SECTION II

ABSTRACTS OF TALKS AT

AMERICAN PHYSICAL SOCIETY MEETINGS

(July 1976-June 1977)

High Spin States of $(fp)^2$ Character in Odd-Mass A = 35 - 43 Nuclei.* H. NANN, Michigan State U.--Recent investigations of the (α,d) reaction on ^{33}S, $^{35,37}Cl$, and $^{39,41}K$ at 40 MeV bombarding energy have resulted in the discovery of many high spin states away from the yrast line. The optimization of the bombarding energy and spectral resolution together with systematic extensive measurements permit the unambiguous assignment of the transfer of different L values in this reaction. Due to the characteristics of the (α,d) reaction, levels of $J_f = J_i + [(1f_{7/2})^2_{J=7}$ or $(1f_{7/2}2p_{3/2})_{J=5}]$, characterized by L = 6 and L = 4 angular distributions, respectively, are strongly populated. The strongest observed L = 6 transition in each nucleus leads to the $[(\text{target})_{J=3/2^+} \otimes (1f_{7/2})^2_{J=7}]$ configuration spin $17/2^+$ state. The L transfers and the strengths of the transitions provide insight into the nature and the purity of the configurations of the states observed. The present results will be compared to the results of the γ-ray spectroscopy of heavy-ion fusion-evaporation reactions[1] and of the inelastic alpha particle scattering.[2]

*Supported by the U.S. National Science Foundation.

[1]P. Gorodetzky et al., Phys. Lett. 31, 1067(1973); A. Poletti et al., Phys. Rev. C13, 1180(1976); E.K. Warburton et al., Phys. Rev. C13, 1762(1976).

[2]M.J.A. de Voigt, D. Cline and R.N. Horoshko, Phys. Rev. C10, 1798(1974).

Interplay Between Collective and Few-Nucleon Motion in High Spin States.* T.L. KHOO, Michigan State U.--In order to investigate the roles of collective and few-nucleon modes of motion in the behavior of nuclei at high spin, the intrinsic and ground band excitations of a number of nuclei in the Hg region have been studied. High spin states populated in (α,xn) reactions were studied by a variety of γ-ray and conversion electron spectroscopic techniques. Many high-K 2-, 4- and 6- quasiparticle structures were identified. In an energy domain not hitherto explored in detail (2-5 MeV), it has been demonstrated that the configurations are well described by the collective model with axial symmetry. Thus, contrary to recent speculation based on the absence of high-K isomers in numerous (heavy ion, xn) studies, axial symmetry is preserved, at least up to that 5 MeV excitation. Changes in the structure of yrast states from that of the ground band to that of different quasiparticle configurations have been observed. This provides the first evidence that intrinsic excitations of heavy deformed nuclei can become yrast. One consequence is the occurrence of several yrast traps; of particular note is a 22^- six-quasiparticle isomer at about 5 MeV in ^{176}Hf. The high angular momenta of intrinsic states are generated by aligning the spins of only a few nucleons along the symmetry axis. In constrast, collective rotation involves many nucleons, with the rotation vector perpendicular to the symmetry axis. The similarities between the observed phenomena and those which are predicted[1] to occur at much high spins (30-80h) will be discussed. At ultra high spins, some nuclei may become oblate, the angular momenta of yrast states will then arise from nucleon alignment instead of collective rotation, and yrast traps may occur.[1]

*Supported by the U.S. National Science Foundation.

[1]A. Bohr and B.R. Mottelson, Physica Scripta 10A, 13(1974).

Isospin Multiplets and Nuclei Far from Stability.* WALTER BENENSON, Michigan State U.--Mass measurements of ^{27}P and ^{31}Cl now virtually complete the T_z=-3/2 nuclei in the p- and s,d-shell. Twenty-one isospin quartets based on these nuclei have been measured and, except for the most accurately measured case (A = 9, ground state), they are in extremely good agreement with the predictions of Wigner's isobaric multiplet mass equation. The second mass quintet, A = 20, has now been completed, and both it and the A = 8 quintet agree well with the multiplet equation. Techniques for reaching the T_z = -3/2 and T_z = -2 nuclei and measuring their masses with high precision are discussed.

*Supported by the U.S. National Science Foundation.

The $^{59}Ni(p,t)^{57}Ni$ Reaction.* H. NANN, A. SAHA, Mich. State U. and S. RAMAN, Oak Ridge Natl. Lab.--Angular distributions of the $^{59}Ni(p,t)^{57}Ni$ reaction at E_p=40 MeV have been measured for states in ^{57}Ni up to an excitation energy of 6 MeV. Spins or limits on spin values are assigned on the basis of the characteristic shapes of the angular disctributions. A comparison with the results of the $^{60}Ni(p,t)^{58}Ni$ reaction reveals that several states in ^{57}Ni can be explained by the weak-coupling core-excitation model in which a $2p_{3/2}$ hole is coupled to the strong collective states in a ^{58}Ni "core".

*Work supported in part by the U.S. National Science Foundation and ERDA under contract with Union Carbide Corp.

The Contribution of Second Forbidden Terms to Allowed ε/β^+ Decay Branching Ratios, R.B. FIRESTONE, WM. C. McHARRIS†, Michigan State Univ.*, and B.R. HOLSTEIN, University of Massachusetts.--Numerous measurements of ε/β^+ decay branching ratios exist which do not agree with the normal allowed theoretical predictions. Calculations have been performed at the Michigan State University Cyclotron Laboratory using both the Holstein-Treiman and the Behrens-Jănecke formulations to show that weak magnetistm, second-class currents, and other second-forbidden terms contribute to the order of a few percent for superallowed transitions and may even dominate the ε/β^+ decay branching ratios for hindered allowed transitions. The well documented anomaly in ^{22}Na decay and the huge anomalies in ^{145}Gd decay will be discussed in terms of the theory through second order.

*Work supported by the National Science Foundation.
†Alfred P. Sloan Fellow, 1972-76.

Three-Quasiparticle States of ^{177}Hf.* I.H. REDMOUNT, T.L. KHOO and R.A. WARNER, Mich. State U.--Studies of gamma-ray and conversion electron spectra of ^{177}Hf, produced in the ^{176}Yb$(\alpha,3n)^{177}$Hf reaction, reveal the existence of three 3-quasiparticle states. In addition to the well-known 1.1 sec. $K^\pi=23/2^+$ state at 1315 keV, two new 3-quasiparticle states have been found: a $25/2^-$ state at 1713 keV and a $(19/2^-)$ isomeric state at 1342 keV. The former decays via a 120.5 keV E1 transition into the $I^\pi K=25/2^+23/2$ state, while the latter decays into the $17/2^-$ member of the $K^\pi= 7/2^-$ ground band via an M1/E2 548 keV transition with a half life of 55.9±1.2 μsec. The energies of these 3-quasiparticle states, compared with the energies of corresponding 2-quasi-particle states in neighboring even-even nuclei, will provide information on the residual nucleon-nucleon interactions.

*Supported in part by the US National Science Foundation.

A 4-Quasiparticle Isomer in ^{180}W.* S.R. FABER, F.M. BERNTHAL, T.L. KHOO, AND R.A. WARNER, Michigan State Univ.--Recent discovery of several high-K multi-quasiparticle isomers in ^{174,176}Hf has motivated a search for similar isomers in the tungsten isotopes. Prompt and delayed γ-γ coincidence experiments carried out following the ^{180}Hf $(\alpha,4n\gamma)^{180}$W reaction have revealed the band structure of the previously known[2] 5.2-msec $K^\pi = 8^-$ isomer in ^{180}W. A delayed transition feeding the spin-14, $K^\pi = 8^-$ band member suggests the expected $K^\pi = 14^-$ or 15^+ 4-quasiparticle state probably lies near 3565 keV. Preliminary analysis of the data indicates a half-life of ≈3 μsec for the proposed 4-quasiparticle isomer. Other high-spin features of the ^{180}W level scheme will be discussed.

*Research supported in part by the U.S. National Science Foundation.

[1]T.L. Khoo et al., Phys. Rev. Lett. 35, 1256(1975).
[2]J. Burde et al., Nucl. Phys. 85, 481(1966).

An Examination of the Structure of ^{192,194,196,198}Pt with the (p,t) and (p,p') Reactions.* P.T. DEASON, C.H. KING, F.M. BERNTHAL, T.L. KHOO, and J.A. NOLEN, JR., Michigan State Univ.--We are studying the (p,t) and (p,p') reactions on ^{194,196,198}Pt in order to learn more about the structure of nuclides in this shape transitional region. Analysis of the (p,t) data is nearly complete and that of the (p,p') reaction is in progress. Our (p,t) results are not easily understood within the context of any standard collective model, such as the rigid rotor, triaxial rotor, or spherical vibrator. There are several trends in the (p,t) data noted among the nuclides studied that will be discussed. For example, the second 4^+ state is strongly populated in all cases and the cross section of the first 2^+ state relative to that of the second 2^+ state increases with neutron number.

*Supported in part by the US National Science Foundation.

Study of ^{198}Tl Levels Populated in the Decay of ^{198}Pb.* M.J. MARSHALL, WM. C. McHARRIS†, R.A. WARNER, R.B. FIRESTONE, and W.H. KELLY, Michigan State Univ.--The decay of 2.4-h ^{198}Pb was studied using Ge(Li) detectors in singles and coincidence modes. Our ^{198}Pb was produced primarily by the reaction ^{198}Hg$(\tau,3n)^{198}$Pb using a 28-MeV τ beam from the MSU Cyclotron. Our γ-ray data confirm a previous decay scheme (containing 8 levels) constructed from conversion-electron data by B. Jung,[1] and we were able to place a number of new transitions on the basis of γ-γ coincidence data. We were also able to place two new levels in ^{198}Tl, at 1140.7 and 1230.3 keV. These states are discussed in shell-model terms.

*Work supported by the National Science Foundation.
†Alfred P. Sloan Fellow, 1972-76.

[1]B. Jung, Nucl. Phys. 10, 440 (1959).

Measurement of $V_{\sigma\tau}$ with the ^{7}Li(p,n)^{7}Be (0.00, 0.43 MeV) Reactions at E_p=25, 35, and 45 MeV.* R.R. DOERING†, L.E. YOUNG, R.K. BHOWMIK, S.M. AUSTIN, S.D. SCHERY, and R. DEVITO, Michigan State Univ.--The ratio of the spin-flip ($V_{\sigma\tau}$) to the non-spin-flip (V_τ) components of the central charge-exchange part of the effective nucleon-nucleon interaction may be determined from the cross sections for the ^{7}Li(p,n)^{7}Be (0.00, 0.43 MeV) reactions. Previous (p,n) experiments have been unable to resolve the ground state of ^{7}Be from the 0.43-MeV state at proton energies above 14 MeV[1]. With the new "beam-swinger" neutron time-of-flight facility at MSU, we have cleanly resolved these states all the way up to E_p=45 MeV (E_n=43 MeV) and have measured their angular distributions from 0° to 150° at E_p=25, 35, and 45 MeV. These data, combined with our previous measurements[2] of V_τ, yield the magnitude of $V_{\sigma\tau}$ over this energy range.

*Supported by the National Science Foundation.
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[1]J.D. Anderson, C. Wong, and V.A. Madsen, Phys. Rev. Lett. 24, 1074(1970).
[2]R.R. Doering, D.M. Patterson, and Aaron Galonsky, Phys. Rev. C12, 378(1975).

Levels of ^{52}Fe.* P. DECOWSKI, H. NANN and W. BENENSON, Michigan State Univ.--At 45 MeV bombarding energy angular distributions of the ^{54}Fe(p,t)^{52}Fe reaction have been measured for transitions to states up to 10.5 MeV of excitation. Many new states have been found. Assignments of the L transfers on the basis of the characteristic shapes of the angular distributions yield several new spin and parity assignments for states in ^{52}Fe. These include 0^+ states at 4.142, 5.363, 5.718, 6.927, 6.634, 6.927, 8.037, 8.122, 8.561 and 10.332 MeV and 2^+ states at 0.850, 2.762, 4.456, 6.034, 6.044, 6.483, 7.289, 7.463, 7.935, 8.354, 8.401, 9.044 and 10.006 MeV.

*Work supported in part by the U.S. National Science Foundation.

Excitation of Giant Resonances by Inelastic Scattering of 130 MeV ^{3}He.* A. DJALOEIS, J.-P DIDELEZ†, AARON GALONSKY††, and W. OELERT, Institute for Nuclear Physics of KFA Jülich, West Germany--Energy spectra of 130 MeV ^{3}He scattered from ^{24}Mg, ^{27}Al, ^{90}Zr, ^{120}Sn and ^{208}Pb have been measured. The spectra exhibit a pronounced "bump" (Giant Resonance) in the excitation energy region around E_x 63 $A^{-1/3}$ MeV. While the giant resonance (GR) region of ^{24}Mg splits into several levels, the shape of that of ^{208}Pb varies with angle, indicating different multipolarities of its components. The angular distributions leading to the GR in ^{90}Zr, ^{120}Sn and ^{208}Pb, the 1.18 MeV 2^+ level in ^{120}Sn and the 2.615 MeV 3^- level in ^{208}Pb have been obtained for $7^o \lesssim \theta_L \lesssim 35^o$. DWUCK calculations using the optical model parameters fitting the elastic data resulted in good fits to the shape of the 2^+ and 3^- levels in ^{120}Sn and ^{208}Pb, respectively. For ^{90}Zr and ^{120}Sn the shapes of the GR angular distributions are well fitted by L=2 only. However, for ^{208}Pb both L=2 and L=4 curves give comparable quality. Results of analysis in terms of the EWSR strengths and comparison with other available data will be presented.

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†On leave from IPN ORSAY, France.
††On sabbatical leave 1975-76 from Michigan State University.

Current and Velocity Fields of Rotating Nuclei.*† MARK RADOMSKI, Michigan State Univ.--Cranking model wave functions and the usual convection current operator imply current fields of nuclear rotation, from which velocity fields can be derived. For the single-particle harmonic oscillator shell model, these can be worked out rather easily. In the cases considered (^{12}C and ^{8}Be) the velocity field does not closely resemble rigid rotation. The model can be compared to experiment for the electroexcitation of the first excited state of ^{12}C.

*Supported by the National Science Foundation.
†Submitted by DAN OLOF RISKA.

Isoscalar Dipole Oscillations in ^{208}Pb.* P. DECOWSKI, H.P. MORSCH and W. BENENSON, Michigan State Univ.--Inelastic α-scattering to 1^- states in ^{208}Pb has been measured at E_α = 48 MeV. Three dipole states are observed at energies of 4.84, 5.29 and 5.50 MeV. Microscopic calculations were performed using 1p-1h shell model wave functions.[1] The calculated cross sections are at least one order of magnitude smaller than the experimental ones. This suggests that the excitation has a high degree of collectivity. A simple collective model in which this excitation is described as a dipole diffuseness oscillation yields a good description of our experimental data with a diffuseness change of 0.4 fm.

*Supported in part by the U.S. National Science Foundation
[1]W.W. True, et al., Phys. Rev. C3, 2421(1971).

(^{3}He,t) Reactions at 130 MeV.* AARON GALONSKY†, J.P. DIDELEZ, A. DJALOEIS, and W. OELERT, Institute for Nuclear Physics of KFA Jülich, West Germany--The giant Gamow-Teller resonance found in the ^{90}Zr(p,n) charge-exchange reaction[1] has now been seen in the charge-exchange reaction ^{90}Zr(^{3}He,t) with 130-MeV ions from the Jülich cyclotron. The triton detectors were Si-Ge, ΔE-E, telescopes[2]. Compared to the (p,n) reaction, the resonance seen in (^{3}He,t) is less pronounced relative to the underlying continuum. A similar broad peak observed near the isobaric analog state (IAS) in the (p,n) reaction on ^{120}Sn and on ^{208}Pb[1] was searched for with (^{3}He,t), but no such broad peak was discernible in the triton spectra. With each of the 3 targets an angular distribution has been measured for the transition to the IAS of the ground state.

*Supported in part by the U.S. National Science Foundation.
†On sabbatical leave 1975-76 from Mich. State U.
[1]R.R. Doering, Aaron Galonsky, D.M. Petterson, and
[2]G.F. Bertsch, Phys. Rev. Letters 35, 1691(1975).
G. Riepe and D. Protić, IEEE Trans. Nuc. Sci. NS-22, Feb. 1975.

Neutron Hole States Observed in the (^{3}He,α) Reaction.* J.-P. DIDELEZ†, A. DJALOEIS, AARON GALONSKY††, and W. OELERT, Institute for Nuclear Physics of KFA Jülich, West Germany--The (^{3}He,α) reaction on ^{90}Zr, ^{120}Sn and ^{208}Pb targets was investigated using the 130 MeV beam from the Jülich isochronous cyclotron. States corresponding to neutron holes in $f_{7/2}$ and $g_{9/2}$ inner shells by ^{90}Zr and ^{120}Sn, respectively, were clearly seen. Angular distributions obtained from 6 to 30 degrees are not very strongly dependent upon the nlj value of the transferred neutron. In the case of ^{90}Zr, however, four states appearing around 10 MeV excitation energy in the ^{89}Zr residual nucleus could be identified by direct comparison to previously obtained ^{90}Zr(d,^{3}He)^{89}Y experimental data[1] to be isobaric analogues of the first four ^{89}Y excited states. The analogue state of the ^{119}In ground state is also seen in the ^{119}Sn spectra around 14 MeV excitation energy. Analysis of the ^{208}Pb data is still in progress. Experimental results will be presented and discussed.

*Supported in part by the National Science Foundation.
†On leave from IPN, ORSAY, France.
††On sabbatical leave 1975-76 from Mich. State U.
[1]The ^{90}Zr(d,^{3}He)^{89}Y spectrum was recorded at the University of Maryland, Cyclotron Laboratory.

Particle-Hole Excitations in ^{16}F.* H.P. MORSCH, W. BENENSON, E. KASHY, D. MUELLER and H. NANN, Michigan State Univ.--In the investigation of giant resonance structures, particle-hole excitations of the closed shell nucleus ^{16}O are of particular interest. In order to study this kind of excitation in the T=1 parent, ^{16}F, we measured the ^{19}F(^{3}He,^{6}He)^{16}F reaction at 70 MeV and the ^{16}O(^{3}He,t)^{16}F at 35 MeV. In the (^{3}He,^{6}He) reaction predominantly 1p-1h and 2p-2h states with the particles occupying only the $1d_{5/2}$ shell are excited, whereas in the (^{3}He,t) reaction 1p-1h states with particles also in higher orbits are populated. Our experiments show that the two reactions do indeed excite the final nucleus quite differently from each other and from the ^{14}N(^{3}He,n)^{16}F reaction.

*Supported in part by the U.S. National Science Foundation.

Deformation Measurements via (p,p') Reactions.* J.E. FINCK, G.M. CRAWLEY, C.H. KING, and J.A. NOLEN, JR., Michigan State Univ.--The (p,p') reaction is being studied on targets of ^{154}Sm, ^{176}Yb, ^{232}Th, and ^{238}U at a beam energy of 35 MeV. Data have been obtained via a magnetic spectrograph with a position-sensitive proportional counter (8-10 keV FWHM) and with nuclear emulsions (5 keV FWHM). Qualitatively the angular distributions of the 0^+, 2^+, 4^+, and 6^+ members of the ground state rotational bands are much more structured than either those from (p,p') reactions on spherical nuclei or on deformed nuclei at lower bombarding energies. Coupled channel calculations including interferences between direct and multiple step excitations, using the nuclear deformation parameters, β_2, β_4, and β_6, from (α,α') work at 50 MeV, and using Becchetti-Greenlees global optical model parameters, produce good fits to the ^{154}Sm and ^{238}U data, but do not do well for the ^{176}Yb. The present results will also be compared to those from previous studies of Coulomb excitation, Coulomb-nuclear interference, and inelastic electron scattering experiments.

* Supported by the National Science Foundation.

[1] D.L. Hendrie, Phys. Rev. Letters 31, 478(1973).

^{93}Ru ε/β^+ Decay.* M. DiSTASIO, WM. C. McHARRIS†, R.B. FIRESTONE, R.A. WARNER, and W.H. KELLY, Michigan State Univ.--The $1/2^-$ and $9/2^+$ isomers of ^{93}Ru have been produced primarily by the ^{92}Mo(α,3n) reaction, using α beams up to 48 MeV from the MSU Cyclotron. The half-life of the $9/2^+$ isomer was determined to be 54.9±1.7 sec, and that of the $1/2^-$ isomer, ≈45 sec. Using a HeJRT system, γ-ray singles and γ-γ coincidence experiments were performed which have enabled us to place the γ rays in a decay scheme containing seven levels in ^{93}Tc. These states are discussed in shell-model terms.

* Work supported by the National Science Foundation.

† Alfred P. Sloan Fellow, 1972-1976.

Optical Model for 130 MeV ^{3}He.* A. DJALOEIS, J.-P. DIDELEZ†, AARON GALONSKY††, and W. OELERT, Institute for Nuclear Physics of KFA Jülich, West Germany--The 130 MeV ^{3}He beam from the Jülich cyclotron has been scattered on ^{24}Mg, ^{90}Zr, ^{120}Sn and ^{208}Pb target nuclei. The charged particles produced were detected by means of Si-Ge ΔE-E telescopes[1] and selected with Ortec particle identifiers. Elastic scattering angular distributions have been obtained in the range $7^o \leq \theta_L \leq 43^o$ and fitted using the optical model code MAGALI[2]. A systematic search of the best-fit parameters was performed for fixed values of the real radius r_V between 1.05 and 1.50 fm. Both volume and surface type of the imaginary potential were considered. In addition, the inclusion and absence of the spin-orbit potential were investigated. The experimental data and the results of the optical model analysis will be presented.

* Work supported in part by the U.S. National Science Foundation

† On leave from IPN ORSAY, France.

†† On sabbatical leave 1975-76 from Michigan State University.

Cyclotron Beam Phase Probe.* PETER MILLER, W.S. CHIEN, J.F.P. MARCHAND, Michigan State Univ.--We have developed an apparatus for measuring the phase of the cyclotron beam with respect to the radio frequency accelerating voltage. A beam stopping target covered with MgO (scintillator) is inserted into the internal beam at the position where the phase is to be measured. The light pulse resulting from each beam pulse is analyzed by a photomultiplier outside of the cyclotron, connected to a computer-monitored sampling oscilloscope. The computer increases the signal-to-noise ratio by averaging many oscilloscope sweeps and processes the data to derive the beam phase. The phase probe has been used with beam currents between 0.3 pμA and 12 pμA (H and He ions). When the measured phase data are used to infer corrections to the field trimming coils, we readily obtain isochronism to within ±5° (2nd harmonic, 210 turns).

*Supported in part by the U.S. National Science Foundation.

Status Report on Superconducting Cyclotron Magnet.* H.G. BLOSSER, Michigan State Univ.--As reported previously[1] a full scale prototype magnet for a 500 MeV superconducting cyclotron is under construction; progress on most major parts has been good. Factory tests of the helium liquifier exceeded performance specifications by 10%; the liquifier is now (Aug. 1976) being set up in East Lansing. Conductor for the coil has all been received; problems with shipping damage, improper cleaning and kinks appear resolved. Critical current for all conductor strands exceeds 1000 amps at 5.5 tesla (specification value 770 amps--design operating current 700 amps). Factory assembly and inspection of the magnet yoke and pole base is scheduled for Aug. 20. The major delayed item in the project is the coil bobbin which was severely warped in fabrication due to an improper welding procedure; straightening and correcting have delayed the order by several months and we now expect to receive the bobbin on Sept. 1. If this is correct we expect to have coil winding completed at the time of the East Lansing meeting and to be engaged in sealing the cryostat.

* Work supported by the National Science Foundation.

[1] H.G. Blosser, Bulletin APS 21 (1976) 611.

Parity-Mixing Limit for $17/2^-$ Isomer of ^{93}Tc.* B.A. BROWN, F.M. BERNTHAL, R.A. WARNER, and L.E. YOUNG, Michigan State Univ.--Earlier published work has shown[1] that parity mixing could result in substantial E2 admixture in the isomeric 750.7-keV, $|17/2^- + \alpha 17/2^+\rangle \rightarrow |13/2^+\rangle$ transition in ^{93}Tc, provided that the parity-mixing matrix element is comparable to that recently observed in ^{19}F, for example.[2] A Si(Li) detector with solenoidal electron guide was used as an electron spectrometer to measure internal conversion coefficients for transitions in ^{93}Tc produced in the ^{92}Mo(α,p2n) reaction with E_α = 43 MeV. The result for the delayed 750.7-keV transition is $\alpha_K^{exp} = (3.31 \pm 0.20) \times 10^{-3}$ compared with theoretical values $\alpha_K(E2) = 1.450 \times 10^{-3}$, $\alpha_K(M2) = 3.921 \times 10^{-3}$, and $\alpha_K(E3) = 3.363 \times 10^{-3}$. Implications of this result for possible mixing of the nearly degenerate $17/2^-$ and $17/2^+$ levels will be discussed.

* Research supported by the National Science Foundation.

[1] B.A. Brown, D.B. Fossan, P.M.S. Lesser, and A.R. Poletti, Phys. Rev. C13, 1194 (1976).
[2] E.G. Adelberger et al., Phys. Rev. Letters 34, 402(1975)

High-Spin States in ^{146,147,148,149}Sm.* C.H. KING, B.A. BROWN, and T.L. KHOO, Michigan State Univ., E. EICHLER and N.R. JOHNSON, Oak Ridge Natl. Lab., A.C. KAHLER and L.L. RIEDINGER, U. of Tenn., and A.G. SCHMIDT, UNISOR--Recent theoretical calculations[1] have indicated that the light Sm nuclides may become oblate at low angular momenta, making possible the existence of yrast traps.[2] We have examined the high spin structures in ^{146,147,148,149}Sm using the (α,xnγ) reactions at MSU and in ^{146,147}Sm using the (^{22}Ne,xnγ) reactions at ORNL. No definite evidence for any rotational structures have been observed for states up to I=16$\hbar$. In addition, γ-time measurements between beam bursts in the (α,xnγ) reactions have revealed no isomers with half-lives longer than a few nanoseconds.

*Supported by the U.S. National Science Foundation and the USERDA.

[1]R. Bengtsson, et al., Phys. Lett. 57B(1975)301, and G. Andersson, et al., to be published.
[2]A. Bohr and B.R. Mottelson, Physica Scripta 10A (1974)13.

A Neutron Scattering Facility.* L.E. YOUNG, R.R. DOERING, R. BHOWMIK, S.M. AUSTIN, A. GALONSKY, and S.D. SCHERY, Michigan State Univ.--A system to measure neutron scattering in the 20-40 MeV range has been constructed. Proton beams from the MSU cyclotron with a time resolution of ΔT (FWHM)$\lesssim$400 ps are passed through a beam swinger onto a ^{7}Li neutron producing target. The resulting monoenergetic neutron beam of ~10^{8} neutrons/cm^2/sec is directed to a scattering sample on the swinger axis. Rotating the swinger allows angular distributions to be taken from 20-165 degrees with a large area fixed detector at a flight path of 4 to 32 meters. Overall time resolutions of 490 ps for γ-rays and 730 psec for neutrons have been observed. Preliminary results of neutron scattering experiments will be described.

*Research supported in part by the National Science Foundation.

Activation Measurements of the ^{7}Li(p,n)^{7}Be (0+0.429 MeV) Reaction to Provide Accurate Cross Sections for Neutron Detector Calibration.* S.D. SCHERY†, L.E. YOUNG, R.R. DOERING, S.M. AUSTIN, and R.K. BHOWMIK, Michigan State Univ.--We have been carrying out activation measurements of the ^{7}Li(p,n)^{7}Be (0+0.429) reaction in the energy range 25 to 45 MeV. Since the 0.429 MeV state of ^{7}Be is the only particle emission stable excited state in ^{7}Be, the measured activation cross section for production of ^{7}Be is exclusively due to the ground state and first excited state reactions. This cross section is measured by observing the 0.478 MeV gamma emission in ^{7}Li that accompanies the decay of ^{7}Be with a branching ratio of 10.4% and is independent of any neutron measurement. The total cross sections obtained by the activation technique have been used to normalize angular distributions of the reaction at a proton energy of 25, 35, and 45 MeV taken with scintillation detectors in neutron time-of-flight experiments.

*Research supported by the U.S. National Science Foundation.

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Ionization Fluctuations in Drift Chambers.* R.C. MELIN and R.G. MARKHAM, Michigan State Univ. --The effect of ionization fluctuations on position resolution has been simulated by dividing the primary ionization path into bins corresponding to constant drift times. A random number generator having a Blunck-Liesegang frequency distribution[1] then assigns a random amount of charge to each bin. From this, the time development of an individual pulse is constructed. By generating many pulses we have studied the effectiveness of various time derivation techniques. In general we find that these ionization fluctuations make a substantial contribution to the spatial uncertainty of the drift chamber.

*Supported in part by the U.S. National Science Foundation.

[1]P.V. Ramana Murthy and G.D. Demeester, Nucl. Instr. and Meth. 56(1967)93.

Giant Gamow-Teller Strength Observed in Charge-Exchange Reactions.* R.R. DOERING, University of Virginia and Michigan State University--In 1963, Ikeda, Fujii, and Fujita[1] predicted that the Gamow-Teller strength function in nuclei with N>Z might be predominantly localized within a relatively small range of excitation energies above the region accessible to β decay. The corresponding giant Gamow-Teller resonance has been observed[2] in several nuclei via (p,n) reactions at E_p = 35 and 45 MeV. Spectra from a recent $^{90}Zr(^3He,t)^{90}Nb$ experiment with $E_{^3He}$= 130 MeV exhibit the same structure, although less pronounced relative to the background than for the analogous (p,n) reaction. For targets of ^{90}Zr and ^{58}Ni both charge-exchange reactions show evidence of a splitting of the Gamow-Teller strength into two major components. High-resolution $^{58}Ni(p,n)^{58}Cu$ spectra reveal a further fragmentation of the high-excitation end of the upper component into the isobaric analogs of individual T = 2 Ml states which have been observed in $^{58}Ni(e,e')$.[4] The strength of these spin- and isospin-flip transitions, relative to the strength of purely isospin-flip transitions, appears to be increasing as a function of bombarding energy. This effect is currently being investigated with the $^7Li(p,n)^7Be$ (0.00 and 0.43 MeV) reactions at E_p= 25, 35, and 45 MeV.

*Supported by the U.S. National Science Foundation.

[1]K. Ikeda, S. Fujii, and J.I. Fujita, Phys. Lett. 3, 271(1963).

[2]R.R. Doering, Aaron Galonsky, D.M. Patterson, and G.F. Bertsch, Phys. Rev. Lett. 35, 1691(1975).

[3]Aaron Galonsky, J.P. Didelez, A. Djaloeis, and W. Oelert, Bull. Am. Phys. Soc. 21, 997(1976).

[4]L.W. Fagg. Rev. Mod. Phys. 47, 683(1975).

Inelastic Proton Scattering from ^{24}Mg.* B. ZWIEGLINSKI, G.M. CRAWLEY, J.A. NOLEN, JR., and H. NANN, Mich. State Univ.--The inelastic scattering of protons by ^{24}Mg has been studied at 40 MeV beam energy using the MSU cyclotron and the Enge split-pole magnetic spectrometer. The detection of protons with a resolution of 10-15 keV FWHM was accomplished by a 50 cm long delay line position-sensitive detector mounted in the spectrometer focal plane. Resolved states were observed in ^{24}Mg up to an excitation energy of 13.5 MeV. The recently reported[1] state at about 15.1 MeV excitation was also seen in this work. Distorted wave calculations with both macroscopic collective model and microscopic form factors are being compared with the experimental angular distributions. Coupled channels calculations are also being carried out for the low lying states.

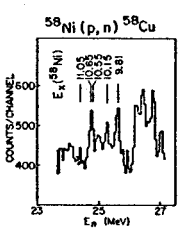
*Work supported by the National Science Foundation.

[1]G.S. Adams, et al., Bull. Am. Phys. Soc. 21, 966 (1976).

Energy Levels of ^{60}Zn, ^{61}Zn.* G.M. CRAWLEY, W. BENENSON, E. KASHY, H. NANN, and D. WEBER, Mich. State Univ.--The reactions $^{58}Ni(^{12}C,^{10}Be)$ and $^{58}Ni(^{12}C,^{9}Be)$ were used to investigate the level structure of the nuclei ^{60}Zn and ^{61}Zn. The 76 MeV $^{12}C^{5+}$ beam from the MSU cyclotron was used in the experiment, and the reaction products were detected in the focal plane of an Enge split pole spectrometer using a pair of resistive wire proportional counters backed by a thin plastic scintillator for time-of-flight measurement. Excellent mass and charge discrimination was obtained by this technique. ^{60}Zn and particularly ^{61}Zn have not been extensively studied, and a number of new levels in these nuclei were observed in the present experiment. These results will be compared with theoretical predictions.

*Work supported by the National Science Foundation.

The Excitation of Ml Strength in the $^{58}Ni(p,n)^{58}Cu$ Reaction at 45 MeV Proton Energy.* L.E. YOUNG, SAM M. AUSTIN, R.R. DOERING, and AARON GALONSKY, Mich. State Univ.--Substantial magnetic dipole strength has been observed in the $^{58}Ni(p,n)$ charge exchange reaction using the time-of-flight technique to generate neutron spectra with ≈100 keV resolution (see figure). The states populated at 9.8 to 11.0 MeV excitation energy in ^{58}Cu have been identified as the analogs of T=2 states in the neighboring nuclei ^{58}Ni and ^{58}Co, as seen in the $^{58}Ni(e,e')$ ^{58}Ni and $^{58}Ni(^3H,^3He)^{58}Co$ reactions. Substantial cross section is present at about 4 MeV lower than the analog states, near the expected position of the anti-analog states of the Ml spin-flip excitation. Such states have been observed in the $^{90}Zr(p,n)$ reaction.



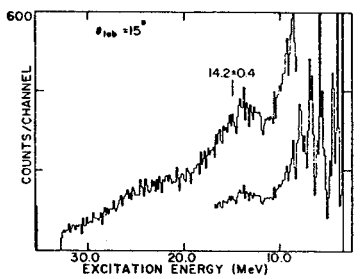
*Research supported by the National Science Foundation.

R(4) Group Theory and Deformed Nuclei.* WM. C. MCHARRIS, Michigan State Univ.--The rotation group in four dimensions, R(4), has been successfully applied to the spectra of diatomic molecules,† and with relatively minor changes it can be used to explain spectra from deformed nuclei in a succinct, elegant manner. Starting with the rigid rotor, it can quickly be extended to include the rotating oscillator and even simple rotation-vibration coupling. The simple formalism will be summarized, and transitions up through electric quadrupoles will be analyzed.

*Work supported in part by the U.S. National Science Foundation.

†B.R. Judd, Angular Momentum Theory for Diatomic Molecules (Academic Press, 1975), and references therein.

Giant Resonance in ^{90}Zr with ^{6}Li Scattering.* R.C. PARDO, R.G. MARKHAM, W. BENENSON, L.W. ROBINSON, AND A. GALONSKY, Mich. State Univ.--A broad structure in ^{90}Zr at 14.2 MeV with a FWHM of approximately 4 MeV has been obtained via ^{90}Zr(^{6}Li,^{6}Li') at 75 MeV. This preliminary information indicates it is the same resonance seen with (α,α')[a]. We also observe a concentration of strength in the 8 MeV region, which may be due to a giant resonance other than E2.



*Work supported by the U.S. National Science Foundation.

[a]D.H. Youngblood et al., Phys. Rev. C13, 994(1976).

High-Spin Levels in ^{200}Hg Revisited.* S.K. SAHA, H. HELPPI, M. PIIPARINEN, P.J. DALY, Purdue Univ., T.L. KHOO, C.L. DORS, F.M. BERNTHAL, Mich. State Univ.--A ^{198}Pt(α,2nγ) study using a highly enriched foil target has yielded a much more detailed ^{200}Hg level scheme than was previously known.[1] Many new high-spin negative parity states have been identified, and the level energies and reduced transition probabilities have been found to be in excellent agreement with recent theoretical predictions[2] based on a semidecoupled band description. Unexpectedly in view of published results[3] for ^{198,196,194}Hg, no moderately intense transition which could reasonably be interpreted as $8^+ \rightarrow 6^+$ was observed in ^{200}Hg; if an 8^+, 10^+ doublet exists in this nucleus at about the same energy as in other Hg nuclei, the population of these levels is less than 0.2% of the total (α,2n) cross section. This puzzling result stimulated us to undertake the reinvestigation of the ^{197,199}Hg level spectra described in the following talk.

*Work supported by the USERDA and the NSF.

[1]Cunnane, Hochel, Yates, Daly, Nucl. Phys. A196 (1972)593.

[2]Toki et al., preprint, 1976.

[3]Proetel et al., Nucl. Phys. A226(1974)237.

High-Spin Level Spectra of ^{197}Hg and ^{199}Hg.* H. HELPPI, S.K. SAHA, P.J. DALY, Purdue Univ., S.R. FABER, T.L. KHOO, F.M. BERNTHAL, Mich. State Univ. --Decoupled $\nu i_{13/2}^{-1}$ bands and three-particle $21/2^-$ bands were identified earlier[1] in ^{197,199}Hg. We have reinvestigated the high-spin levels of these nuclei by (α,3nγ) reactions on enriched ^{196}Pt and ^{198}Pt targets and have considerably extended the level schemes. Levels up to $37/2^+$ of the $\nu i_{13/2}^{-1}$ band in ^{197}Hg have been firmly identified; this band exhibits sharp backbending above the $25/2^+$ level, and the results demonstrate that two-proton structures such as $\pi h_{11/2}^{-2}$ must be included in the rotation alignment description of the ^{198}Hg level structure. In ^{199}Hg, the $\nu i_{13/2}^{-1}$ decoupled band faithfully reproduces the ground band structure of ^{200}Hg core, with no backbending. A probable explanation for the contrasting ^{197}Hg and ^{199}Hg results will be given, and other interesting new features of the level spectra will be discussed.

*Work supported by the USERDA and the NSF.

[1]Proetel, Diamond, Stephens, Nucl. Phys. A231(1974) 301.

Particle Decays of the Lowest T=2 State in ^{36}Ar.* S.J. FREEDMAN†, M.A. OOTHOUDT††, R.G.H. ROBERTSON†††, and F.J. ZUTAVERN, Princeton U, E.G. ADELBERGER, U. of Washington, and A.B. MCDONALD, ACEL Chalk River Nuclear Labs--We have observed the charged particle decays of the lowest T=2 state in ^{36}Ar. The T=2 state was populated by the ^{38}Ar(p,t)^{36}Ar reaction using a 42 MeV proton beam and a gas cell target. Tritons were detected at $\theta_{Lab} \approx 22^o$ in a QDDD spectrometer and decay particles in a solid state detector telescope at -90^o. The data indicate a ~100% decay by particle emission to the ground state of ^{35}Cl, with upper limits of 4-5% on other possible decay modes. The results are compared to our results for analogous decays in this mass region.

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Mass of Lowest T=2 State of ^{12}C.* R.G.H. ROBERTSON, T.L. KHOO, AND G.M. CRAWLEY, Mich. State Univ., A.B. MCDONALD, Atomic Energy of Canada Ltd, E.G. ADELBERGER, Univ. of Wash., and S.J. FREEDMAN, Stanford Univ.--Despite many efforts, the T=2 state of ^{12}C has not been seen in isospin-forbidden resonance reactions, although there is evidence[1,2] for weak ground-state proton and deuteron decays. In order to check the possibility that the resonance might have been missed owing to an error in the accepted value for the excitation energy of the state (27.603±0.14 MeV), and to improve the precision in that quantity, we have remeasured the ^{14}C(p,t)^{12}C (T=2) Q-value. Tritons from this reaction were detected in nuclear emulsions in the focal plane of a split-pole spectrograph simultaneously with protons, deuterons, and alphas from reactions on ^{12}C and ^{14}C. An electrostatic deflector in the spectrograph was used to separate different particle types. In a preliminary analysis of the data, we find E_x=27.626±.007 MeV.

*Work supported by the National Science Foundation.

[1]S.J. Freedman et al., unpublished.

[2]D. Ashery et al., Phys. Rev. C13, 1345(1976).

Gamow-Teller Beta Decay of sd-shell Nuclei.* B.A. BROWN and B.H. WILDENTHAL, Mich. State Univ.--The beta-decay matrix elements $\langle\sigma\tau\rangle_{th}$ have been calculated for almost all sd shell nuclei using complete $(sd)^n$ shell-model wave functions generated with the Chung-Wildenthal empirical two-body matrix elements.[1] The experimental data has been analyzed to extract $\langle\sigma\tau\rangle_{exp}$ for several hundred transitions in the region $17<A<39$. The mass and orbital dependences of the ratios $\langle\sigma\tau\rangle_{exp}/\langle\sigma\tau\rangle_{th}$ are being studied. In one such analysis the four single-particle matrix elements were fitted to ten transitions selected by their large strength and small experimental uncertainty with the result for the ratios $\langle j||\sigma\tau||j'\rangle_{exp}/\langle j||\sigma\tau||j'\rangle_{sp}$ of 0.85,0.72,0.66, and 0.72 for $2j2j'=55,11,33$, and 35, respectively.

*Supported by the U.S. National Science Foundation.

[1]W. Chung and B.H. Wildenthal, to be published.

Status Report on 500 MeV Superconducting Cyclotron Magnet.* H.G. BLOSSER, Mich. State U.--All major parts for the full scale prototype magnet have been received and final assembly is underway. Progress is somewhat delayed as compared with forecasts in previous talks[1], the most recent delays resulting from numerous repair operations on unexpected conductor defects. Coil winding is now 95% complete (JAN 25) and should be fully complete in two more days. About three months will be required for instrumenting, closing and insulating the cryostat so that the magnet will be ready for cooling at about the time of the Washington meeting and initial field measurements should start shortly thereafter. Overall, the project schedule remains in reasonable accord with original proposal estimates, recent delays offsetting earlier periods of advancing more rapidly than expected. (Coil winding is finishing for example at 19.5 months after funding vs. 18 months projected in the proposal to reach this milestone. Costs for the project are also in close accord with proposal estimates, and contingency funds are fully intact.

*Work supported by the National Science Foundation.

[1]H.G. Blosser, Bulletin APS 21(1976)611 and 989.

Heavy Ion Beam Acceleration on the Michigan State University Cyclotron.* M.L. MALLORY, P.S. MILLER, and W.S. CHIEN, Mich. State Univ.--An axial code cathode Penning heavy ion source has been operating on the Michigan State University Cyclotron since Sept. 1976. Ion beams from lithium to argon and charge states up to 8^+ have been accelerated and extracted from the cyclotron. Extracted beam intensities greater than 1eμA have been obtained for lithium, carbon, nitrogen, and oxygen beams. The lithium beam was obtained from LiF pellets, which were sputtered by a "rebombardment beam" of neon. The heavy ion source has also been used for the production of a proton beam. The ion source is designed for long cathode live and short maintenance times. Maintenance is routinely handled by the experimentalist.

*Work supported by the National Science Foundation.

Anomalous A-Dependence ($23<A<130$) for the Absorptive Potential for Protons below the Coulomb Barrier.* C.H. JOHNSON, Oak Ridge National Laboratory and A. GALONSKY, Mich. State Univ.--Johnson, et al.[1] found from accurate (p,n) cross sections that the proton strength functions for Sn isotopes exhibit giant p-wave resonances with the peak energies varying smoothly with A. An optical model analysis gave a constant volume integral for the real potential at each resonance. The surface absorptive potential had W_D=11.5 MeV and a_D=0.4 fm. We have extended this analysis to our earlier (p,n) cross sections on nuclei from ^{93}Nb to ^{130}Te. Using real potentials consistent with those deduced[1] for Sn we find that the diffuseness a_D remains nearly constant at 0.4 fm over this mass region but that the strength W_D must vary rather smoothly with A. The value at A = 103 is much larger than for Sn and the value at A = 93 is only about 7 MeV. A partial explanation in terms of vibrational nuclei will be presented.

*Research sponsored by the US ERDA under contract with Union Carbide Corporation and NSF.

[1]C.H. Johnson, J.K. Bair, C.M. Jones, S.K. Penny and D.W. Smith, Phys. Rev. C15 (January 1977)

High-Spin Isomers in ^{212}Rn.* D. HORN†, A.B. McDONALD, O. HAUSSER, T.K. ALEXANDER, T. FAESTERMANN†, J.R. BEENE†Δ, AECL Chalk River Nuclear Labs. and C.J. HERRLANDER, Michigan State Univ. & AFI, Stockholm--High-spin isomers in ^{212}Rn have been populated by means of the ^{204}Hg(^{13}C,5n)^{212}Rn reaction. Excitation functions, g-factors, angular distributions, and half-lives have been measured. The level ordering obtained is well explained by theory[1] up to the 6.20 MeV ($T_{½}$ = 113 ns) level. On the basis of the excitation energy and the g-factor (0.70±0.01), coupling to the 5^- state of the ^{208}Pb core is proposed, specifically $J^\pi = 22^+$ $[(\pi h^3_{9/2}\pi i_{13/2}) \otimes (\nu g_{9/2}\nu p^{-1}_{1/2})5^-]$. Three consecutive transitions feeding this level were identified from γ-γ coincidence data, placing the uppermost level ($T_{½} \geq 100$ ns) at more than 8.5 MeV in excitation, with a possible spin of 25 or 26. Additional isomers were found at energies of 2.86 MeV ($T_{½}$ = 13 ns), 3.34 MeV($T_{½}$ = 8 ns), 4.05 MeV ($T_{½}$ = 28 ns, g = 1.03±0.02) and 7.90 MeV ($T_{½}$ = 35 ns, g = 0.60±0.07).

*†Supported in part by the National Science Foundation.
ΔNRC Postdoctoral Fellow.
[Δ]Present address: Oak Ridge Nat. Lab., Oak Ridge, Tennessee.

[1]J. Blomquist, private communication.

Many Body Exchange Current Effects on the Charge Form Factors of ^{3}He and ^{4}He.* D.O. RISKA and M. RADOMSKI, Mich. State U.--We have evaluated the three- and four-pion-exchange contributions to the charge form factors of the three- and four-body nuclei. At momentum transfers $10\text{fm}^{-2} < q^2 < 20\text{fm}^{-2}$ the three-pion-exchange effect is somewhat smaller but of the same order of magnitude as that of the two-pion-exchange effect.[1,2] The four-pion exchange effect is considerably smaller. When ρ-meson exchange is taken into account in addition to pion exchange, the role of the many-body currents is reduced significantly.

*Work supported by the National Science Foundation.

[1]W. Kloet and J. Tjon, Phys. Lett. 49B, 419(1974).
[2]J. Borysowicz and D.O. Riska, Nucl.Phys. A254, 301(1975).

Nuclear Scattering of Low Energy Pions.*
H. MCMANUS, and K.S. STRICKER, Michigan State Univ.--The sensitivity of low energy (10-60 MeV) pion nucleus scattering to effective s and p-wave pion-nucleon scattering lengths is investigated. The relationship of these scattering lengths to those used in pionic atoms, and the impulse approximation, is discussed.

*Work supported by the U.S. National Science Foundation.