and showed that the latter assumption gives a better agreementcompared to the former.

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2. G.R. Keepin; Physics of Nuclear Kinetics (Addison Wesley Co, Reading, Massachusets, 1969)
3. L. Tomlinson, "Delayed Neutrons from Fission: A compilation and Evaluation of Experimental Data", AERE-P 6993 (1972)

4. S.A. Cox, "Delayed Neutron Data - Review and Evaluation". ANL/NDM-5, (1974)

5. R.J. Tuttle, Nucl. Sci. & Eng., 56, 37 (1975)

6. S. Krishnan, M.L. Sharma and S.M. Lee, "Analysis of Selected Fast Critical Experiments using Recent Delayed Neutron Yield Evaluations", (To be published in Atomkernenergie).

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1. A Study of the Transfer Amplitude in Heavy Ion Transfer Reactions - Hashima Hasan - An attempt is made to understand the exponential fall off with respect to the angular momentum of relative motion of the interacting nuclei of the transfer amplitude for single nucleon transfer reactions and to obtain the decay constnat. The semiclassical transfer amplitude is simplified assuming that the transfer probability is maximum for a gazing collision and when the nucleon is near the plane of the reaction. The relative motion is approximated by a straight line and the radial wave functions by square well functions. The final expression is a product of a constant containing the z-dependence of the orbital angular momenta of the nucleon in the initial and final states and an exponential function decaying with respect to the distance of closest approach with a decay constant depending on the initial binding energy of the nucleon. The transfer amplitudes calculated with this formula for the reaction $^{26}Mg(^{11}B,^{10}B)^{27}Mg$ at 114 MeV laboratory energy compare well with a full calculation. Angular distributions calculated with its help give good qualitative agreement with experiment.

2. σ (n,2n) and σ (n,3n) Cross-sections on the basis of Statistical-Model for Heavy Nuclei - M.L. Jhingan - Pearlstein[1] has given a formalism to calculate σ (n,2n) as a function of

energy on the basis of statistical model. But his calculations do not agree with the measured data for Th^{232} and U^{238} for energies above (n,3n) threshold. We have improved his calculations for Th^{232} and U^{238} and developed a computer code by taking into account the effect of second neutron spectrum on σ (n,2n) and σ (n,3n), Our results agree quite well with the experimental data. We also considered various level-density formulae and found that the level density parameter, a required to fit σ (n,2n) and σ (n,3n) data are quite different from those obtained by other nuclear processes.

1. Pearlstein, S., Nucl, Sci. Eng. 23 (1965) 238.

3. <u>Level Scheme of ^{81}Kr</u> - Y.K. Agarwal, C.V.K. Baba*, S.M. Bharathi, V.M. Datar*, H.C. Jain and B. Lal** - The level scheme of ^{81}Kr was studied through the $^{81}Br(p,n)$ reaction with the 5.5 MeV Van-de-Graaff accelerator at Trombay. Measurements were made of γ-ray excitation functions, $\gamma - \gamma$ coincidences and coversion coefficients of some low lying transitions in ^{81}Kr. New levels are proposed including a level at 50 KeV associated with the go/2 neutron orbital. The half-life of the 50 keV level was measured to be 4.0 $\pm$ 0.4 nsec.

4. <u>Equation of State for Interacting Neutron Fluid at High Temperatures</u> - B. Banerjee, S.M. Chitre and I. Ramarao - The equation of state of an interacting nucleon system at non-zero,

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temperature is needed in the study of shock wave phenomenon in high energy nucleus-nucleus collision and in supernova hydrodynamics. We have calculated the equation of state of a system of interacting neutrons treating them classically. This approximation is valid in the temperature and density ranges $6 \times 10^{10} - 10^{12}$ °k and $10^{11} - 3 \times 10^{14}$ g/cm^3, (relevant in supernova hydrodynamics) because the degeneracy parameter is small. The method used is to solve the hypernetted chain (HNC) integral equation satisfied by the radial distribution function. We have massumed the neutron-neutron interaction to be a spin-averaged Reid potential.

5. Three Body Correlations in Liquids - R.K. Tripathi and I. Ramarao - The three body correlation energies in liquid He have been calculated for the Frost-Musulin potential using momentum space methods in the Brueckner-Goldstone formulation. The methods employed are similar to those of Depp[1] and of Day Coester and Goodman[2] for nuclear matter. Near the density obtained in the fully self consistent two-body calculations, the three-hole line contributions to the binding energy are found to be small. These results will be compared with the corresponding co-ordinate space calculations in the literature.

1. J.G. Depp, Ph.D. Thesis, Carnegie-Mellong University (1969).
2. B.D. Day, F. Coester and A. Goodman, Phys. Rev. C6 1992 (1971).

SAHA INSTITUTE OF NUCLEAR PHYSICS, CALCUTTA 700 009.

1. Semimicroscopic Description of $^{103,105}Ru$.- S. Bhattacharya and S.K. Basu - The level schemes of ^{103}Ru and ^{105}Ru are calculated in the intermediate coupling version of the unified model in which the neutron quasi-particle motion in $2d_{5/2}$, $3s_{1/2}$, $1g_{7/2}$, $2d_{3/2}$ and $1h_{11/2}$ orbitals in the N = 50-82 shell is coupled to the quadrupole vibrations of the corresponding even Ru-core. The occupation and non-occupation probability factors for different single particle levels are calculated from stripping reaction data. The quasiparticle energies and the quasi-particle phonon interaction strength are tested as adjustable parameters. The calculated results are compared with the available experimental data for these nuclei.

2. Positive Parity States of ^{85}Kr - S.K. Basu and S. Bhattacharya - The positive parity states of ^{85}Kr are calculated in the framework of intermediate coupling version of the unified model in which the neutron quasiparticle motion in $1g_{9/2}$, $2d_{5/2}$, $3s_{1/2}$ and $2d_{3/2}$ orbitals is coupled to the quadrupole vibration of the even ^{84}Kr core. The quasiparticle energies, the occupation and non-occupation probability factors are obtained from stripping reaction data and are kept fixed in the calculation. The calculated energy spectra and spectroscopic factors have been found to be in reasonable agreement with those observed in recent (d,p) reaction experiment.

3. <u>Level Structure of Odd-A Cu Isotopes in the Particle - Phonon Coupling Model</u> - Rupayan Bhattacharya and K. Krishan - and R.K. Gauchait* - The low level structures of the odd-A Cu Isotopes have been reproduced using the phonon - particle coupling model, which couples the motion of a single proton with the vibration of the corresponding even Ni core- The so far available theoretical calculations for the odd-A Cu isotopes use too many parameters and it is very difficult to investigate which parameter compensates the effect of the other, However, the present calculations have the advantage of being almost parameter free, the obly parameter being the phonon-particle coupling strength. The reduced electromagnetic transition probabilities among the various low lying levels have also been reproduced.

4. <u>Effect of Non-Eikonal Propagation in Glauber Formula in Scattering of 1 GeV Protons by Deuterons</u> - S. Debi and S.K. Sharma - Recently we have derived corrections to the Glauber multiple scattering series due to non-eikonal propagation. The resulting expression has the advantage that it depends only on quantities which can be directly determined from experiments. The formula was also tested numerically for the case of two fixed coincident scattering centres. In this paper we present

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result of our calculation in a realistic situation of scattering of 1 GeV protons by deuteron. The results show sufficient improvement over Glauber results at large angles.

5. Correct Ions to Glauber Multiple Scattering Series due to Non-eikonal Propagation - S.K. Sharma and S. Debi - Several attempts have been made to include corrections due to non-eikonal propagation in the Glauber theory. In most of these calculations, the resulting formulae depend on the interaction potential between the particles which can be obtained only from a theoretical analysis of the experimental data. We present here an alternative derivation of corrections to the Glauber formula due to non-eikonal propagation. The result depends only on quantities which can be determined directly from experiments, namely, particle-particle scattering amplitude. As a numerical example we have considered scattering from two fixed coincident scattering centres. The results show considerable improvement over Glauber theory results at large angles.

6. A Study of the $^{12}C(p,\pi^-)^{14}O$ Reaction at 185 MeV - A. Choudhury and J. Mahalanabis - A simple model for the production of negative pions by a proton incident on ^{13}C is analysed. The process must necessarily be a two-nucleon mechanism with only the target neutrons participating. We therefore suppose that the incident proton first charge-exchange with any one of the target neutron in a two-body p-n reaction. The resulting neutron then decays via the usual

Chew-Low interaction into a π^- and proton, which is subsequently captured. The intermediate states of the process corresponds to the propagation of an excited N^{14}.

7. <u>A Theoretical Study of $\pi^{\pm}$ -Total Cross-sections of some Light Nuclei near the 3-3 Resonance Energy Region</u> - Jayanti Mahalanabis - The total cross-section for some light nuclei e.g. ^4He, ^6Li, ^7Li, ^9Be, ^{12}C and ^{16}O for positive and negative pion scattering have been obtained in the energy range 50-260 MeV. We have used a variety of optical models for the pions and have taken into account the Coulomb effects. Different forms of density distribution were considered. The importance of such calculations for odd mass nuclei and for iso-scalar nuclei with N=Z are wellknown. The effect of distortion of the Coulomb field was found to be important at low energies and Coulomb-nuclear interference was obtained. The results are studied together with the experimental data.

8. <u>An Impulse Model Calculation of $\pi^- - {}^4He$ Elastic Scattering Around the (3,3) Resonance</u> - J. Mahalanabis and A. Choudhury - The differencial cross-section data of Binon et al, for $\pi^- - {}^4He$ elastic scattering show the very novel feature that the position of the first minimum is independent of the pion incident energy, occuring at a fixed c.m. angle, in contrast to the $\pi^- - {}^{12}C$ data which has the first minima at a fixed t for all energies. Using the experimental π -N phase shifts and the r.m.s. radius of ^4He as the inputs, we have calculated the differential cross-sections

for $\pi^- - {}^4He$ in the impulse approximation, since as shown by Gibbs multiple-scattering corrections are not significant for energies above 100 MeV. Agreement with data is good, the first minima being reproduced at a fixed c.m. angle of the $\pi^- - {}^4He$ system for all energies.

9. Comparison of the Characteristics of Thermal Neutron Induced and Spontaneous Fission - Harashit Majumdar and Aparesh Chatterjee* - A comparative study, utilising our modified RGM formulation, of the fission energy partitions in the thermal neutron induced fission of 245Cm, 239 Pu and 251Cf and the spontaneous fission of 246Cm, 240Pu and 252Cf has been made and compared with some recent experimental results. After solving the modified RGM-PES energy balance equation for the spontaneous fission case, a semi-empirical formula for the partitioning of the additional excitation energy between the conjugate fragments was tried. Assumed excitation dependence of the RGM corrections and hence of the stiffness parameters and the scission point deformations of the nascent fragments introduces relative changes of the parameters over the spontaneous case. The calculated results for 245Cm(n,f) and 246Cm(s,f) and 239Pu(n,f) and 240Pu(s,f) showed good agreement with the recent experimental results. In all the cases studied the average total kinetic energy increase in the (n,f) cases is about 20% of the total additional excitation energy of the compound nucleus.

10. Relative Yields of Fragment Pairs in Spontaneous and Slow Neutron induced Fission in terms of Double Core Model - M.L. Chatterjee and K. Krishan - The mass and charge distributions of the fission fragments in spontaneous and slow neutron induced fission for several nuclei in the A = 230 to 256 and Z = 90 to 100 have been calculated using the double core model. It has been observed that the same set of core parameters reproduce the experimental yield curves both in charge and mass distributions for ^{230}Th, ^{234}U, ^{240}Pu, ^{246}Cm, ^{250}Cf and ^{256}Fm fissioning systems. The physical justification of the parameters occurring in the yield formula have been discussed in detail.

11. A Study of Nuclear Reaction in the Light of Statistical Mechanics - R. Bhattacharya and B.B. Baliga - An effort has been made to describe the process of nuclear reaction from the point of view of conditional probability approach using the well known Champman Kolmogorov equation and functional integration method. The final form of the equation reduces to a Fokker-Planck type of equation which includes dissipation (in a sense inelastic scattering) and diffusion which amounts to nucleon transfer in heavy ion induced reaction. As the final distribution depends only on the initial one, it is shown that the process is irreversible and produces minimum entropy.

12. <u>The Lipkin Model and Bloch States</u> - Ajoy Choudhuri and Binayak Dutta-Roy - It is shown that the Bloch or angular momentum 'coherent' states furnish a particularly efficacious basis for the discussion of the Lipkin model of the nucleus. The Hartree-Fock and the projected Hartree-Fock descriptions are elegantly obtained in this frame work. It is demonstrated that the monopole transition probability between the first excited and the ground state is proportional to the square of the number of "nucleons" and thus represents (in contrast to what obtains in the RPA approximation) a co-operativity of the super radiant type, thereby allowing contact between the aspect of collective phenomena in nuclear physics with a well studied area in atomic physics.

13. <u>Collective States in ^{18}O</u> - Nandita Rudra - The collective Hamiltonian consists of potential energy, vibrational kinetic energy and rotational kinetic energy. The first two quantities for ^{18}O were computed and reported earlier. The rotational moment of inertia is computed by cranking model formula and also by BCS theory and a comparison is made. Once the numerical Hamiltonian is set up the corresponding schrodinger equation for collective motion in β space is converted into a matrix from and solved numerically to obtain the collective states in ^{18}O. A rotation vibration coupling calculation is also done and both are compared.

ALIGARH MUSLIM UNIVERSITY, ALIGARH

1. Elastic Scattering of high-energy Protons on ^6Li -

I. Ahmed and Z.A. Khan - Glauber multiple scattering theory has been applied to calculate the elastic scattering of 600 and 1040 MeV protons on ^6Li in the α -d cluster model. It is shown that the model provides a very satisfactory account of the recent Saclay data. Predictions of two different wave functions for the relative motion of the α -and d- clusters which are consistent with the electron scattering experiments upto fairly large momentum transfers are also compared.

2. Statistical Analysis of Neutron-Reduced Widths -

H.M. Agrawal and M.L. Sehgal - The analysis of the distribution of experimental neutron-reduced widths by Porter and Thomas (1956) confirmed the X^2-distribution with degree of freedom 'ν' = 1. Since then a lot of new experimental data of neutron-reduced widths for low, intermediate and heavy mass nuclei with good energy resolution and fair statistical accuracy have accumulated. To analyse this experimental data, the "maximum liklihood method" has been used to determine the value of appropriate to individual nuclei. A departure from the Porter and Thomas distribution is established for many nuclei in mass regions $A \approx 55$ and $A \gtrsim 150$. Possible explanations for this departure are given on the basis of nuclear reaction theory as well as nuclear structure.

ALIGARH MUSLIM UNIVERSITY, ALIGARH

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3. <u>Compound Nucleus Contributions in the Differential and Double Differential Cross-sections for $^{24}Mg(d,p\gamma)^{25}Mg$</u> - S.R. Verma and Rajendra Prasad - The published angular distribution and angular correlation data (1,2) for the reaction $^{24}Mg(d,p\gamma)$ at 10 MeV show that the data can not be reproduced completely by DWBA calculations, particularly at backward angles. This may be due to the presence of compound nucleus reactions. The compound nucleus contributions have been calculated on the basis of Hauser-Feshbach theory and are added to those from DWBA. It is shown that satisfactory fits are obtained to the differential and double differential cross sections. Moreover Hauser-Feshbach calculations alone reproduce the cross sections of levels of spin $7/2^+$ and $9/2^+$ and double differential cross sections for $3\rightarrow0$ and $8\rightarrow3$ correlations. Thus it is possible to account for the strength of levels, which do not have the obvious direct stripping pattern, simply by compound nucleus processes.

1. U. Scheib et al, Nucl. Phys. A203, 177 (1973).
2. F. Vogler et al, Phys. Rev. C9, 242 (1974).

4. <u>K-electron Capture to Positron Emission Ratios for Allowed Transitions and Second Class Current</u> - M.A. Ansari and M.L. Sehgal - K-capture to positron emission ratios for allowed transitions have been calculated, considering the radiative correction and the effect of hole in the daughter atom. These theoretical values are compared with the available experimental

results. It is found that the values are higher than the experimental ones in high Z-region and this difference increases in a systematic manner. The disagreement is accounted for, by using shape correction factor when mesonic second class currents are taken into consideration. A Correlation between the $(K/\beta^+)_{Expt.}/(K/\beta^+)_{THEO}$ and positron energy has been discussed.

ANDHRA UNIVERSITY, WALTAIR

1. Pre-compound Decay in (n,2n) Reactions at 14.2 MeV. - N. Lakshmana Das, C.V. Srinivasa Rao, B.V. Thirumala Rao and J. Rama Rao - Total (n,2n) cross sections at 14.2 MeV have been measured in the heavy mass region using the mixed powder technique and high resolution Ge(Li) detector. The neutron irradiations were carried out at the Cascade Accelerator of Andhra University. The experimental values, in all cases, were found to be smaller than the predictions based on statistical theory of nuclear reactions. The discrepancies are attributable to the non-inclusion of pre-compound decay in the statistical model calculations. A tentative calculation of the pre-compound contribution using the Exciton, Hybrid and Unified models gives a magnitude which is consistent with the observed discrepancies.

2. Shape Factor Studies on Beta Transitions in Ga-72 and Pm-149 - T. Seshi Reddy, Rajan Mathews, B. Mallikarjuna Rao and K. Venkata Reddy - For the first time, shape factor analysis of the beta transitions in Pm-149 were carried out employing a thoroughly tested Siegbahn-Slatis beta-ray spectrometer. As there are discrepancies in the reported values, both in end point energy and shape factor coefficients, a reinvestigation of the shapes of the 3135 keV and 2529 keV beta transitions in Ga-72 were felt worthwhile. The results of the present measurements are given below:

Isotope	Energy (keV)	Shape factor coefficient
Pm-149	1062	a=-0.079±0.02
Pm-149	776	a= 0.01±0.02
Ga-72	3137	D= 6.5±1.2
Ga-72	2529	D=10.0±5.1

3. <u>($5/2^- \rightarrow 5/2^+$) 803 keV Beta Transition in Nd-147</u> - S. Lakshminarayana, M. Srinivasa Rao, V. Sesharigi Rao and D.L. Sastry - The existing experimental results on the $5/2^- \rightarrow 5/2^+$ 803 keV beta transition in Nd-147 are mutually contradictory to classify it under ξ -approximation. The earlier works did not take account of the attenuation in Correlation Coefficient A_2 due to the finite life time ($\approx$ 2.5 n secs.) of the intermediate level at 91 keV in the daughter nucleus Pm-147. In the present work, therefore, the $\beta - \gamma$ directional correlations as a function of energy are carefully performed using a conventional fast-slow coincidence scintillation system. The attenuation factor G_2 in this case turned out to be 0.64±0.05. The results on the longitudinal electron polarization and the shape measurements are combined with the present results and an attempt is made to extract the nuclear matrix elements governing this first forbidden non-unique beta transition following Sim's formalism.

4. Anomalous Shape of the First Forbidden Beta Transition of Ho-166 - K. Venkata Ramaniah, S. Bhuloka Reddy, M.V. Ramana Murty and K. Venkata Reddy - The anomalous shape of the $0^- \rightarrow 2^+$ beta transition in Ho-166 needs confirmation of such large deviation from unique first forbidden shape hitherto reported and a probable explanation is needed for this highly interesting transition. The shape of this transition in coincidence with 80 keV gamma is found to be anomalous with an estimated end point energy of 1771 ± 2 keV. A shape factor of $1+(1.6 \pm 0.03)W$ is required for its complete description in addition to its unique shape. The Nilsson model matrix elements explained the present shape in a satisfactory manner and also the shape is in accordance with the approximation of Abecasis and Krmpotic.

5. Internal Conversion Coefficients of Transitions in Co-59 - K. Venkata Ramaniah, S. Bhuloka Reddy, P.R.L. Sarma and K. Venkata Reddy - The K-conversion coefficients of the 141, 192, 334 and 1291 keV gamma transitions in the beta decay of Fe-59 have been determined. The internal conversion line in intensities are determined employing a thoroughly tested intermediate image beta ray spectrometer of Siegbahn-Slatis type at its best performance conditions after a suitable calibration of the spectrometer with standard conversion lines. The relative gamma intensities of

Narasimham[1] employing a 2cc Ge(Li) detector are employed. The conversion coefficients are dtermined through the relatively intense 1095 keV gamma transition with its pure E2 value of the K-conversion coefficient. The conversion coefficients are discussed with reference to the spins of different levels in Co-59.

1. K.L. Narasimham, Ph.D. Thesis, 1973, Andhra University, Waltair.

BANARAS HINDU UNIVERSITY, VARANASI

1. Coincidence Studies in the Decay of ^{134}Cs - Lakshman Chaturvedi - Gamma ray spectra in the decay of ^{134}Cs have been recorded with 32.2 cc coaxial Ge(Li) detector and 4096 channel analyser. Uncertain transitions of 1401, 1570, 1770 and 1970 keV have been studied carefully employing NaI(Tl)-NaI(Tl) sum-coincidence technique, in order to remove recent controvercies about the level structure of ^{134}Ba. Relative intensities of various gamma rays have been calculated and the values compared with earlier reported results. A modified level structure of ^{134}Ba have been proposed on the basis of the present measurements.

2. Description of the Highly Perturbed Rotational Band Levels in Odd-Proton Odd-Mass Rare Earth Nuclei - P.C. Joshi - Recently some rotational levels, which have been ascribed in literature as belonging to the $1/2^-(541)$ based rotational bands have been identified in odd-proton odd-mass deformed rare earth nuclei, The structure of these rotational levels is found to be quite complex in comparison to other K=1/2 band levels observed in this region. The usual phenomenological expressions, used in framework of the strong coupling scheme do not fit the level energies satisfactorily. In the present investigations we attempt to explain the structure of these bands in the framework of the rotation aligned coupling scheme. We assume these bands

to consist of two separate α (projection of j on the rotation axis) bands and discuss the decoupling nature of these α-bands by comparing their structure with the ground state rotational bands in neighbouring even-even nuclei. The usual phenomenological models are used to describe the level energies in these α-bands.

3. <u>The Pairing Attenuation Model Applied to the Even Even Nuclei in Actinide Range</u> - A.K. Jain - An exponential dependence of the moment of inertia on pairing correlations along with a simple pairing attenuation has been found to be extremely successful in describing the low as well as high spin yrast states (including the backbending region) of well-deformed even even nuclei in the rare-earth region. Such a description involves only two free parameters namely the moment of inertia at zero pairing and an effective pairing gap. The pairing attenuation model is here applied to fit the yrast band levels of actinide nuclei and the systematics of the parameters so obtained is studied. The model is also applied to fit the recently observed rotational bands in the secondary minimum and a comparison of the parameter values so obtained with those corresponding to the band in the first minimum is made.

4. <u>Physically Acceptable Eigenvalues in use for Hard Core Potentials</u> - C. Maheshwari - It has been shown that the

eigenvalues λ_n occurring in constructing a Unitary Pole Expansion for a local potential V should be such that the potential $\lambda_n V$ not only preserves the bound state pole in the s-matrix at the same energy but it should also preserve the effective range parameters of the original potential V. Based on this, it has been shown that the recently suggested negative zero eigenvalues in case of potentials with hard core are not acceptable as they do not satisfy the latter criterion. These eigenvalues are further discarded on the ground that they effectively demand binding from the hard-core region which is not justified. It has been re-emphasised that the hard-core should be treated using the Kowalski-Feldmann prescription.

5. <u>On the Validity of U.P.A. for Positive Energies for Hard-Core Exponential Potential</u> - Reeta Vyas and V.S. Mathur - Exact analytic expressions for the s-wave phase shifts and half-shell functions have been obtained in the case of exponential potentials with and without hard-core. The same quantities have also been computed in the Unitary Pole Approximation (UPA) to the same potentials. A comparison of the exact and UPA values of these quantities supports the contention that ~~UPA values of these quantities supports the contention that UPA~~ is a fairly good approximation at positive energies also, specially when the potential has an infinite repulsive core.

6. <u>Possible Separable form for Half Shell Functions Constructed entirely from Phase Shifts and Bound State</u> - C. Maheshwari and A.V. Lagu - Using the relation between the t-matrix and the scattering state an expression for the half shell function is derived avoiding the use of the underlying potential explicitly and instead using the phase-shifts and the bound state wave-function, in case potential admits a two body bound state. It has been shown that a reasonable break up of the actual scattering wavefunction $|\psi_k^\circ\rangle$ as

$$|\psi_k^\circ\rangle = |\chi_k^\circ\rangle + |\xi_k^\circ\rangle$$

where $|\chi_k^\circ\rangle$ is the scattering state obtained through the knowledge of the bound state alone via the method of UPA, leads to a separable form for the half-shell function. The field theoretic constraints on $|\psi_k^\circ\rangle$ can be incorporated in $|\xi_k^\circ\rangle$ in a simple manner. From these half-shell functions full t-matrix elements can be obtained without any difficulty.

7. <u>Conversion Coefficients and Multipolarities of the Transitions in 75As</u>.- Rajendra Prasad - The accurate intensity values of all the gamma transitions including the new ones observed[1] in the decay of 75 Sc using high resolution Ge(Li) detector, have been combined with proper literature data and conversion coefficients for various transitions have been determined. The multipolarities of some of the transitions have also been infered from the comparison of the

conversion coefficients with the theoretical values. The results for established transitions compare well with the literature values. These data and the half lives of some excited states, measured by others, have been used to calculate the transition rates in ^{75}As.

BERHAMPUR UNIVERSITY, BERHAMPUR

1. Study of Exotic nuclei with Skyrme Interaction - R. Nayak and L. Satpathy* - The stabilities (relative to nucleon emission) of highly neutron rich nuclei of He, C, O and Si are investigated in the frame-work of Hartree-Fock calculation employing varkous Skyrme interactions. It is shown that Hartree-Fock model as well as Skyrme interactions are suitable for the description of such exotic species far from the stability valley. The existence (in the sense of stability against decay with the emission of a neutron) of as yet undetected C^{20}, C^{22}, O^{28} and Si^{42} nuclei are predicted. The importance of the component of nucleon interaction in the triplet triplet state on the stability of neutron rich nuclei is demonstrated.

2. A Microscopic Triaxial Description of OS and PT Nuclei - R. Sahoo and M. Satpathy**, A. Ansari* and L. Satpathy* - We have developed a scheme to project good angular momentum states from a triaxial intrinsic wave function in an approximate way. Then using pairing + Q.G. interaction of Baranger and Kumar, we have performed Hartree-BCS calculation for triaxial shape coupled with variation after angular momentum projection to determine the equilibrium deformation parameters β and γ and the energies of each angular momentum states of the ground-state band as well as of γ-band of some Os and Pt isotopes. Preliminary results are in good agreement with experiment and also compare with those of Baranger and Kumar.

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BURDWAN UNIVERSITY, BURDWAN

1. Reaction Matrices for Two-Nucleon Scattering and Nuclear Matter - B.C. Baranta and J. Dey* - Half-off-shell reaction matrices for two nucleon scattering (R) and nuclear matter (G) have been calculated for two local potentials - The Reid soft core potential and the super soft core potential of de Tourreil, Rouben and Sprung for the $^1S_0$ state at different laboratory energies ($E_{lab} = 82.94^\circ k^2$ where k is the momentum in fm^{-1}) by the matrix inversion method. It is found that the magnitude of R is larger than that of G for lower k values whereas it is smaller for larger k values. In between, at a k value close to the most probable k in nuclear matter viz. 0.6 k_F where k_F is the fermi momentum, the two matrices are remarkably close to each other. With explicit inclusion of Δ (1236) resonance into the calculations, the half-off-shell behaviour of R and G matrices is also studied.

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CALCUTTA UNIVERSITY, CALCUTTA

1. Pairing-Plus-Surface-Tensor-Interaction: An Effective Interaction for f-p Shell Nuclei - D. Banerjee and I.K. Chakraberti - Different set of matrix elements for f-p shell nuclei obtained by empirical method, reaction-matrix method and phenomenological-interaction method are analysed. It is absolutely necessary to have average repulsion for $f_{7/2}$-$p_{3/2}$ matrix elements for good reproduction of experimental values. In particular, the $\langle f_{7/2} p_{3/2} J=5 | V_{12} | f_{7/2} p_{3/2} J=5 \rangle$ matrix element should be highly repulsive which indicates the triplet repulsion character of the effective interaction. Pairing-plus-surface-tensor-interaction which we have used extensively for shell-model calculations, more or less fulfils the above requirements. The form of the interaction is

$$V_{12} = -A\, q_{12} + B_T \left(\frac{r^2}{r_0^2} \right) \delta(r_1 - R_0)\, \delta(r_2 - R_0)\, S_{12}$$

where $$S_{12} = \left[\frac{(\vec{\sigma}_1 \cdot \vec{r})(\vec{\sigma}_2 \cdot \vec{r})}{r^2} - \frac{1}{3} (\vec{\sigma}_1 \cdot \vec{\sigma}_2) \right]$$

and the operator q_{12} is defined by its antisymmetrized matrix elements

$$\langle j_a j_b J M | q_{12} | j_c j_d J M \rangle = \left[(2j_a+1)(2j_c+1) \right]^{\frac{1}{2}} \delta_{j_a j_b} \delta_{j_c j_d} \delta_{J0}$$

2. An Anomaly in the Fission-Character of a-Decay and its 'α-Decay without Tunneling' Explanation - M.K. Basu - For some families of even-even α-emitters ($N > 138$, $Z \geqslant 92$), classified

according to the decay sequence (A,Z)-a (A-4,Z-2)-a , log-expt. a-decay $T_{1/2}$ decreases with increasing Z and also linearly with increasing Z^2/A; but for other families ($126 < N \leq 138$, $84 \leq Z \leq 92$), it increases with increasing Z and also linearly with increasing Z^2/A. So one notices an anomaly in the fission-charecter of a-decay[1], the anomaly being that in the former cases, Coulomb repulsive energy acts as the cause of a-decay, while in the latter it acts as a barrier. But in the same study, when repeated in the 'a-decay without tunneling' (ADWT)[2] model, log $T_{1/2}$ decreases linearly with increasing $E_{coul}(max)/E_{core}$, an ADWT parameter, for all the families, thus removing the anomaly. Again as $E_{coul}(max)/E_{core} > 1$ always for an a-emitter, it clearly demonstrates that Coulomb energy is always the cause of a-decay rather than a barrier to it.

1. M.K. Basu, Pramana 9, 149(1977).
2. M.K. Basu, Proc. Nucl. Phys. and Solid State Phys. Symp. 19A, 87 (1976).

3. Nuclear Matter Calculations by the Matrix Inversion Method - J. Dey and B.C. Samanta* - Matrix inversion in momentum space is a powerful method for solving the Lippmann-Schwinger equation in two-nucleon scattering and the Bethe-Goldetone equation in nuclear

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matter. However, the application of the method was limited to potentials having analytic form in momentum space. With careful numerical integration in co-ordinate space we have seen that the method can also be applied to potentials having no analytic form in momentum space. For this we have used the super soft core potential of de Tourreil, Rouben and Sprung which has a step function like core of about 200 MeV and a complicated structure. Recently the effect of Δ (1236) resonance on the binding and saturation of nuclear matter has been investigated by Green and Niskanen and others for the Reid soft core potentials. We have seen that the matrix inversion with numerical integration in co-ordinate space also works for the Reid potential when the effect of Δ (1236) is explicitly included into the calculations. The effect of Δ on the binding of nuclear matter using the super soft core potential has also been studied.

4. <u>Nuclear Matter Calculations using various non Local $^1S_0$ P-P Potentials</u> - S. Bhattacharya and M.K. Roy - To remove the knoll that appeared in their local p-p potentials Kermode and McKorrell[1] proposed several potentials with both local and non local parts which reproduce $^1S_0$ phase-shifts almost exactly. They took three simple forms for the non-local term $\lambda r^{\beta} e^{-\alpha r} r'^{\beta} e^{-\alpha r'}$ with β =-1,0 and +1 and α =2.1 fm^{-1}; λ is the nonlocal

strength. Here we use $\beta = -1$ and $\beta = +1$ with the corresponding local parts in nuclear matter calculations and compare the binding energy per particle in nuclear matter with those obtained previously[2] with $\beta = 0$.

1. McKerrell A and Kermode M.W., J. Phys. G: Nucl. Phys. V2 (1976), 375.
2. S. Bhattacharyya and M.K. Roy, Proc. Nucl. Phys. and Solid State Phys. Symposium, Ahmedabad, VI9B: Nucl. Phys. (1976), 237.

CALICUT UNIVERSITY, CALICUT.

1. Breathing Modes of ^{40}Ca and ^{208}Pb - P. Ramachan and S.C.K. Nair - A generator coordinate method (GCM) is applied for the study of the monopole modes in ^{40}Ca and ^{208}Pb using the Skyrme interaction. In the harmonic approximation a correction to the usual formula relating the breathing mode frequency and the compressibility coefficient is obtained for ^{40}Ca and this is of the order of 14% and the corrected frequency is 22.8 MeV. We have also observed that in our GCM only the particles in the major shell contribute significantly. The relationship between the GCM description and the RPA description, the dependence of the frequency on the details of the density dependence, in particular the possible $\rho^{2/3}$ and ρ dependence are being investigated.

D.A.V. POST GRADUATE COLLEGE, BULANDSHAHR

1. R-Matrix Approach to the Analysis of Neutron Scattering from ^{6}Li - M.C. Gupta and C.S. Shastry* - The differential cross section and Polarization are calculated for n-^{6}Li system in the energy range 0-5 MeV using the general R-matrix theory and replacing the inversion of the channel matrix $(1-RL^{o})$ by the inversion of a level matrix whose dimensions equal the number of proper levels λ of the compound nucleus ^{7}Li. The results are compared with the experimental results and a comparative study of our calculations has been made with the earlier calculations. Our calculations provide a simpler way for the analysis on n-^{6}Li resonance reaction in the energy range 0-5 MeV and also take into account the contribution of nondiagonal terms of the scattering matrix.

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HIMACHAL PRADESH UNIVERSITY, SIMLA.

1. A Two-Centre Model for Deformed Nuclei - S.D. Sharma and S.S. Chandel - Recent experiments[1] on high energy electron scattering from the deformed nuclei like ^{166}Er, ^{176}Pb, show that these nuclei cluster into two separate centres. We present a two-centre model for such deformed nuclei. A deformed nucleus is represented by a two-centre potential. The parameters needed in the study of high energy electron scattering from such nuclei, are calculated and suitability of the model is also studied. A method to obtain the differential scattering cross-section is also suggested.

1. T. Cooper et al., Phys. Rev. 13, 1083 (1976).

INDIAN ASSOCIATION FOR THE CULTIVATION OF SCIENCE CALCUTTA.

1. Higher Order Eikonal Approximation in Scattering T-matrix - S. Sarkar and Sofia Khatun - We have calculated some higher order terms to be considered along with the eikonal phase corrections (for scattering T-matrix) of Wallace to Glauber's results in order to deal with large angle potential scattering more satisfactorily. Wallace has considered phase correction terms correctly through 3rd order in inverse momentum. We have extended it by calculating phase corrections involving V^2 type terms (in which potential V occurs in 2nd order) through 4th order to 7th order in inverse momentum. Phase corrections involving V^3 type terms of fourth order have also been determined. Wallace's results, though quite good for smoothly varying potential is not so satisfactory (for large angle scattering) for rapidly varying potential like Gaussian type or for potential producing diffractive differential scattering e.g. Wood Saxon potential. In these causes inclusion of additional phase correction terms, having increasing number of oscillations over the range of impact parameter, makes our formula more satisfactory for larger scattering angle associated with increased number of diffraction minimum. We have also investigated differential cross section and polarization when optical model for potential is used.

2. <u>Angular Distribution and Circular Polarization of γ-rays Emitted from Electroexcited Deformed Nuclei</u> - S. Sarkar and Sofia Khatun - We investigate angular distribution and circular polarization $C_{J_f \to J'}(\theta_\gamma, \beta)$ of γ rays emitted in the transition of a nucleus from spin state J_f (electro-excited from the oriented ground state J_i) to state J' and also $C_{J' \to J_i}(\theta_\gamma, \theta'_\gamma, \beta)$ of possible second γ -ray emitted from the nuclear state J'. Here θ_γ, θ'_γ are the emission angles of 1st and possible 2nd γ-rays respectively and β is the angle between the electron momentum transfer and the orientation direction of the nucleus. We have determined the statistical tensors, $f_z^{J_f}$ (describing the orientation state of nuclei) in terms of $f_z^{J_i}$'s (appropriate, for oriented ground state of nucleus) and also $f_z^{J'}$'s as required for above processes. We have noted that for fully polarized electron and initially unoriented nucleus $C_{J_f \to J'}(\theta_\gamma, \beta)$ is nonvanishing when we use eikonal approximation instead of Born approx. to calculate $f_z^{J_f}$'s. When initially the nucleus in the state J_i was fully oriented and $\beta = 0$ the expression for $C_{J_f \to J_i}(\beta = 0, \theta_\gamma = 0)$ indicates complete polarization of γ-rays emitted in the forward direction ($\theta_\gamma = 0$). Further $C_{J' \to J_i}(\theta_\gamma = 0, \theta'_\gamma = 0, \beta = 0)$ of possible second γ-ray is found to be complete when the 1st γ-ray is completely right circularly polarized.

3. <u>Four-Body Equations for one Distinct and Three Identical Particles</u> - H. Roy-Choudhury and V.P. Gautam and D.P. Sural*

In the present work we have investigated, with the Faddeev-Yakubovsky (FY) approach, the problem of a four-body system consisting of three identical particles and the fourth one quite distinct from the rest of the three. Unlike the case of four identical particles, the symmetry properties of the system in our problem are quite different. The dynamical equations in momentum representation for the four-body system - one distinct and three identical particles are obtained in FY formalism. In this case the number of coupled integral equations turns out to be five. Partial wave reduction of these equations has also been made for two-body separable s-wave interactions. The set of equations obtained by us will be useful for studying the corresponding four-body systems in the same way as FY equations derived for the four identical particle case in the momentum representation, have been used for obtaining numerical results with different approximations at two-body and three-body levels. Our non-variational dynamical equations will be useful to study the systems e.g. $^{13}_{\Lambda}C$, $^{4}_{\Lambda}H$, $^{4}_{\Lambda}He$ etc.

INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY

1. Absolute Internal Conversion Coefficient Measurements of Some Transitions in the Decay ^{228}Ac - ^{228}Th - M.S. Bidarkundi and A.S. Mahajan - The absolute internal conversion coefficients of the following transitions have been measured in the decay of ^{228}Ac: α_K values for the 204.1-, 270.3-, 328.0-, 338.0-, 409.4 and 463.0- keV transitions; L subshell α values for the 57.76-, 99.45-, 129.1-, and 184.6- keV transitions. The gamma spectrum was observed with a 20 c.c Ge(Li) detector and the conversion electron spectra were observed using a $\sqrt{2}$ double focussing β-spectrometer with a resolution of 0.1% or better. The theoretical value of α_{LIII} for the 129.1 keV transition was used for reference. In a few cases where earlier results are available, our results are in agreement with these. For the remaining transitions, absolute conversion coefficients are being reported for the first time.

2. Generalized Broken Pair Formalism as an Approximation to Seniority Shell Model - Y.K. Gambhir, S. Haq and J.K. Suri - The Broken Pair Approximation (BPA) is extended to include the cases where both neutrons and protons are present in the valence shell. As a first approximation the ground state is assumed to be a product of proton pair (similar to the projected BCS) state and a similar neutron pair state. The ground state parameters for protons and neutrons are determined independently

by minimizing the Hamiltonian with respect to the respective proton pair and neutron pair states. The basis space is then constructed by replacing one of the proton distributed pair by an arbitrary two proton configuration and a similar replacement for the neutron part. The basis states contain all the components with seniority (ν) zero, two and four except $\nu = 4$ for only protons and $\nu = 4$ for only neutrons. All the relevant expressions required in the energy and transition rate calculations have been derived. For the case of four-particles (two-protons and two-neutrons) the formalism becomes identical to the exact shell-model. To test the computer code, the exact shell-model results of ^{92}Zr (with two-protons restricted to the $2p_{1/2}$, $1g_{9/2}$ orbitals and two valence neutrons confined to the $2d_{5/2}$, $3s_{1/2}$ orbitals) are reproduced.

3. <u>Effective Matrix Elements and the Truncation of the Configuration Space</u> - Y.K. Gambhir and G. Basavaraju - The effect of the truncation of the $1d_{3/2}$ shell is investigated on the effective matrix elements (m.e.) in the 2s-1d shell by the perturbation method and the projection method. It is shown that for the case of two valence particles the projection method is equivalent to summing up all the diagrams of the perturbative expansion. The renormalized Hamiltonian is no longer Hermitian. The non-Hermiticity is small. Procedures for making the Hamiltonian in the truncated space Hermitian are examined. Two sets

of m.e. viz. those of Vary and Yang derived from the Reid Soft core potential corrected for core polarization effects and the phenomenological set of Chung and Wildenthal, are used. The mee. in the truncated space are found to be similar to the corresponding phenomenological m.e. The Hartree-Fock calculation for $^{20,22,24}Ne$ are performed in the full space and the truncated space with the corresponding m.e.

4. Tabakin Interaction Matrix-Elements in 2p-1f Region - Y.K. Gambhir - Nonlocal separable potential in each partial wave ($l \leq 2$) of Tabakin is used to calculate the effective interaction matrix-elements (m.e.) in the Harmonic-oscillator basis appropriate to the structure calculations for 2p-1f shell nuclei. Two types of second-order corrections are incorporated by perturbation theory. The first is the second-order Born term in which plane-wave intermediate states are used. It corresponds to the scattering to the very high lying($\simeq$ 130 MeV) intermediate states. These corrections are found to be important for T = 0 m.e. in general and for the $^3p_1$(T=1) state, the maximum contribution being 25% of the bare-term. In the second the core-polarisation corrections are included with 3-particle 1-hole (3p-1h) intermediate states. Two cores (^{40}Ca and ^{56}Ni) are used separately. For the ^{56}Ni core, six hole-states ($0p_{3/2}, 0p_{1/2}, 0d_{5/2}, 1s_{1/2}, 0d_{3/2}, 0f_{7/2}$) and eight particle states ($1p_{3/2}, 0f_{5/2}, 1p_{1/2}, 0g_{9/2}, 1d_{5/2}, 0g_{7/2}, 2s_{1/2}, 1d_{3/2}$) are used while for the ^{40}Ca case the only difference is that the

of $_{1/2}$ state is excluded from the hole states. The calculated m.e. are compared with the corresponding m.e. in this region calculated by Kuo and Brown using Hamada-Johnson hard core potential, and are found to be similar.

INDIAN INSTITUTE OF TECHNOLOGY, KANPUR.

1. Positive Pion Absorption by Carbon-12 - N. Chandrasekhar and Y.R. Waghmare - The process of free pion absorption by ^{12}C with the emission of single nucleon at the pion kinetic energy of 70 MeV has been studied. The previous attempts ignoring the pion distortion due to strong interactions have not given very satisfactory results.

In this work thermolear wave functions are taken to be Hartree-Fock wave functions based on (hard core) realistic interaction which take into account some effects of short range correlations. The emitted proton energy being nearly 167 MeV, its distortion has been included through the high energy Glauber approximation. Pion wave functions are obtained by solving the Klein-Gordan equation with different pion-nucleous optical potentials. Three different π-nucleus potentials, the Kisslinger form, the local (Laplacian) form and the modified Kisslinger form have been employed, and the results are compared.

2. Yields and Energy Spectra of LCP in Low-Energy Neutron Induced Fission of ^{239}Pu - B. Krishnarajulu, S. Sen and G.K. Mehta - The yields of light-charged-particles (LCP) emitted in the fission of ^{239}Pu have been measured in the neutron energy range of 100 keV to 1 MeV. An ionisation chamber was

used to detect the fission fragments in coincidence with the LCP which were detected by a solid-state detector.

The yield of long-range-alpha particles (LRA) shows an increase of about 7% over that for thermal fission in the neutron energy region around 200 keV and a drop of about 14% between 250 and 300 keV. The extracted 'triton' yield shows an increase over the thermal value in the energy region 200-400 keV. These results are compared with ^{235}U results obtained earlier (1) and are analysed in terms of the properties of the Saddle-point states (channels).

1. B. Krishnarajulu, G.K. Mehta, R.K. Choudhury, D.M. Nadkarni an and S.S. Kapoor, Pramana 8, 315 (1977).

3. Isospin-Structure of Giant States of ^{16}O - R.S. Bhalerao and A.K. Singh - Brueckner-Random-Phase approximation calculations of the 1^-, 2^+ and 3^- giant states of ^{16}O were reported recently*. Hamada-Johnston potential was used in these calculations and the particle-hole interaction was constructed using the Landau Theory. We have studied the isospin-structure of these states and it is found to depend on the interaction used.

* Y.R. Waghmare, Pramana 8 (1977) 7.

INSTITUTE OF PHYSICS, BHUBANESWAR

1. Hartree-Fock Equations with Large K Quantum Number - C.R. Praharaj - Hartree-Fock equations are written with a J^2 constraint term added to the nuclear Hamiltonian. It is shown how to obtain self-consistent solutions of these equations, retaining axial symmetry but without time-reversal symmetry are evaluated. $K \neq 0$ self-consistent solution of these equations obtained.

KURUKSHETRA UNIVERSITY, KURUKSHETRA

1. Analysis of Neutron Elastic and Inelastic Scattering From ^{186}W, ^{238}U - A.B. Kulkarni and N. Nath - Differential elastic and inelastic cross sections for neutron scattering by ^{186}W and ^{238}U have been analysed in the energy range 0.50 to 3.0 MeV. Calculations were performed in terms of Optical Model, Hauser-Feshbach theory and adiabatic coupled channel theory. Both compound nucleus (CN) and Direct Reactions (DI) are likely to contribute to the cross-sections over the neutron energy range considered. The onset of DI mechanism is seen to be significant even at lower energies. The contribution of CN process is estimated in terms of Wilmore-Hodgson's parameters R. The resulting theoretical predictions are found to be in good agreement with available experimental data for both elastic and inelastic channels.

2. Neutron Elastic and Inelastic Scattering from ^{140}Ce - A.B. Kulkarni and N. Nath - Differential elastic cross sections for neutron scattering (En=0.78, 1.511, 2.014, 3.2 and 5.0 MeV) by ^{140}Ce have been analysed in terms of optical model, Hauser-Feshbach theory and Adiabatic Coupled channel theory. Both compound nucleus (CN) and direct interaction (DI) mechanisms are likely to contribute over the neutron energy range considered. The contribution of CN process is estimated in terms of

Wilmore-Hadgson's parameter R. It is found that the shape elastic (from optical model calculation) and compound elastic (from Hauser-Feshbach calculations) with proper admixture, give good fit to elastic data without recourse to adiabatic coupled-channel calculations thus indicating minor deformation in the ground state configuration. Also the differential inelastic cross section and the excitation function for the 2^+ and 4^+ levels are predicted.

3. Evaluation of Neutron Induced Cross-sections - H.C. Sharma, Ram Raj and N. Nath - The evaluation of some neutron induced reaction cross sections at low energies (upto 2.5 eV) for a number of nuclei in various regions of the periodic table have been carried out using the Hauser-Feshbach and Moldauer formalisms. The results are compared with available experimental data with a view to ascertain the validity of the nuclear reaction theories in different mass regions. Conclusions are deduced from the point of nuclear reactor design and basic nuclear spectroscopic information.

4. Calculated Energy & Angular Distributions of $Ni^{58}(n,p)$ Reaction at 14 MeV - R.K. Mohindra and Nirmal Singh. - The energy and angular distributions of the emitted protons from $Ni^{58}(n,p)$ reaction at 14 MeV neutron energy have been computed using

Newton's shell dependent level density formula with dependence on spin cut off parameter ($2\sigma^2$) and spin. The calculated angular distributions are depicted in mb/sr for direct comparison with the observed angular distributions in different energy regions. The spectra computed for $2\sigma^2 = 10$, gives fairly good agreement with the recent experimental data[1,2].

1. Alver et al; Nucl. Phys. A 195 (1972) 289.

2. Douglas & McDonald; Nucl. Phys. 13(1959) 382.

5. <u>Internal Bremsstrahlung (I.B.) Measurements in ^{45}Ca using Ge(Li) Detector</u> - Ganga Ram, Nirmal Singh and N. Nath - Measurements on the I.B. spectrum of ^{45}Ca using NaI(Tl) detectors have been reported earlier. We decide to re-investigate this standard I.B. radioisotope in order to improve upon the available experimental data through the use of high resolution Ge(Li) detector. We used a 4.2 c.c. Ge(Li) detector having 3.736 keV resolution for 661 keV γ-ray. The absolute peak efficiencies were measured using calibrated sources for a 10 cms. source to detector distance used in the experiment. I.B. Spectrum of ^{45}Ca radioisotope was measured and was found to be consistant with the Lewis & Ford theory. The results indicated higher contributions than predicted by the modified KUB theory in the higher energy portion of I.B. spectrum.

KASHMIR UNIVERSITY, SRINAGAR

1. Gamma-Gamma Directional Correlation Measurements in ^{129}I - Ayub Thuker and N.N. Raina - Gamma-gamma directional correlation measurements have been performed on the following cascades in ^{129}I, using conventional fast slow coincidence spectrometer. The expansion coefficients after applying solid angle corrections are:

(459.40 - 27.77)keV : $A_2 = -(0.0117 \pm 0.0010)$,

$A_4 = -(0.0061 \pm 0.0022)$

(1083.99 - 27.77)keV : $A_2 = -(0.0201 \pm 0.0021)$,

$A_4 = -(0.0034 \pm 0.0029)$.

Our A_2 value for the (459.60 - 27.77) keV cascade appears to be attenuated which has been confirmed from the recent time differential perturbed angular correlation measurements in which the existence of extranuclear perturbation has been established. Mixing ratio for the 1083.99 keV transition has also been estimated after allowing for the extranuclear perturbation of the (1083.99 - 27.77) keV cascade and a spin 7/2 has been assigned to the 1111.75 keV level in ^{129}I for which some uncertainty existed.

K.G.K. COLLEGE, MORADABAD

1. Nuclear Matter Test for a Separable Non-local N-N Interaction - M.I. Sharma & Lal Singh - A nuclear matter test has been conducted on a separable non-local n-n interaction proposed by Sirohi and Sriwastava. This potential is being studied because of its unique feature in the off-shell behaviour which is similar (Oscillatory) to that of a local potential. The potential had been constructed by fitting the phase-shifts and its off-shell behaviour and accuracy in UPA had already been studied. The purpose of the present study is to be whether it can also reproduce the correct nuclear matter parameters. The results obtained are extremely good especially in case of B.E. These are comparable to Tabakins ones in each partial wave. Binding energy per particle is 19.4 MeV and symmetry energy coefficient is 66.5 MeV. at Kf = 1.65 fm^{-1}. The single particle potentials generated out of this NLSI has in general the same shape as the one obtained through Tabakin potential. Finally as test of non-locality we have calculated the integrated photo absorption cross section parameter h where $\sigma_{int} = 60 \frac{NK}{A} (1+h)$ The value of h comes to be 1.03 and is in agreement with the other reported values.

MARATHAWADA UNIVERSITY, AURANGABAD

1. Electromagnetic Properties of 1181 keV state in ^{123}Sb - P.N. Patravale* and R.G. Kulkarni - The positive parity 1181 keV state in ^{123}Sb was Coulomb excited with 3.0 to 4.5 MeV protons from the BARC Van-de-Graaff Accelerator. A Ge(Li) detector was used in measuring gamma ray yields at various energies. Gamma ray angular distribution measurements taken at Ep = 3.5 MeV establish spin value of 5/2 or 7/2 for the 1181 keV state. A B(E2) ↕ value of 85±8 e^2f^4 has been found for the first time to this 1181 keV state in ^{123}Sb. The $B(M_1)\downarrow$ values obtained for the 5/2 and 7/2 spin are 0.0726±0.0068$(nm)^2$ and 5.3800±0.5000 $(nm)^2$, respectively.

2. Gamma-Gamma Angular Correlation of 1355 - 603 keV Cascade in ^{124}Te - D.P. Navalkele, K. Andhradev and R.G. Kulkarni - The spin-parity of 1957 keV level in ^{124}Te has been assigned to be 2^+ and 4^+ by different investigators. To remove this controversy, the directional correlation of 1355-603 keV cascade has been measured at increments of 10° from 90° to 180° using two NaI(Tl) detectors. The observed correlation function is

$$W(\theta) = 1+(0.052\pm0.003)\ P2\ (\cos\theta) + (0.015\pm0.005)\ P4\ (\cos\theta).$$

The present work favours 2^+ instead 4^+.

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* HPT Arts and RYK Science College, Nasik.

3. <u>Coulomb Excitation of 2.73 MeV Level in ^{27}Al</u> -

V.N. Kulkarni, P.N. Patrawale*, V.U. Patil and R.K. Kulkarni -

The level at 2.73 MeV in ^{27}Al has been Coulomb excited for the first time with 2.5 - 3.0 MeV protons from BARC Van de Graaff accelerator. The gamma ray yield was measured with a 30 cm^3 Ge(Li) detector. The B(E2) value determined for this level is 20 $\pm$ 2.8 e^2f^4. The present B(E2) value compares very well with theoretically calculated value obtained from the excited core model.

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* HPT Arts and RYK Science College, Nasik.

NORTH EASTERN HILL UNIVERSITY, SHILLONG

1. The Intrinsic State as a sum of two Determinants for a Degenerate Hartree-Fock Problem - R. Shanker and C.S. Warke* and K.K. Gupta - The lowest deformed Hartree-Fock (H.F.) solutions of the 4n-2s-1d shell nuclei are approximately doubly degenerate, a typical example being ^{28}Si. The projected spectra from one of these degenerate H.F. (i.e.; the oblate) solutions of this nucleus is in violent disagreement with the observed states. This points to the construction of an Intrinsic state as a sum of two Slater determinants (I.S.T.D.), which could break the degeneracy. The previous results obtained in a model I.S.T.D. calculation have encouraged us to apply the fully self-consistent (S.C.) I.S.T.D. theory to ^{28}Si. Firstly an I.S.T.D. is chosen with Nilsson-orbitals as the single-particle orbits and the energy is minimised in the I.S.T.D. by varying the two quadrupole deformations and one mixing variable. Then using the formalism of B. Bremond this problem is solved in a fully S.C. way by the method of diagonalizing coupled S.C. Hamiltonians. The results of the S.C. calculation tallies with that of Nilsson-Slater Determinants. In either case the energy is not lowered substantially below the H.F. value.

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* T.I.F.R., Bombay-5.

PHYSICAL RESEARCH LABORATORY, AHMEDABAD

1. Single Particle Separation Energies in the Density Dependent Hartree-Fock Theory - V.B. Kamble and S.B. Khadkikar -

Koopman's theorem strictly holds when the Hamiltonian does not explicitly depend on the particle number A. When the centre-of-mass motion is incorporated or a density dependent interaction is used, the Hamiltonian depends on A. In this case Koopman's theorem no longer holds and the separation energies are different from Hartree-Fock (HF) single particle energies. We show this by using the band-averaged scalar density dependent two-body Skyrme interaction (S.B. Khadkikar and V.B. Kamble, Phys. Lett. 65B (1976) 131). We derive expressions for the HF single particle and separation energies and compare with the expressions of Vautherin and Brink (Phys.Rev. C5 (1972)626) who use three-body contact Skyrme force rather than the equivalent two body density dependent interaction for even-even nuclei. Our expression for HF single particle energies is identical with that of Vautherin and Brink and so with their separation energies, however our expression for separation energies is different.

2. A Note on Pairing with Skyrme Interaction - V.B. Kamble and S.B. Khadkikar - The Skyrme interaction has been quite successful in reproducing bulk properties of nuclei all over the periodic table. However, before applying it to calculate the spectroscopic properties of nuclei, it is necessary to test the suitability of

the interaction for that purpose. Sharp and Zemick report that the pairing matrix element ($of_{7/2}$) gives a repulsive value for the J=0, T=1 and higher states and thus it would lead to an unphysical energy spectrum for ^{42}Ca, It is therefore necessary to check the pairing matrix elements for Skyrme interaction. We show that the difficulty raised by Sharp and Zamick can be overcome by a proper choice of the oscillator parameter b. The m.e. of various parts of the Skyrme interaction have a strong b dependence. There is a competition between the s-state attractive and s-state repulsive m.e. which leads to the pairing or antipairing property of the m.e. For b value larger than the critical b value, the total m.e. becomes attractive. It is therefore necessary to optimize b for every nucleus in question before proceeding to the calculation of nuclear properties. We discuss the behaviour of the matrix elements $(os1/2)^2$, $(op3/2)^2$, $(od5/2)^2$ and $(of7/2)^2$ with J=0, T=1 as a function of the oscillator parameter b.

3. <u>Angular Momentum Projected Spectrum of Hg^{188}</u> - S.B. Khadkikar and C.R. Praharaj* - The spectrum of the neutron-deficient Hg^{188} nucleus has been calculated by projecting good angular momentum states from the Oblate Hartree-Fock solution and particle-hole excitations on it and by mixing bands. Two

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* Institute of Physics, Bhubaheswar.

lowlying bands are obtained after orthonormalisation, in reasonable agreement with experiment. The starting single-particle energies are chosen so as to reproduce the single-particle spectrum near Pb^{208}. A Surface Delta force has been used in the calculation.

4. Fine Structure in Mass Distribution for Low Energy Fission of U to Cf Isotopes - M.N. Rao - The fission yields in the mass-region A = 131-136 determined mass-spectrometrically in spontaneous and thermal neutron-induced fission of U,Np,Pu,Am,Cm and Cf isotopes are analysed with a view to study fine structure effects in low energy fission. It is shown that the 134/136 ratio (indicator of fine structure effects in mass distribution) decreases with increasing mass of the fissioning nucleus, A_F, from uranium to americium isotopes. Also for a given Z, this ratio decreases as A_F increases. As this decreasing trend is found to hold good till americium isotopes, it is expected that a similar trend is followed in the neighbouring curium isotopes. In cases where mass-spectrometric data are not available in the mass-range A = 131-136, these yields were obtained from the radiochemical/ γ-ray spectrometric measurements where the quoted errors are not more than 5%. These data suggest that fine structure effect follows a decreasing trend from U-Cf isotopes and is unlikely to show a "fine structure spike" in Cm-248 spontaneous fission, in the same way as the U-235 thermal neutron-induced fission shows.

5. SU(6) ⊗ SU(4) Tensor Decomposition of Interactions in S-D Shell and Calculation of SU(4) Mixing Ratios -

M. Chakraborty, V.K.B. Kota and J.C. Parikh - We have decomposed two-body interactions in s-d shell into [SU(6) ⊃ SU(3)] ⊗ SU(4) tensors using Draayer's [1] formalism. These tensors are further recoupled via SU(6) ⊃ SU(3) cfp's to give SU(6) ⊗ SU(4) tensor decomposition of various s-d shell interactions. These coupled tensors are used to calculate, directly (2), the necessary inputs for SU(4) widths propagation. This method avoids the lengthy shell model calculations needed for the evaluation of the inputs, as being conventionally done, Using the codes developed for evaluating SU(4) partial widths, we have studied the mixing ratios of various SU(4) representations for A=20-36 nuclei using Rosenfeld and Preedom-Wildenthal matrix elements.

1. J.P. Draayer, Nucl. Phys. A216 (1973) 457.
2. K.T. Hecht and J.P. Draayer, Nucl. Phys. A223 (1974) 285;
   K.T. Hecht, J. of Math. Phys. 15 (1974) 2148.

6. Eigenvalue Density and Spacing Distributions for Ensemble of Two-body Random Hamiltonians - V. Potbhare and V.K.B. Kota - The results of Monte-carlo calculations for iso-scalar, rotationally invariant 2-body ensembles have been obtained in 4-particle, J=2, T=0 (56 dimensional) space in d-s shell. The changes in the eiganvalue density function with respect to the mean value of the two-body matrix elements can be seen. The spacing distribution, however, retains the characteristic

shape; viz. the Wigner distribution.

7. Eigenvalue-Density for Ensemble of k-Body Random Hamiltonians - V.K.B. Kota and V. Potbhare - We obtained an expression for the ensemble-averaged moments in m-particle space of k-body random Hamiltonians with same non-zero mean for the matrix elements, in the limit $N \to \infty$. The eigenvalue density function can then be immediately obtained in terms of the eigenvalue density for zero mean ensembles. The eigenvalue density goes over into a sum of two semi-circles for $m = k$ from a sum of two Gaussians for $m \gg k$.

8. Enhanced Isospin Dependence of the Particle-Hole Effective Interaction - D.P. Ahalpara and K.H. Bhatt - In the simple effect interaction method of using empirical effective interaction matrix elements as deduced from the spectra of two particle like nuclei one finds that the separation between T=0 and T=1 centroids of the interaction which reasonably fit the multi-particle spectra is large for particle hole interaction as compared to particle-particle interaction (1,2).

This puzzling feature is understood in terms of the general framework of effective interaction theory to arise as a result of truncation from the full $(s-d)^2$ or $(f-p)^2$ shell space to the $(d_{5/2})^2$, $(f_{7/2})^2$ or $(d_{3/2}^{-1}\, f_{7/2})$ space.

1. Phy. Lett. 11, 145 (1964) R.K. Bansal and J.B. French.
2. Ann. of Phys. 77, 230 (1973) L. Zamick.

9. Collective Bands of Hole States in $f_{7/2}$ Nuclei - D.P. Ahalpara - Several odd-A $f_{7/2}$ shell nuclei have displayed low-lying positive parity states forming into band of collective states. With the recent availability of empirical effective interaction matrix elements in the $(d_{3/2} - f_{7/2})^2$ space it is interesting to see whether it reproduces the observed energy systematics of hole states in $f_{7/2}$ shell nuclei. In the framework of deformed Hartree-Fock theory we have obtained the energy spectra from the lowest energy intrinsic states with one hole configurations in a Q_0^2 field. We find that the bands of positive parity states in Ti^{45}, $V^{47,48,49}$ and Mn^{51} are in reasonable agreement with experiment.

10. On the High-Spin Yrast Cascade in ^{60}Ni - V. Potbhare, S.K. Sharma and S.P. Pandya - Shell model calculations for ^{60}Ni in the space of f 3/2, p3/2, p1/2 and g9/2 orbits, have been done using an effective interaction renormalized with respect to ^{56}Ni core. The role played by the g9/2 orbit in the recently observed anomalous high-spin Yrast cascade $(9 \rightarrow 7 \rightarrow 6 \rightarrow 4^+ \rightarrow 2^+ \rightarrow 0^+)$ is examined. The high-spin sequence is correctly reproduced. A number of electromagnetic transitions are predicted.

PUNJAB UNIVERSITY, CHANDIGARH

1. Effective Two Body Interaction from Nuclear Spectra -

R.P. Singh and R.K. Bansal - Calculations of nuclear structure properties with model interaction due to Kuo-Brown and other[1] types, do not often seem to reproduce, the absolute magnitudes of energies, although the general feature of the spectra and transition rates are reproduced. Thus there seems to be a need of a phenomenological potential which when used in structure calculations would produce better agreements between the calculations and the experimental data.

An attempt in this direction has been made by choosing a, seven parameter two-body, potential of the type

$$V(r) = [V_0 + V_\sigma(\sigma_1\cdot\sigma_2) + V_\tau(\tau_1\cdot\tau_2) + V_{\sigma\tau}(\sigma_1\cdot\sigma_2)(\tau_1\cdot\tau_2) + V_{LS}\, L\cdot S + V_T\, S_{12}]\, e^{-r/R}/r/R$$

Experimental data of the two body spectra, from all available sources, has been exploited to calculate the values of V_0, V_σ, V_τ, V_{LS}, $V_{\sigma\tau}$ and V_T, for a finite range, R, of 2.0. Fermis. The least square fitted parameters are re-employed to re-caloulate the experimental spectra. The values of the two-body potential parameters are obtained.

1. S. Shelly, Ph.D. Thesis, Panjab University, May, 1976.

2. <u>Energies and Life Times of the Levels in Si^{28}</u> - V.K. Mittal, D.K. Avasthi, and L.M. Govil - The energy levels of Si^{28} have been measured using $Al^{27}(p,\gamma)Si^{28}$ reaction. The capture γ-ray spectrum was taken for the protons at different energies. The resonance was observed at 2046 keV Proton Energy.

At this energy, the γ-rays were detected using ORTEC 55 cc. Ge(Li) detector at two angles viz 0° and 120°. The lifetimes of the various levels were derived using Doppler Shift Attenuation Technique. The life times of the excited states at E_n (MeV) = 4.78, 4.62, 6.23, 6.38, 7.42, 9.93, 10.42, 10.60, 10.72, 10.95, 11.10, 13.56 have been measured. Lifetimes of some of the levels are reported earlier and are in close agreement with our measurements while the lifetimes of excited states at E_n(MeV) = 6.23, 9.93, 10.95, 11.10 and 13.56 are the new measurements.

3. <u>Angular Distributions of Protons and γ-Rays in $^{27}Al(p,p'\gamma)^{27}Al$ Reaction at 2.5 and 4.0 MeV</u> - K.P. Singh, S.C. Gupta, D.C. Tayal, B.K. Arora, T.S. Cheema and H.S. Hans - An experiment on proton scattering from aluminium target has been performed at 2.5 to 4.0 MeV proton energies. Angular distributions of proton elastic and inelastic scattering have been measured from 30° to 160° at an interval of 10° with a

solid state detector of $50mm^2$ active area and 300 micron thickness. In addition the angular distributions of some strong γ-ray transitions have also been measured with a 50 c.c.Ge(Li) detector. The results of the above experiment are analysed in terms of the plausible reaction mechanism for proton scattering at these energies.

4. Energy Intensity and Angular Correlation Measurements for Various Transitions in the Decay of Ag-^{110}m - H.R. Verma, A.K. Sharma, Ravinder Kaur, K.K. Suri and P.N. Trehan - The decay of ^{110m}Ag to the levels of ^{110}Cd has been investigated using 64.1 cc Ge(Li) and 3" x 3" NaI(Tl) detectors alongwith 4096 channel analyser in singles and coincidence modes. The existence of 133.45, 267.0, 365.46, 397.21, 626.30, 907.0, 1117.46, 1334.60, 1421.55 and 1903.85 keV gamma transitions has been confirmed while the 566,667,753, 785 and 1443 keV gamma rays reported by other workers have not been detected. The intensity of the intense gamma rays have been measured to an accuracy of ~ 2%.

The angular correlation measurements have been done using Ge(Li)-NaI(Tl) combination for 26 cascades gating 658, 885, and 937 keV gamma-peaks on NaI(Tl) side and observing the other coincidence transitions with each gated energy on multichannel analyser. The slow-fast coincidence set up having time resolution of 8-nsec was used for these measurements. From these measurements the spin of 2220 keV level

has been confirmed to be 4^+. The mixing ratio (E2/M1) obtained from our measurements for various transitions are;

$\delta(446)=-0.4^{+0.2}_{-.25}$; $\delta(620)=-0.85\pm0.3$; $\delta(677)=-0.25\pm0.15$;
$\delta(687)=-0.46^{+.24}_{-.40}$; $\delta(707)=-1.78^{+.56}_{-.37}$; $\delta(818)=-0.27\pm.10$;
$\delta(1384)=-.35\pm.05$; $\delta(1505)=-0.40\pm.10$.

5. <u>A Weak Coupling Model for the Spectroscopy of Heavy Nuclei</u> - Ashwani Kumar and R.K. Bansal - A weak-coupling model is proposed for the structure of nuclei with large neutron excess, such that the active protons and active neutrons fill different shells. The active protons and active neutrons, named as sub systems, 1 and 2 respectively are treated exactly by the shell theory, using mixed configuration multishell codes prepared at the Panjab University, Chandigarh. The two subsystems having n_1 active protons and n_2 active neutrons are then weakly coupled, to calculate the spectra and other relevant properties of the nuclei under study. The advantage of this approach obviously lies in reducing the size of the dimensionality that the exact calculation(without invoking the weak coupling approximation) would require by applying suitable cut offs to the spectra of the sub systems.

6. <u>Sum Rule for M1 Transition Strengths from Isobaric Analog States</u> - S. Shelly - The partial sums of M1 transition strengths $\sum_{y} B^{(ML)}_{xJT \rightarrow J_f T_f y}$, for transitions from isobaric Analog state (xJT) in a neutron rich nucleus to sets of various low-

lying states characterised by definite angular momentum and isospin quantum numbers are expressed in terms of single-particle magnetic moments as well as angular momenta and isospin values of initial and final states. It is shown that each partial sum is a constant determined by the model wave function for the Isobaric Analog state and is independent of the microscopic structure of final states. Application to nuclei in ($1f_{7/2}$ - $2p_{3/2}$) region indicates that these partial sums of M1 transition strengths can serve as useful constraints on the choice of model wave functions for a given state.

Basic equations expressing the partial sums of strengths for a general transition operator in terms of the properties of initial state are given by J.B. French[1].

1. J.B. French, in proceedings of the international School of Phys. Enrico Fermi Course 36, C. Block editor, (1966) 278.

7. <u>Angular Correlation Studies in the Decay of ^{56}Co</u> - A.K. Sharma, H.R. Verma, Ravinder Kaur, K.K. Suri and P.N. Trehan - Gamma-gamma angular correlation measurements in ^{56}Fe have been done extensively using Ge(Li)(64.1 cc)-NaI(Tl) (3"x3") fast coincidence set-up having a time resolution of 8 nsec which was achieved by using constant fraction discriminators and time to pulse height converter. Investigations on 20 cascades have been made by gating 846 and 1238 keV gamma ray peaks on NaI(Tl) detector side and taking the rest of the

coincidence spectrum on a 4096 channel analyser. Our results obtained.

It has been possible to assign spins 3^+, 4^+ and 3^+ to 4049, 4100 and 4120 keV levels respectively from our angular correlation measurements. The mixing ratios δ(E2/M1) for various transitions measured in the present study are as follows:

γ 977(0.05±0.03); γ1038(0.0±0.02); γ1175(-0.41±0.07); γ1238(0.00±0.02), γ1360(0.07±0.02); γ 1771(0.0±0.02); γ1964(.0.22±0.07); γ 2015(-0.65±0.05); γ 2035(0.25±0.03); γ2598(0.27±0.04); γ3202(-0.46±0.09); γ 3254(-0.12±0.05).

8. <u>Level Structures Studies in ^{124}Te</u> - A.K. Sharma, Ravinder Kaur, H.R. Verma, K.K. Suri and P.N. Trehan - The level structure of ^{124}Te has been investigated by studying the gamma rays emitted following the decay of ^{124}Sb using 64.1 cc Ge(Li) detector in singles and coincidence modes with 3"x3" NaI(Tl) detector in conjunction with 4096 channel analyser. Time resolution of 8 nsec was achieved with a time to pulse height converter and constant fraction discrimination. The measured energies have an accuracy of 0.05 keV and the intensities of the intense gamma rays are accurate to ~ 2%. The energy, intensity and coincidence studies of 73 gamma rays coupled with angular correlation measurements for 10 cascades involved in this decay have enabled us to arrive at the level structure

of ^{124}Te. The existence of gamma rays with energies 185.44, 1248.34 and 1732.12 keV has been confirmed, whereas 15941 1747.21, 1957.70, 1971.11 and 2871.12 keV gamma transitions reported earlier have not been observed in the present studies. The gamma-gamma coincidence study confirms the existence of a level at 2335 keV.

Multipole admixture for various gamma-rays have been obtained as under from our angular correlation measurements: γ646: E2 +(0.0$\pm$0.1)% M3; γ713: M1 +(56$^{+7}_{-11}$)% E2, γ 723: M1 + (93$\pm$0.5)% E2; γ 968: E1 +(10$\pm$2)% M2; γ 1045: E1 +(1.5$\pm$1.5)% M2 γ 1368: E1 +(10.5$\pm$1.5)% M2; γ 1691: E1 +(0.3$\pm$0.15)% M2 and γ 2091: E1 +(0.1$\pm$0.1)% M2. 2^+ and 3^- spins have been assigned to the levels at 2039 and 2693 keV.

9. <u>Hyperfine Interaction for Ta in Gadolinium Metal and for Hf in Iron & Nickel by PAC Technique</u> - A. Kumar, N. Aggarwal, S.C. Bedi, B.P. Singh and H.S. Hans - The DPAC measurements have been carried out for ^{181}Ta cascade (133-482 keV) in the Gadolinium host using level $5/2^+$(482.1 keV) with $T_{1/2}$= 10.6 nsec. The values for electric field gradient above the Curie temperature and the simultaneously acting electric and magnetic hyperfine fields below the Curie temperature have been measured.

Also Integral perturbed angular Correlation (IPAC) measurements have been carried out for the magnetic hyperfine fields acting on ^{177}Hf in iron and nickel. The spin precession

of the $9/2^+$(208 keV) $9/2^-$(113 keV) $7/2^-$, - direction correlation in ^{177}Hf was used for the above purpose.

PUNJABI UNIVERSITY, PATIALA

1. Neutron Separation Energies in ODD-ODD Nuclei Beyond 2p-1f Shell - S.D. Sharma, V.P. Garg and A.K. Verma -
It is found that in case of most of the deformed odd-odd nuclei like Eu^{172}, Lu^{174}, Np^{238}, Bk^{250} etc. the odd neutron gets excited to higher levels giving rise to many rotational bands, while proton retains its ground state configuration upto about 2 MeV or even higher. In order to investigate the reasons for such a behaviour the separation energies for last nucleus in these nuclei are calculated using Moizacker's mass empirical formulas. In these calculations the separation energies of last neutron and found quite higher than the separation energies for last protons. In all these cases the results are consistently supporting the expected behaviour of odd neutron under excitation energies.

2. Pairing Energies in Odd-Odd Nuclei - S.D. Sharma -
The negative pairing energy terms in empirical mass formulae for odd-odd nuclei in 2s-1d and 2p-1f shells are investigated on theoretical grounds using δ-type nucleonic interactions. The results are compared with the positive pairing energies in case of adjacent even-even nuclei. Justifications for empirical estimates (pairing energy $\pm 0.36A^{-3/4}$) are sought for in view of these investigations.

3. Kinking and Odd-Even Shifts in Deformed Odd-A and Odd-Odd Nuclei - S.D. Sharma, A.K. Verma, V.P. Garg - An extension of Davidov and Fillippov's non axial rotor model is applied to study the effects of kinking and odd-even shifts in odd- and adjacent odd-odd isotopes and isotones. These effects are viewed as a generalization for single and double corriolis couplings. In adjacent odd A and odd-odd nuclei single coriolis results in kinking effect and if in the adjacent odd-odd nuclei, the additional nucleon too has projection of its angular momentum equal to 1/2, then the rotational bands show odd-even shifts which goes on decreasing with increasing spin. Here the role of nucleonic forces is very important. In order to study the nature of nuclear forces, it is realized that such rotational bands deserve complete theoretical analysis. In our study, we have analysed the isotones of P^{30}, Mn^{54} Mn^{56} and Co^{56}etc. the effect of these couplings on static magnetic moments and transitions probabilities too, have been studied and all these results are compared with available experimental reports.

4. Angular Correlation Studies in the Decay of ^{124}Sb - V.S. Puri, H.S. Sahota and C.S. Khurana - Gamma-gamma directional correlation studies have been carried out in four different cascades in ^{124}Te using a slow-fast coincidence assembly having resolving time of about 40 nsec. From the present measurements the value of the mixing ratio for the 1691 keV, 2091 keV and 1045 keV transitions are $\delta(1691) = -0.044 \pm 0.006$, $\delta(2091) =$

$-0.60 + 0.012$ and δ (1045) $= 0.033 \pm 0.030$ respectively. A new spin assignment to the 2701-8 keV level has been made from the (1398+1376) -1325 keV directional correlation which is consistent with the conversion coefficient data from the β^+ decay of ^{124}I.

5. <u>Internal and External Bremsstrahlung Spectra in Lead Excited By ^{32}P</u> - Salim Ahmed, M.S. Powar and M. Singh - The internal bremsstrahlung accompanying the allowed beta decay in ^{32}P (with $E^{max} = 1.71$ MeV) has been investigated. By the same isotope the external bremsstrahlung spectra in lead is also investigated. The experimental measurements are done with a multichannel NaI(Tl) scintillation spectrometer alongwith a standard geometrical arrangement. After making all the necessary corrections, the final distributions are compared with theories for internal bremsstrahlung (IB) and external bresstrahlung (EB).

RAMJAS COLLEGE, DELHI

1. Effect of the Finite Neutron Charge on the Charge Structure of Light Nuclei - R.S. Kaushal - We calculate the charge form factors of light nuclei in the harmonic oscillator model by accounting for the finite charge structures of both the proton and the neutron. We assum that (i) inside a nucleus the neutron as a whole no more remains neutral rather it carries a small fraction of negative charge (say ε) while a proton carries a positive charge little larger (by the same amount ε) than unity, and (ii) both the nucleons move in different oscillator potentials. These assumptions, which may offer a substitute for various short-distance effects (such as short range correlations, exchange currents, off-mass-shell contribution), are based on a rather deep insight into the detailed structure of nucleon in the light of quark-diquark model and lead to a satisfactory explanation of the observed diffraction minima in the form factors of ^{3}He and ^{4}He. It is found that the same set of parameters reproduces the data for both the nuclei upto fairly large values of q^2. Further for p-shell nuclei, it is noticed that the situation becomes complicated since the number of adjustable parameters increases.

SAMBALPUR UNIVERSITY, SAMBALPUR.

1. Real Part of Ion-Ion Interaction Potential using Energy Density Formalism - B. Behera, K.C. Panda and R.K. Satpathy - The real part of ion-ion interaction potential is generated within framework of energy density formalism using Brueckner's sudden approximation. The energy density is calculated by using a simple effective interaction consisting of a density dependent δ -function repulsion and a single Gaussian attraction. This interaction gives good results for various properties of nuclear matter and three double-closed-shell nuclei ^{4}He, ^{16}O and ^{40}Ca [1]. By expanding the Negele-Vautherin functions $A(\rho)$, $B(\rho)$ and $C(\rho)$ obtained with this interaction, in a Taylor series about nuclear matter density and retaining terms upto quadratic in density, it is found that these functions are well reproduced. The simple analytic form of the energy density, constructed in this way is used to calculate the real part of ion-ion potential for ^{16}O-^{16}O, ^{40}Ca-^{16}O and ^{40}Ca-^{40}Ca. A Thomas-Fermi approximation is used for the kinetic energy density thereby taking antisymmetrization effects approximately. The positions and heights of the interaction barriers, calculated for the three pairs of nuclei are in good agreement with those obtained by Brink and Stancu[2], using Skyrme force.

1. B. Behera & R.K. Satpathy, Nucl. Phys. & Solid State Phys. (India) 19B, 238 (1976).

2. Fl. Stancu & D.M. Brink, Nucl. Phys. A270, 236(1976).

2. <u>Single Particle Potential its Isotopic Spin Dependence and Symmetry Coefficient in Nuclear Matter</u> - B. Behera and R.K. Satpathy - Single particle potential, its isotopic spin dependence and symmetry coefficient in nuclear matter are calculated using an effective interaction (1), consisting of a density dependent delta-function repulsion and a single Gaussian attraction. This interaction gives good results for binding energy and compressibility in nuclear matter and root mean square radii and ground-state energies of three double-closed-shell nuclei ^{4}He, ^{16}O, and ^{40}Ca.

It is found that the single particle energy at the Fermi surface exactly equals the binding energy per particle in nuclear matter, thereby satisfying the HV theorem. The symmetry coefficient, which also includes the rearrangement contribution, is found to be 32.6 MeV. This is in excellent agreement with the value quoted by Brueckner and Dabrowski, and is better than the value 43.16 MeV found by Khanna and Barhai[2], using a Volkov type density dependent effective interaction. The isotopic spin dependent part of the single particle potentiel has a value of 99.14 MeV, which can be compared with the recent estimate of 100 ± 50 MeV[2].

1. B. Behera & R.K. Satpathy, Nucl. Phys. and Solid State Phys. (India), <u>19B</u>, 238(1976).

2. K.M. Khanna & P.K. Barhai, Phys. Rev. <u>C11</u> 264 (1975).

UNIVERSITY OF INDORE, INDORE

1. Effective Interactions in sd Shell - K.P. Joshi, S.C. Gupta*, G.K. Upadhyay* and A.N. Mishra - A central problem in nuclear structure theory is to determine the effective interaction in nuclei. A number of them have been employed by the different authors. As the two-body matrix elements (TBME) give little idea abouth the nature of the interaction, we examine them in terms of the relative matrix elements for the various spin-tensor components. The latter are mere transparent to the nature of the interaction. Thus the interaction of Freedom and Wildonthal has been found to have a few unpalatable features. We also analyse the effect of the truncation of confugaration space on the nature of the interaction.

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UNIVERSITY OF JODHPUR, JODHPUR

1. The Spectrum of Virtual Quanta Emitted from an Electron Scattering in a Nuclear Coulomb Field - K.K. Sud and A.R. Sud - An electron moving in the field of the nucleus emits virtual photon which is detected at the nucleus by causing a transition. The techniques for the calculation of the matrix elements between Dirac-Coulomb wavefunctions have been described earlier.(Ref.1,2). In this work we consider the incident electron as a plane wave whereas the scattered electron by a Dirac-Coulomb function. Expressions are developed for the virtual photon spectrum. The resulting radial integrals are expressed in terms of generalised hypergeometric series $F_2(\alpha, a_1, b_1, 2a_1, b_2: x,y)$.

1. K.K. Sud and L.E. Wright, Nucl. Phys. & Solid State Physics, 19B (1976) 70.
2. K.K. Sud et al. J. Math. Phys. 17 (1976) 2175.

UNIVERSITY OF MADRAS, MADRAS

1. Scattering of Pions by Deuterons - V. Girija and V. Devanathan - The scattering of π^+ by deuterons has been studied using the impulse approximation which is quite a valid approximation for the loosely bound deuteron. Simple expressions for the scattering amplitudes for the elastic, inelastic and charge exchange reactions have been derived using the pion nucleon amplitudes given by Koltun. Numerical calculations have been done for the above three processes over the energy range 60-300.MeV and found to yield the same results as those obtained by performing the calculations using Chow-Low amplitudes for the π N interaction. Here the calculations have been done in the pion-deuteron centre-of-mass system. For the elastic differential scattering cross-sections at 250 MeV, we obtain quite a good fit with the experimental data given by Gabathuler et al[1]. The calculations have been done using all the p-wave and s-wave phase-shifts. The cross-sections of inelastic and charge exchange scattering processes are compared with the available experimental results.

1. K. Gabathuler, C.R. Coz, J.J. Domingo, J. Rohlin, N.W. Tanner and C. Wilkin, Nucl. Phys. B55 397)(1973).

2. Semiclassical Treatment of the Collision of Kr^{84} with U^{236} - M. Rajasekaran - The collision of Kr^{84} with U^{236} is studied using the JWKB method U^{236} has a deformed stable state and its shape is determined from the shell-correction calculations of Strutinsky. It is found to have a spheroidal shape with $\delta \approx 0.3$, δ being the Nilsson deformation parameter. The parameter r_0 of the Woodsaxon potential is slightly increased to allow for the deformation. The coulomb energy is worked out for the spheroidal shape. Both these changes are found to be necessary. The integrals involved in the JWKB calculation have been evaluated by the method of Gauss-quadrature and oso is more accurate than the method used by Morsy and Toepffer[1] who experimnced difficulties due to the singularities at the lower limits (nuclear and coulomb turning points). In this study, the partial wave summation in the scattering amplitude is replaced by an integral which is also evaluated by the method of Gauss-quadrature for greater accuracy. Ultimately the bound state energies of a few low-lying states of a nuclear molecule (Kr^{84}-U^{236}) are also investigated.

1. M.W. Morsy and C. Toepffer, Z. Physik, 263, 227-250 (1973).

3. <u>Oblate and Prolate Asymptotic Quantum Numbers of Nilson States</u> - G. Shanmugam, P.R. Subramanian, M. Rajasekaran and V. Devanathan - The eigenvalues and eigenvectors of the Nilson Hamiltonian have been obtained in the cylindrical representation (CR). The asymptotic behaviour of the Nilson states for both positive and negative deformations can be best understood in CR. It has been found that two trials of the form ($N\ N_z \Lambda$), one for positive deformation and the other for negative deformations, should be used to characterize a given Nilsson state uniquely. Simple-relations exist between these quantum numbers charactorizing a given state uniquely. The Nilsson curve is amenable to a physical interpretation in CR. At large positive deformation, the Nilsson curve starts from a pure CR state, gets a large admixture of the other CR states due to the spin-orbit interaction as the deformation is reduced and with the change in sign of the deformation, one of the other CR basis states becomes increasingly dominant and the Nilsson curve finally emerges as another pure CR state for large negative deformation.

UNIVERSITY OF MYSORE, MYSORE

1. INELASTIC PHOTOPRODUCTION OF POSITIVE PIONS FROM ^{16}O - K. Venkatesh and G. Ramachandran - The knock-out reaction $\gamma + {}^{16}O \rightarrow {}^{15}N + \pi^{+} + n$ is studied in the impulse approximation. The $^{1}p_{1/2}$ nucleon momentum distribution in ^{16}O is calculated in the volume and surface production models and the Helm Model. The results are compared with the recent experimental data from Glasgow, U.K. The effect of 2p-2h correlations in the ground state wave function of ^{16}O on the differential cross section for the above process is also studied.

2. Pion Scattering on Nuclei - R.S. Keshavamurthy and G. Ramachandran - An empirical result is found on the basis of existing experimental data on π-nucleus scattering at intermediate energies on nuclei ranging from Li to Pb. We find that

$$\sigma_{\pi\text{-nucleus}} - (\sigma_{\pi\text{-}p} + \sigma_{\pi\text{-}n})$$

is a quantity which is linearly related to the B.E. of the nucleus in the cases of both π^{+} and π^{-} scattering. The slope is found to increase with energy upto the (first) resonance and then decrease for higher energies.

3. Description of Oriented and Non-Oriented Nuclei with Higher Spins - G. Ramachandran and M.V.N. Murthy - In reactions involving nuclear targets, the spin state of the

recoil nucleus is in general that of a non-oriented system. A method based on the group SU(n) is presented which is capable of describing both oriented and non-oriented systems. In the case of oriented systems the equivalence of this method of description to the description in terms of Fano statistical tensors is established. This method may also be applied to discuss nuclear reactions with targets which are non-oriented but whose spin states are not randomly distributed.

4. <u>Experimental Study of Internal Bremsstrahlung Accompanying Beta of Y-90 using Magnetic Deflection Method</u> - P. Venkataramaiah and B. Sanjeevaiah - The experimental study of Internal Bremsstrahlung (IB) accompanying beta decay provides a secondery information regarding the type of interactions in the beta decay process. In addition, it also provides information on higher order process like detour transitions in which nuclear rediation contributes to the continuous energy distributions in forbidden beta transitions. IB accompanying the unique first forbidden beta decay in Y-90 has been studied using both single counter and coincidence techniques by several prople and the results from one group to another are diverging or contradictory. Conclusive evidence for detour transitions has not been established.

We report here the study of the IB from this isotope using magnetic deflection technique which reduces the number of corrections to be applied. This method has not been used in the investigation of IB from this isotope by others. The evaluation of the true spectrum has been made using the inverse of the detector response matrix unlike the methods adopted by most of the people. The experimental results are compared with the results of others obtained using conventional techniques and also with the various theories available.

UNIVERSITY OF ROORKEE, ROORKEE

1. 1. Negative Parity States in Nd^{144} and Multipolarity of Gamma-transition from $1^- \rightarrow 2^+$ state - I.V.S. Rathore and B.P. Singh - Some of the low lying states in many isotopes (Nd^{144}, Sm^{148}, Gd^{152} and Gd^{156}) show a similar typical behaviour. The first 2^+ is regarded as single quadrupole phonon state and 3^- as a single octupole phonon state. The levels with the spins and parities of 1^-, 5^-, 3^-, 4^- etc. are considered due to simultaneous excitation of quadrupole and octuple phonons. If this consideration is correct then transition from J^- to 2^+ state must contain appreciable E3 content.

Beta-gamma-gamma angular correlation coefficient is used to estimate E3 content in E1 transition in Nd^{144} and estimate is also made for other Nuclei. The method of beta-gamma-gamma is given.

2. Beta-Gamma-Gamma Angular Correlation Studies of the Radiations from the Decay of Eu^{152} and Eu^{154} and Studies of Negative Parity States in Gd^{152} - I.V.S. Rathore and B.P. Singh - Beta-gamma-gamma angular correlation studies are done for the radiations from the of Eu^{154} and Eu^{156} for the following cascades: Beta- rays of $E_{max.}$ 590 keV $\rightarrow$ gamma-rays of 1278 keV $\rightarrow$ gamma-rays of 123 keV and Beta-rays of $E_{max.}$ 360 keV $\rightarrow$ gamma-

rays of 779 keV $\rightarrow$ gamma-rays of 344 keV. Anguler correlation coefficients thus obtained are analysed and spins of the excited states and multipolarities of gamma-transitions are determined. A method for the estimation of the mixture of dipole + quadrupole + octupole for triple angular correlation coefficient is also given.

3. <u>Survey and Analysis of Angular Correlation Data for the Cascade $2^+ \rightarrow 2^+ \rightarrow 0^+$ in Even-Even Nuclei and Its Systematics</u> - I.V.S. Rathore and B.P. Singh - $A_{22}^{Expt.}$ and $A_{44}^{Expt.}$ angular correlation coefficients for the cascade $2^+ \rightarrow 2^+ \rightarrow 0^+$ for almost all the even-even nuclei have been used to recalculate the amplitude mixing ratio (δ) for $2^+ \rightarrow 2^+$ gamma-transitions alongwith its phases. The plot of $\ln |\delta / E_\gamma|$ versus mass number (A) is given alongwith the values predicted by Greiner's Model[1] and that of Krane[2].

1. Walter Greiner, Nucl. Phys. A-80, 417 (1966)

2. K.S. Krane, Phys. Rev. C10, 1197 (1974).

VISVA-BHARATI UNIVERSITY, SANTINIKETAN

1. Off-Energy-Shell Jost Function for Nonlocal Potentials - R.N. Chaudhuri and B. Talukdar - Phase-amplitude method is used to study the off-shell scattering by nonlocal potentials. Certain computational advantages are derived thereby. The formalism developed is utilized to relate off-shell Jost functions for a number of realistic nucleon-nucleon potentials to elementary transcendental functions. All results are found to satisfy a recently proposed generalised form of the Jost-Pais theorem.

2. Solutions of the Van-Lemuwen - Reiner Equation for Nonlocal Potential - B. Talukdar, U. Das and S. Mukhopadhyaya - Analytical expressions for l -wave off-shell wave functions corresponding to physical, regular and irregular boundary conditions are derived for an N-term separable potential by using a coordinate space approach. The special cases of Yamaguchi and Mongan potentials are studied. It is seen that bound states embedded in the continuum are characterized by both on- and off- the energy shell moments, while spurious states are free from the off-shell effect.

3. <u>Combined Variable-Phase-Off-Shell Scattering Theory</u> - B. Talukdar, N. Malick and U. Das - Basic results of the variable-phase approach (VPA) are rederived. The relation between the amplitude function $\alpha_\ell(k_\infty)$ and the modules of the ordinary Jost function $f_\ell(k)$ is established from a more elementary level than the dispersion theoretic argument. This observation has been found crucial for relating the parameters of the VPA to observations of a two-particle system. As a natural extension of the on-shell theory the variable-phase approach is adapted to study the off-shell potential scattering. Expressions for off-shell T and K matrices are derived.