SECTION II

ABSTRACTS OF TALKS AT
AMERICAN PHYSICAL SOCIETY MEETINGS

(July 1974-June 1976)

Study of the (p,d) Reaction on Odd-Mass Nuclei of the sd-Shell.* B.H. WILDENTHAL, Mich. State Univ.--Targets of ^{23}Na, ^{27}Al, ^{32}S, ^{33}S, ^{34}S, ^{35}Cl, ^{37}Cl and ^{39}K have been bombarded with 35-MeV protons and the emergent deuteron spectra measured with good energy resolution (∿8 keV) and good counting statistics between 4° and 50°. The analysis of the data yields insights into i) the meaningfulness of a DWBA interpretation of this type of reaction; ii) the limits of viability of sum-rule analyses of complex transfer data; iii) the stability and consistency of the agreement between general shell-model expectations and DWBA-extracted experimental trends; and iv) the success, and the attendant limitations, obtainable in the prediction of spectroscopic details via the shell model.

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

CCBA Calculations of (p,t) Reactions in the Lower s-d Shell.* C.H. KING, H. NANN, M.A.M. SHAHABUDDIN, and B.H. WILDENTHAL, Mich. State Univ.--We have investigated the influence of multistep inelastic-plus-transfer processes on the reactions ^{26,24}Mg(p,t)^{24,22}Mg and ^{22}Ne(p,t)^{20}Ne by performing coupled-channel Born approximation (CCBA) calculations. These calculations were made assuming the macroscopic rotational model to describe the inelastic scattering and form factors based on shell model wavefunctions to describe the transfers. We have found that a meaningful comparison of the results of (p,t) reactions on highly collective nuclei with predictions of the shell model must include such multistep processes explicitly. The cross section for the ^{24}Me(p,t) reaction to the first 2^+, for example, is increased by a factor of 2000 by the inclusion of these processes. A discussion of the influence on the calculations of uncertainties in the optical model parameters will be presented.

*Supported by the National Science Foundation.

(α,d) Reaction on Several Odd-A Nuclei in the 2s-1d Shell.*† W.S. CHIEN, B.H. WILDENTHAL, H. NANN, Mich. State Univ.--We have measured the angular distributions at 40 MeV for (α,d) reactions on ^{23}Na, ^{35}Cl, ^{37}Cl and ^{39}K, as well as ^{34}S, using the alpha beam from the MSU cyclotron. The normalization was obtained by monitoring elastically scattered α-particles with solid state detector. The outgoing duterons were analyzed in a split-pole magnetic spectrograph and detected in a position-sensitive single-wire proportional counter with an energy resolution of about 80 keV. The dominant peak in each spectrum was assigned $13/2^+$ for ^{25}Mg(5.24 MeV) and $17/2^+$ for ^{37}Ar (7.01 MeV), ^{39}Ar(5.54 MeV), and ^{41}Ca(5.22 MeV) on the basis of strength and shape of angular distributions. The results for other levels in these nuclei as well as the predictions of shell-model calculations will be reported.

*Submitted by C.H. King.
†Work supported by the National Science Foundation.

Rotational Band Structure of ^{178}W, C.L. DORS, F.M. BERNTHAL, T.L. KHOO, C.H. KING, Mich. State Univ.--The rotational band structure of ^{178}W is being investigated via in-beam gamma ray spectroscopy. Levels in ^{178}W are populated in the ^{177}Hf (α,3n) reaction induced by 37 MeV alphas from the MSU Cyclotron. γ-γ coincidence, angular distribution, prompt and delayed singles data are being used to characterize the band structure. The ground band has been identified up to spin 16 and the $K=2^-$ octupole band to spin 12. Agreement with ^{178}Re decay data[1] for the lower spin members of these bands is good. Other bands associated with ^{178}W are also seen and will be discussed.

[1]P.F.A. Goudsmit, J. Konijn, F.W.N. de Boer, Nucl. Phys. A151, 513(1970).

High Spin Level Structure in ^{190}Pt.* M. PIIPRINEN, J.C. CUNNANE, P.J. DALY, Purdue Univ. and F.M. BERNTHAL, C.L. DORS, T.L. KHOO, Mich. State Univ.--Levels of ^{190}Pt populated in the ^{190}Os(α,4nγ) reaction have been studied using the M.S.U. cyclotron. The measurements have included prompt and delayed γ-ray singles, γ-γ coincidence, angular distribution and excitation function determinations. An extensive ^{190}Pt level scheme will be presented and compared with that of ^{192}Pt which we established earlier.[1] Two intense de-excitation branches are observed in each nucleus, one involving even-spin positive parity levels and the other a 5^-, 7^-, 9^-... level sequence. In both nuclei, isomeric 12^+ states intrude into the positive parity yrast sequences giving the appearance of highly exaggerated back-bending type behaviour; in addition, there is considerable side-feeding into the high-spin members of these "bands." New 10^- isomers which play a major role in the de-excitation cascades have also been discovered. The interpretation of these findings will be discussed.

*Work supported by the USAEC and the NSF.
[1]Bull. Am. Phys. Soc. 19 (1974) 597.

Comparative Study of (p,t) and (p, ^{3}He) Reactions on T=1/2 Nuclei in the 2s-1d Shell.* H. NANN, W. BENENSON, and B.H. WILDENTHAL, Mich. State U.--The comparative investigation of (p,t) and (p, ^{3}He) reactions on T_z=1/2 targets is of interest for two reasons, (a) study of the spin-isospin dependence of the interaction potential, and (b) test of current shell-model wave functions. We have measured the (p,t) and (p, ^{3}He) reactions on ^{39}K, ^{35}Cl, ^{31}P, ^{27}Al and ^{23}Na at 40 MeV bombarding energy. The reaction products were detected in a wire-counter plastic-scintillator combination on the focal plane of a split-pole magnetic spectrograph. This equipment provided excellent particle identification and an energy resolution of about 25 to 30 keV. The measured angular distributions were compared with microscopic DWBA calculations based on shell-model wave functions. In most cases the agreement between theory and experiment is quite good. Ingredients of the analysis are discussed.

*Supported by the National Science Foundation.

Improved Energy Resolution with the MSU Cyclotron.* J.A. NOLEN, JR. and P.S. MILLER, Mich. State U.--With the recent advances in high resolving power large solid angle magnetic spectrographs such as the Q3D system, energy resolution of 1 part in 10^4 FWHM should be obtained when not limited by the accelerator. Such resolution has been achieved in the Enge split-pole spectrograph at the M.S.U. Cyclotron by operating in the energy-loss mode with the spectrograph stopped down to 0.3 msr to reduce aberrations. Recent cyclotron improvements and further reduction of the aperture to 0.06 msr have led to improved resolution, $\Delta E/E$= 1:20,000 or 1.7 keV FWHM at 35 MeV proton energy. The line width in the focal plane of the split-pole spectrograph at this resolution is 50μm FWHM, maintained without drifts for runs an hour long with a beam current ~1μa an target. The parameters of the cyclotron which are most significant in the energy loss mode will be discussed and empirical data on the effects of very thin targets on line shapes and energy resolution will be presented.

*Supported by the National Science Foundation.

Observation of T=2 State in ^{8}B *. R.G.H. ROBERTSON and W.S. CHIEN, Mich. State U.--The lowest T=2 state in ^{8}B is predicted from the isobaric multiplet mass equation (IMME) to be at 10.720(70) MeV. We have used the isospin-allowed ^{11}B(^{3}He,^{6}He)^{8}B reaction at 72 MeV to populate this state, the first T=2 state to be observed in a T_z=-1 nucleus. The measured excitation energy is 10.619(9) MeV, and upper limit for its width is 90 keV. This is the fourth member of the A=8 quintet to be found, and permits a new test of the IMME.

*Supported by the National Science Foundation.
[1]R.G.H. Robertson, S. Martin, W.R. Ralk, D. Ingham and A. Djaloeis, Phys. Rev. Lett. 32, 1207(1974).

Observation of T=2 States in ^{8}Li and ^{8}Be *. W.S. CHIEN and R.G.H. ROBERTSON, Mich. State U., D.R. GOOSMAN, Brookhaven National Lab.--The lowest T=2 states in ^{8}Li and ^{8}Be have been observed via the ^{10}Be(p,^{3}He) and (p,t) reactions, thus completing for the first time as isobaric quintet. Targets[1] of ^{10}BeO with a 94% enrichment of 1.6 My ^{10}Be were bombarded with 45 MeV protons and reaction products analyzed in an Enge split-pole spectrograph. The narrow resonance observed by Black, et al.[2] in ^{6}Li+d is confirmed to be the T=2 state in ^{8}Be, and the analog in ^{8}Li was readily observed in (p,^{3}He). Results and implications for the isobaric multiplet mass equation will be presented.

*Supported by the National Science Foundation and the Atomic Energy Commission.
[1]D.R. Goosman, Nucl. Instr. Meth. 116, 445(1974).
[2]J.L. Black, W.J. Caelli, D.L. Livesey and R.B. Watson, phys. Lett. 30B, 100(1969).

The Production of ^{7}Li in the α+α Reaction.* H.H. ROSSNER, C.H. KING, W.S. CHIEN, and S.M. AUSTIN, Mich. State U.-- Measurements of σ for the reactions ^{4}He(α,p)^{7}Li and ^{4}He(α,n)^{7}Be have been performed at energies between 39 and 50 MeV. The ^{4}He(α,p)^{7}Li cross sections were determined from measurements of σ(θ) for the outgoing protons. The cross sections for the transition to ^{7}Li(g.s.) were found to agree very well with those inferred by detailed balance from ^{7}Li(p,α)^{4}He measurements.[1] The ^{4}He(α,n)^{7}Be cross sections were determined by stopping the ^{7}Be recoils in an Al absorber, and then detecting in a Ge(Li) detector the 478 keV γ-rays following their decay to the first excited state of ^{7}Li. Implications of these measurements for the nucleosynthesis of ^{7}Li will be discussed.

*Research supported by the National Science Foundation
[1]G.S. Mani, et al., Nucl. Phys. 60,588(1964).

Γ_{rad}/Γ for the 7.66 MeV state of ^{12}C and the 3-α Reaction Rate.* R.G. MARKHAM, SAM M. AUSTIN and M.A.M. SHAHABUDDIN, Mich. State U.--The rate of three alpha fusion to form ^{12}C in stellar helium burning is proportional to the branching ratio Γ_{rad}/Γ for radiative decay of the 7.66 MeV state of ^{12}C. Unfortunately the most precise measurements of this ratio are in substantial disagreement. We have populated the state by the ^{12}C(α,α') reaction at 40 MeV and counted the recoiling ^{12}C ions in coincidence with the inelastic α-group from the 7.66 MeV state. The ratio Γ_{rad}/Γ is obtained by dividing the number of ^{12}C-α coincidences by the number of inelastic events. The ^{12}C ions are detected and identified in a gas-solid-state telescope which provides ΔE-E and time of flight information as well as position information in two dimensions. The coincidence detection efficiency is nearly 100%. A preliminary value of Γ_{rad}/Γ will be presented.

*Research supported by the National Science Foundation.

AMERICAN PHYS. SOC. PITTSBURGH MEETING CONT. Oct. 1974

Characteristics of a 400(Q^2/A) MeV Superconducting Heavy-Ion Cyclotron.* H.G. BLOSSER, D.A. JOHNSON and M.M. GORDON, Mich. State Univ.--Recent studies at MSU have led to an attractive design for a compact heavy-ion cyclotron. The main field is derived from a pair of superconducting coils of 56" I.D., 5-1/2" wide and 19" high. The coils are housed in an independent cylindrical cryostat with a clear, 50" dia., room temperature bore. A 4 sector iron pole tip inserted in this bore provides focusing adequate for 100 MeV protons. The pole tip and the iron yoke increase the 3.1 tesla air core field, such that the average field of the coil and iron together is 4.7 tesla. The field edge is relatively sharp; extraction with conventional electromagnetic elements is feasible although superconducting magnetic shields appear to be a superior technique. Engineering consultants estimate the coil, cryostat, refrigeration system, yoke and pole tips to cost $638,000. Including a 4 dee rf system, vacuum system, injection system, etc. the cost of the complete cyclotron appears to be well below $2,000,000.

*Supported by the National Science Foundation.

AMERICAN PHYS. SOC. ANAHEIM MEETING, Jan. 1975

New Tests of the Isobaric Multiplet Mass Equation.* R.G.H. ROBERTSON, Mich. State Univ. --Until recently the IMME could only be experimentally tested in the T=3/2 multiplets, which have four members. A series of new experiments on T=2 states now permit tests of the IMME in isobaric quintets. By means of the reactions $^{12}C(\alpha,^{8}He)^{8}C$, $^{11}B(^{3}He,^{6}He)^{8}B(T=2)$, $^{10}Be(p,t)^{8}Be(T=2)$, and $^{10}Be(p,^{3}He)^{8}Li(T=2)$, a quintet has been completed for the first time, and an appreciable departure from the IMME is indicated. Also, the observation of the $^{24}Mg(\alpha,^{8}He)^{20}Mg$ reaction brings to 4 the number of T=2 states known in the A=20 quintet. The implications for the IMME of these and other new results will be discussed.

*Supported by the National Science Foundation.

High-Spin Level Structure of ^{182}W.* B.D. JELTEMA, F.M. BERNTHAL, T.L. KHOO, And C.L. DORS, Mich. State Univ.--The $^{180}Hf(\alpha,2n\gamma)$ reaction was used to carry out in-beam γ-ray spectroscopy of ^{182}W. Three-parameter (γ-γ-t) coincidence, angular distribution, excitation function, and prompt and delayed γ-ray singles experiments were used to assign 59 levels to the ^{182}W level scheme. Eleven rotational bands were identified, and most of these were characterized. The large number of bands populated results from an unusually high density of states near the yrast band. The 1.4-μsec 10^+ isomer previously observed by Nordhagen[1] was characterized from intraband branching ratios to be predominantly the $9/2^+[624]$, $11/2^+[615]$ two quasi-neutron state, and indications are that a crossing between this band and the highly regular ground band should occur near spin 16. A low-lying probably $I^{\pi}K=6^+6$ two-proton state was found to decay promptly to the ground band, a behavior attributed to an accidental near-degeneracy of that state and the spin-6 member of the γ-vibrational band.

*Work supported by the USAEC and by the NSF.

[1]R. Nordhagen, R.M. Diamond, and F.S. Stephens, Nucl. Phys. A138, 231 (1971).

The $^{17}O(\alpha,d)^{19}F$ Reaction.* L.R. MEDSKER and H.T. FORTUNE, Univ. of Pennsylvania; B.H. WILDENTHAL, H. NANN, and W.S. CHIEN, Mich. State Univ.--Angular distributions have been measured for states below 8 MeV in ^{19}F populated in the $^{17}O(\alpha,d)^{19}F$ reaction at E_x= 47.5 MeV. Outgoing deuterons were detected in a proportional counter placed in the focal plane of a split-pole magnetic spectrograph. The target was Au-backed WO_3. DWBA angular distributions calculated with the use of $(sd)^3$ shell-model wave functions give reasonable agreement with the data--especially for the high-spin states.

*Work supported by the National Science Foundation.

AMERICAN PHYS. SOC. ANAHEIM MEETING CONT. Jan. 1975

Weak Coupling Relations Between ^{33}Cl and ^{32}S.* H. NANN, K.K. SETH, A.K. SAHA and B.H. WILDENTHAL, Mich. State Univ. and Northwestern Univ.--In recent (p,t) experiments on s-d and f-p shell nuclei, we have discovered weak coupling relationships between excited 0^+ states in even-A nuclei and excited states with the same J^π as the ground states in adjoining odd-A nuclei.[1] In the present study of the $^{35}Cl(p,t)^{33}Cl$ and $^{34}S(p,t)^{32}S$ reactions 40 MeV we find the same relationship between the 0_2^+ state at 3.78 MeV in ^{32}S and the $3/2^+$ state at 3.98 MeV in ^{33}Cl. In addition we find a quartet of states with $J^\pi=1/2^+-7/2^+$, with a centroid at 2.42 MeV, which appears to correspond to the weak coupling partners of the 2^+ state at 2.23 MeV in ^{32}S. These results verify predictions obtained from multiconfiguration shell-model wave functions.[2]

*Research supported in part by the National Science Foundation.
[1]K.K. Seth, et al., Phys. Rev. Lett. 30, 132(1973), also Phys. Lett. 49B, 157(1974).
[2]B.H. Wildenthal, et al., Phys. Rev. Lett. 32,794 (1974).

Weak Coupling Relations Revealed by (p,t) Reactions on ^{60}Ni and ^{61}Ni. K.K. SETH, A.K. SAHA, H. NANN, W. BENENSON and B.H. WILDENTHAL Northwestern Univ. and Mich. State Univ.*--In a recent series of (p,t) experiments on $f_{7/2}$ shell nuclei, we have discovered weak coupling relationships between 0^+ states of even-A nuclei and corresponding $7/2^+$ states of adjoining odd-A nuclei.[1,2] It was found that enhanced L=0 transitions are only observed to the g.s and to one $7/2^-$ state in each odd-A nucleus at an excitation energy which is approximately 400 KeV lower than the energy of 0_2^+ state in the even-A partner. In the present (p,t) experiments on $^{60,61}Ni$ at Ep=40 MeV similar L=0 enhancement is observed for the 3.45 MeV $3/2^-$ state in ^{59}Ni and correspondence is established with the L=0 transition to the 2.94 MeV 0^+ state in ^{58}Ni. The weak coupling interpretation is examined in terms of multi-shell shell-model calculations.

*Supported in part by the National Science Foundation.
[1]K.K. Seth et al., Phys. Rev. Lett. 30, 132(1973).
[2]K.K. Seth et al., Phys. Lett. 49B, 157(1974).

AMERICAN PHYS. SOC. WASHINGTON MEETING April, 1975

Superconducting Cyclotrons: Injection and Extraction.* H.G. BLOSSER, Mich. State Univ. THe strong magnetic field of a superconducting cyclotron makes beam extraction a dominant design problem; injection presents similar, closely related difficulties. Building on the early Chalk River superconducting cyclotron design,[1] we have numerically studied injection and extraction in such cyclotrons, using realistic magnetic fields derived from the uniform magnetization approximation. A promising design for a $400(Q^2/A)$ MeV cyclotron has evolved from these studies. The injection path, the acceleration process, and the extraction path all have attractive properties. Extraction is possible with conventional eletromagnetic elements; the interesting alternate of superconducting shields[2] is being experimentally explored. Injection paths depend on whether a tandem accelerator or a preceding large cyclotron is assumed as the pre-accelerator. Matching requirements for a number of likely accelerator combinations have been worked out, and from these comparative estimates of overall system performance are derived.

*Supported by the National Science Foundation.
[1]J.S. Fraser and R.R. Tunnicliffe, Atomic Energy of Canada, Report AECL-4913(1974).
[2]F. Martin, S.St. Lorant, and W. Toner, Nucl. Inst. and Meth. 103, 503(1972).

Analysis of the $^{22}Ne(p,t)$ Reaction.* W.S. CHIEN, C.H. KING, H. NANN, M.A.M. SHAHABUDDIN,and B.H. WILDENTHAL, Mich. State Univ.--A measurement of the $^{22}Ne(p,t)^{20}Ne$ reaction was made using 40 MeV protons from the Michigan State University Cyclotron. The outgoing tritons were analyzed in a split-pole magnetic spectrograph and detected in a position-sensitive single-wire proportional counter with a resolution of 60 keV FWHM. Angular distributions were obtained for transitions to states with excitation energies up to 12 MeV. These transitions are being analyzed using spectroscopic amplitudes determined from shell model wave functions. Both DWBA and CCBA models are being applied to describe the reaction mechanism. The results will be discussed in terms of their implications for the quality of the shell model wavefunctions as well as for the adequacy of the descriptions of the reaction mechanism.

*Work supported by the National Science Foundation.

The $^{34}S(p,t)^{32}S$ Reaction.* H. NANN and B.H. WILDENTHAL, Mich. State Univ.--Angular distributions of the $^{34}S(p,t)^{32}S$ reaction at E_p=40 MeV have been measured for states in ^{32}S up to an excitation energy of 10 MeV. The reaction products were detected in a position sensitive wire-counter plastic-scintillator combination on the focal plane of a split-pole magnetic spectrograph. For the level at 6.410 MeV in ^{32}S an unambiguous spin assignment of 4^+ was found. Transitions to several unnatural parity states in ^{32}S were observed with a cross section of about 1 μb/sr. The measured angular distributions for transitions to natural parity states were compared to microscopic DWBA calculations based on shell-model wave functions.

*Supported by the National Science Foundation.

States in ^{116}Sb From the Beta Decay of ^{116}Te and the (p,nγ) Reaction,* C.B. MORGAN, J.A. GUILE, R.A. WARNER, L.E. SAMUELSON**, WM.C. McHARRIS, W.H. KELLY, Mich. State Univ., E.M. BERNSTEIN, and R. SHAMU, Western Mich. Univ.--The beta decay of ^{116}Te is observed to directly feed 4 excited levels in ^{116}Sb. The de-excitations of these levels produce 21γ-rays allowing the placement of 4 additional levels. These 8 states and 13 others were observed in the (p,nγ) experiments. Spin and some parity assignments have been made based upon the beta decay in conjunction with in-beam gamma-ray angular distributions and excitation function measurements to 21 levels below 1250 keV. These are 0(3^+), 93.7(1^+), 103.0(2^+), 410.9(4^+), 455.2(3), 466.0(3) 503.1(5), 517.9(2^+), 550.9(2^+), 574.4(2^+), 612.5(4) 654.1(3), 731.6(1^+), 815.1(3), 820.6(5), 841.1(6), 881.5(3), 917.7(1^+), 948.0(4), 1127.2(2), 1158.3 (1^+), 1222.9(2) keV. The lifetime of the hindered 455.2 keV state has also been measured to be 1.9±0.1 ns.

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**Now at Dept. of Physics, Purdue Univ., W. Lafayette, Indiana.

K=14⁻ Four Quasiparticle Band in ^{176}Hf.* T.L. KHOO, F.M. BERNTHAL, R.G.H. ROBERTSON, and R.A. WARNER, Mich. State Univ.--A K=14⁻ four quasiparticle isomer in ^{176}Hf has been established at 2866 keV and its lifetime measured at 401±7 μsec. Its configuration is probably (7/2 (404)$_p$, 9/2 (514)$_p$, 7/2 (514)$_n$, 5/2 (512)$_n$) and it decays through two previously identified K=8⁻ two quasiparticle bands. The isomer was populated in the (α,4n) reaction, receiving an unsually high proportion (∿30%) of the total cross section. By means of a delayed coincidence technique to be described, we have isolated the γ-rays which feed the isomer, and by γ-γ coincidence measurements constructed a well-behaved rotational band (up to spin 18) built on the isomer and a highly perturbed structure whose character is as yet unknown.

*Supported by the National Science Foundation and U.S. Atomic Energy Commission.

The Decay of $^{145m_1+m_2}Gd$,* R.A. WARNER, R.B. FIRESTONE, WM.C McHARRIS, and W.H. KELLY, Mich. State Univ.--$^{145m_2}Gd$ was produced by 40-MeV ^4He on enriched (95.10%) $^{144}Sm_2O_3$ targets at the Michigan State University Sector-Focused Cyclotron. The activity produced was transported by a He-Jet transport system to a low background area where γ-γand x-γ coincidence experiments were performed. An isomer in ^{145}Gd at 27.3±0.1 keV is reported with a half-life of 11.5±0.3 nsec and an internal conversion coefficient α_L=16.9±1.4. The $11/2^-$ isomer in ^{145}Gd is now established at 748.7 keV which is consistent with the nearby N=81 $11/2^-$ isomers. B(M4) values were calculated for all of the N=81 $11/2^-$ decays from ^{133}Te through ^{147}Dy indicating almost constant reduced transition probabilities throughout this region.

*Work supported by the USERDA and the NSF.

An Ultra Thin, ΔE-E Telescope with 2-D Position Sensitivity.* R.G. MARKHAM, SAM M. AUSTIN and H. LAUMER,** Mich. State Univ.--A versatile proportional-counter (ΔE), surface-barrier (E) particle telescope having the following characteristics will be described: large area (400mm^2), thin ΔE counter (∿300 μg/cm^2), good time and energy resolution, event location in two dimensions (ΔX, ΔY <1.5mm) and event rate capability in excess of 5 kHz. Position determination is by charge division in one direction and electron drift time in the other. The detector has been used to detect and identify low energy target recoils and fission fragments. Other applications will be discussed.

*Supported by the National Science Foundation.
**Present address: Dept. of Physics, University of Kentucky, Lexington, Kentucky.

High Spin Level Structure of ^{177}W.* C.L. DORS, T.L. KHOO, F.M. BERNTHAL, C.H. KING, Mich. State Univ.--Levels in ^{177}W are being investigated via the ^{177}Hf (α,4nγ) reaction using gamma-ray singles, angular distribution, excitation function, γ - γ, and γ-t coincidence data. Three bands based on the $1/2^-$[521], $5/2^-$[512] and $7/2^+$[633] states have been tentatively identified. The low spin members of the $1/2^-$[521] ground band show agreement with recent conversion-electron data from ^{177}Re decay.[1] The ^{177}W rotational band structure will be discussed in light of the sharp decrease in hexadecapole deformation recently suggested to occur in this region.[1] Relevance to the ^{178}W ground band structure reported earlier by us[2] will be considered.

*Work supported by the U.S. Atomic Energy Commission and by the National Science Foundation.
[1]B. Harmatz, et al., Bull. Am. Phys. Soc. 20 96(1975)
[2]C.L. Dors, et al., Bull. Am. Phys. Soc. 19, 1012 (1974)

Resolution of the ε/β⁺ Anomalies-All Matrix Elements Great and Small. R.B. FIRESTONE, R.A. WARNER, WM. C. McHARRIS, and W.H. KELLY, Mich. State Univ.--Large anomalies for ε/β⁺ ratios from ^{145}Gd and ^{143}Sm decays are explained in terms of second order interferences. Reasonable values of the Morita parameter[1] η are shown to yield ε/β⁺ ratios greater than 100 times the normal allowed predictions. The general correction terms for calculating these interferences, using Morita's simplified matrix elements[1] are

$$C(\mp) \approx [1 + 3/20(D_1 + N_1)\alpha Z\eta]^2 |^A F_{01}^{01}|^2 D_1 + N_1 - W_0 R/3 + \alpha|Z|/2$$

where the upper sign refers to electron capture and the lower sign to position decay. In addition, a small anomaly in the accurately measured ^{22}Na ε/β⁺ ratio is shown to lead to a value of η identical to that obtained from β-γ angular correlations.[2] This comparison is model independent, justifying the explanation of the anomalies.

*Work supported by the USERDA and the NSF.
[1]M. Morita, Phys. Rev. 113, 1584 (1959).
[2]M. Subotowicz, Bull. Acad. Sci. USSR, Phys. Ser. 33, 1496 (1969).

A study of the $^{43}Ca(p,t)^{41}Ca$ Reaction at 42.1 MeV.* A. SAHA and KAMAL K. SETH, Northwestern Univ. W. STEWART, Lewis Research Centre (NASA), and W.A. LANFORD, W. BENENSON, B.H. WILDENTHAL and H.NANN, Mich. State U.--The reaction $^{43}Ca(p,t)^{41}Ca$ has been studied at 42.1 MeV using the Michigan State University Cyclotron and split-pole spectrograph. A position-sensitive single-wire proportional counter was used in the focal plane, in conjunction with a plastic scintillator counter to permit particle identification. An energy resolution, FWHM, ≥30 keV was realized. Differential cross sections were measured for 15 angles between 6° and 50° for about 35 transitions to states in ^{41}Ca up to about 7.2 MeV excitation. The energy levels observed in the present experiment are compared to the results of other reactions which populate ^{41}Ca. The results of DWBA analysis of the differential cross sections will be presented and the consequent implications for nuclear structure discussed.

*Supported by the National Science Foundation.

Empirically Renormalized Hamiltonians for $d_{5/2}$-$s_{1/2}$-$d_{3/2}$ Shell-Model Calculations.* B.H. WILDENTHAL and W. CHUNG, Mich. State Univ.--We have determined Hamiltonians for full $d_{5/2}$-$s_{1/2}$-$d_{3/2}$ shell-model calculations which are optimized relative to the level-energy data at either the lower or upper end of the sd-shell. We describe above the general procedures by which these empirical matrix elements are obtained from the Kuo-type starting values. The data set for the lower sd-shell interaction is comprised of 200 levels, while the upper sd-shell set is comprised of 140 levels. Mass-independent, state-independent 1-+2- body Hamiltonians suffice to fit the known binding energy data either over the range A=17-26 or A=30-39 with an rms deviation of ≤ 200 keV, at the level of >7 data elements per parameter. However, it is not possible to fit in similar fashion the A=17-26 and 30-39 data simultaneously.

*Supported by the National Science Foundation

Search for Isospin Mixing of the Lowest T=2 States in ^{44}Ti, ^{48}Cr and ^{52}Fe.* M.A.M. SHAHABUDDIN, A. MOALEM. R.G. MARKHAM and H. NANN, Mich State U. --In a recent study of the $^{58}Ni(p,t)^{56}Ni$ reaction[1] a triplet of 0^+ states was observed in the excitation energy region where the lowest T=2 state is expected to lie indicating isospin mixing of the double analog state with close lying 0^+ states of lower isospin. We have studied the $^{46}Ti(p,t)^{44}Ti$, $^{50}Cr(p,t)^{48}Cr$ and $^{54}Fe(p,t)^{52}Fe$ reactions and found a doublet of 0^+ states in the region of the double analog state in ^{44}Ti(9.13 and 9.33 MeV) and in ^{48}Cr(8.74 and 8.75 MeV) with the cross section ratios 0.25 and 0.90, respectively. From this information we estimated the isospin violating matrix elements and the mixing of the states.

*Supported by the National Science Foundation
[1]H. Nann and W. Benenson, Phys. Rev. C10, 1880(1974)

The MSU On-Line Mass Identification System.* M. EDMISTON, K. KOSANKE, WM. C. McHARRIS, R.A. WARNER, and W.H. KELLY, Mich. State Univ.--The Michigan State University on-line mass separator, SIEGFRIED, is now complete and undergoing preliminary tests to measure efficiency and resolution.[1] The instrument uses the time-of-flight method to determine the masses of nuclei recoiling from β decay. The mass information is used to label the photopeaks in the resulting γ spectrum. Activity is produced by either the MSU cyclotron or from a recently purchased ^{252}Cf source and quickly brought to SIEGFRIED by MSU's He-jet transport system. This yields nearly on-line mass separation permitting fast analysis of spectra far from β stability.

*Work supported by USERDA and NSF.
[1]K.L. Kosanke, M.D. Edmiston, and Wm. C. McHarris, MSU Cyclotron Annual Report 1972-73, p.93.
[2]M.D. Edmiston, K.L. Kosanke, Wm. C. McHarris, R.A. Warner, and W.H. Kelly, MSU Cyclotron Annual Report 1973-74, p. 86.

Techniques for Using Energy-Level Data to Renormalize Shell-Model Hamiltonians.* W. CHUNG and B.H. WILDENTHAL, Mich. State Univ.--We describe some extensions and refinements to the technique of using level-energy data to determine shell-model interactions. We have modified the Oak Ridge-Rochester and Glasgow shell-model codes so as to be able to evaluate 1-and 2- body density matrices conveniently. These results are then manipulated in an iterative least-squares search routine so as to arrive eventually at the "best" interaction for the data set used. We have attacked the root problem of this technique, namely the mismatch between a physically "realistic" orbit space and a "manageable" number of Hamiltonian matrix elements, by reconstituting the search into one over the N best determined (to some controlled level of uncertainty) orthogonal linear combinations of parameters. These linear combinations thus express the physically relevant (so far as energies are concerned) aspects of the shell-model interaction.

*Supported by the National Science Foundation.

The ε/β^+Decay of $^{143g+m}Gd$.* WM.C. McHARRIS, R.B. FIRESTONE, R.A. WARNER, and W.H. KELLY, Mich. State Univ.--$^{143g+m}Gd$ were produced by 52-MeV ^3He on enriched (95.10%) $^{144}Sm_2O_3$ targets at the Michigan State University Sector-Focused Cyclotron. Activities produced were transported by a He-Jet transport system to a low background area where excitation function, $t_{1/2}$,γ-γ coincidences and singles, and delayed proton spectra were taken. The half-lives of ^{143g}Gd and ^{143m}Gd were measure to be 39±2 sec and 112±2 sec, respectively. Approximately 61 γ-rays deexciting 35 levels were assigned to ^{143m}Gd decay and 7 γ -rays from 6 levels were assigned to ^{143g}Gd decay. A small delayed proton branch was observed comprising >0.001% of all $^{143+gm}Gd$ decays. ^{143}Eu was also studied by pulsed beam experiments using the $^{144}Sm(p,2n)^{143}Eu$ reaction. The half-life of the $11/2^-$ state in ^{143}Eu was measured to be $t_{1/2}$ =50.0±0.5 μs.

*Work supported by the USERDA and the NSF.

On the α+α Reaction at 140 MeV and the Formation of ^{7}Li in Nature.* G.J. MATHEWS, V.E. VIOLA, R.G. CLARK, Univ. of Maryland; H.H. ROSSNER, SAM M. AUSTIN, C.H. KING, W.S. CHIEN, Mich. State Univ.--Cross sections for the ^{4}He(α,p)^{7}Li and ^{4}He(α,d)^{6}Li reactions at 140 MeV were determined from the angular distribution of the protons and deuterons leading to bound states. These results, together with previous measurements at lower energies,[1] introduce new estimates for the spallation production rates of ^{7}Li and ^{6}Li in the Galaxy. These estimates support a need for an alternate production mechanism to account for the observed Li isotopic ratio and abundance.

*Research supported by the USAEC and the NSF.
[1]H.H. Rossner et al., BAPS 19, 1036(1974).

Shell-Model Calculations for the Zinc Isotopes.* J.F.A. VAN HIENEN,** W. CHUNG, and B.H. WILDENTHAL, Mich. State Univ.--Shell-model calculations for the zinc isotopes have been carried out in the full $p_{3/2}$-$p_{1/2}$-$f_{5/2}$ model space with the effective Hamiltonian (based on a fit to Ni and Cu level energies) of Koops and Glaudemans.[1] Results for excitation energies, spectroscopic factors, electromagnetic moments and transition rates, Gamow-Teller log ft's and inelastic electron scattering form factors have been obtained. The adequacy of the model space and the Hamiltonian in accounting for these phenomena will be discussed.

*Research supported in part by the U.S. National Science Foundation.
**Fellow of the Niels Stensen Foundation, The Netherlands.
[1]P.W.M. Glaudemans, private communication.

Resolution of Discrepancies Associated with Analog States of Pb and Bi.* AARON GALONSKY, G.M. CRAWLEY, R.R. DOERING, P.S. MILLER, and D.M. PATTERSON,+ Mich. State Univ.--It has been reported[1] that the cross section for the reaction ^{209}Bi(p,n)^{209}Po (IAS) at 25 MeV is 5.4 mb, whereas the cross section for proton decay of the IAS is almost 15 mb. The discrepancy may be due to errors in determining each of the cross sections. A larger (p,n) cross section is extracted from the data if a Lorentzian, not a Gaussian line shape is assumed for the IAS. A small (p,n$\hat{p}$) cross section is obtained if one takes proper recognition of the fact that the background in the $\hat{p}$ spectrum is expected to be peaked right under the $\hat{p}$ peaks. The Coulomb-barrier cutoff of the proton evaporation spectrum produces the background peak. Similar effects arise with targets of the lead isotopes. The peaked proton background may also resolve a discrepancy noted in determining the widths of these IAS.

[1]S.M. Grimes, et al., Phys. Rev. Lett. 30, 922(1973)
*Supported by the National Science Foundation and the Office of Naval Research.
+Present address: Univ. of Texas, Austin, Texas 78712.

Energy Levels of ^{31}P.* J.A. NOLEN and H. NANN, Mich. State Univ.--Spectra of protons inelastically scattered from ^{31}P at 35 MeV have been recorded on nuclear emulsions in an Enge split-pole magnetic spectrograph with a resolution of 2.5 keV FWHM. Excitation energies for the states observed have been determined with uncertainties of <1 keV independent of previous assignments in ^{31}P. In the bound state region of the spectra (below 7.3 MeV excitation) several new levels have been identified. Of the approximately 70 particle unbound states observed in the region between 7.3 and 10 MeV excitation, many correspond to levels seen previously as resonances, but many were previously unknown. The two sets of levels will be compared to determine the usefulness of the direct (p,p') reaction for level density measurements.

*Supported by the National Science Foundation.

AMERICAN PHYS. SOC. AUSTIN MEETING, Oct. 1975

Inelastic Electron Scattering Form Factors and B(E2) Values.* B.H. WILDENTHAL and W. CHUNG, Mich. State Univ.--Measurements of B(E2) values for sd-shell nuclei which are characterized by both small uncertainties and good reproducibility are now available. The form factors for inelastic electron scattering to the 2^+ states of even-even sd shell nuclei have also been measured.

The juxtaposition of the two types of data allows the possibility of disentangling contributions of the radial extent of single-particle wave functions and of effective charges to the probabilities for $0^+ \to 2^+$ excitations calculated with model wave functions. Results from full sd-shell space calculations for nuclei in the range ^{20}Ne-^{36}Ar will be discussed.

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

First Observation of ^{59}Mn.* E. KASHY, W. BENENSON, D. MUELLER, H. NANN, and L. ROBINSON, Mich. State Univ.--A new reaction, (^{3}He,^{8}B) has been used to measure the mass of the previously unobserved isotope ^{59}Mn. The 74 MeV ^{3}He beam of the MSU Cyclotron induced the reactions, and the products were analyzed in an Enge split-pole spectrograph. The position in the focal plane was determined with a resistive wire proportional counter. Particle identification was accomplished by measuring the specific ionization of the particles as well as their pulse height in a plastic scintillator and their time of flight in the spectrograph. The (^{3}He,^{8}B) reaction on ^{27}Al, which leads to ^{22}Ne, was also observed, and the transitions to the 0^+ ground state and 1.275 MeV 2^+ state of ^{22}Ne served as calibration for the ^{59}Mn mass. A preliminary value of -55.52±.04 MeV for the mass excess of ^{59}Mn has been obtained. Details of the experiment and comparison of the results with various mass prediction will be presented.

*Supported by the National Science Foundation.

AMERICAN PHYS. SOC. AUSTIN MEETING CONT. Oct. 1975

Measurements of Excited levels in ^{55}Ni and ^{43}Ti.* D. MUELLER, E. KASHY and W. BENENSON, Mich. State Univ.--The ^{58}Ni(^{3}He,^{6}He)^{55}Ni and ^{46}Ti(^{3}He,^{6}He)^{43}Ti reactions have been employed to observe and measure excited levels in ^{55}Ni and ^{43}Ti. The ^{6}He particles were detected in the focal plane of an Enge split-pole spectrograph with a resistive-wire proportional-gas counter. Partial angular distributions have been taken for these reactions. The low cross sections of .03 μb/sr to 1.0 μb/sr limit the extent and accuracy to the angular distributions. Analysis of the data has yielded 15 states in ^{55}Ni and 7 states in ^{43}Ti below 7 MeV excitation. Comparisons of the Coulomb displacement energies of the lowest lying $1/2^+$, $3/2^+$ and $7/2^+$ levels are made with calculations. Systematics of the Coulomb displacement energies are discussed.

*Supported by the National Science Foundation.

Proton Decay of the Isobaric Analogs of the Grounds States of ^{207}Pb and ^{208}Pb.* R.K. BHOWMIK R.R. DOERING, A. GALONSKY, and P.S. MILLER, Mich. State Univ.--The proton decays of isobaric analog states of ^{207,208}Pb in the reactions ^{207,208}Pb (p,n) have been studied using a neutron-proton coincidence technique. Together with the p groups in coincidence with IAS neutrons, a peak in the proton spectrum is observed in coincidence with lower energy neutrons. The presence of this peak can explain the anomalously large IAS cross sections and widths previously inferred from (p,np) singles spectra.

*Supported by the National Science Foundation.

Study of (p,α) on ^{24}Mg at 35 MeV,* R.K. BHOWMIK, J.A. NOLEN, P.A. SMITH, R.G. MARKHAM and M.A.M. SHAHABUDDIN, Mich. State Univ.--The ^{24}Mg (p,α) and ^{26}Mg (p,α) reactions have been studied using the 35 MeV proton beam of the MSU cyclotron. The energy resolution (~30 keV) has been sufficient to resolve most of the states of ^{21}Na and ^{23}Na up to 10 MeV excitation. The yields to some states which require seniority 3 transfer are comparable to those in which seniority one is allowed. A state in ^{23}Na is seen with relatively large cross section at the position of the $13/2^+$ state seen in the ^{12}C(^{12}C,p) reaction.[1] Transitions to two different states with the same spin and parity do not always have similar angular distributions; however, the corresponding states between ^{21}Na and ^{23}Na do have similar shapes. A microscopic model for the 3 nucleon pickup form factor has been programmed using single particle Woods-Saxon wave functions. DWBA calculations using these form factors, as well as cluster transfer form factors will be presented.

*Supported by the National Science Foundation.
[1]G.J. Kekells, A.H. Lumpkin and J.D. Fox (unpublished)

AMERICAN PHYS. SOC. WASHINGTON MEETING April 1976

The Nuclear Physics of Helium Burning Stars* SAM M. AUSTIN, Mich. State Univ.--Determining the ratio of ^{12}C to ^{16}O at the completion of helium burning in a stellar core is one of the important questions of astrophysics, since the ashes of the helium burning stage serve as the initial conditions for later stages of stellar evolution. Two reaction rates, that for the triple-alpha process ($3\alpha \rightarrow ^{12}$C) and that for the ^{12}C(α,γ)^{16}O reaction determine the relative production of ^{12}C and ^{16}O. These rates in turn depend primarily on the detailed properties two nuclear energy levels: The 0^+ level near 7.65 MeV in ^{12}C and the 1^- level near 7.1 MeV in ^{16}O (indeed, Hoyle predicted on the basis of astronomical evidence that there must be a 0^+ level near 7.7 MeV in ^{12}C). In recent years a series of difficult experiments have fixed the properties of these levels with sufficient accuracy to conclude that ^{12}C is the major product of helium burning for most stars. These experiments form almost a catalog of the techniques of modern nuclear physics, involving measurements of such diverse quantities as electron-scattering cross sections, branching ratios for γ-ray and pair decay, excitation energies and nuclear masses. I will review the present status of our knowledge of the reaction rates and their astrophysical implications, with emphasis on recent work concerning the 3α process done at Michigan State University. A new measurement which may decrease the uncertainty in the ^{12}C (α,γ)^{16}O rate will be discussed.

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

Monopole Excitations in Inelastic Hadron Scattering.* H.P. MORSCH, Mich. State Univ. --Shape transitions without transfer of angular momentum are among the least understood excitations in nuclei. Two different monopole excitation modes are possible, one arising from n particle-nhole configuration mixing in the wavefunctions of ground and low lying 0^+ states and the other from the 1p1h giant monopole excitation. This breathing mode of the nucleus is particularly important because it gives information on the compressibility of nuclear matter, a property which has not experimentally been determined up to present. Admixtures into low lying 0^+ states enter into several different problems, such as the Nolen-Schiffer anomaly and the isotope shift.

A systematic study of low lying monopole transitions in ^{3}He and α scattering from sd and $f_{7/2}$ shell nuclei has been performed at Heidelberg and Minnesota. The data, which show very pronounced angular distributions, could be successfully described in a microscopic model. Derived monopole transition densities yield E0 matrix elements and transition radii consistent with electron scattering. The angular distributions were found to be extremely sensitive to the transition form factors and thus yield detailed information on the structure of ground and excited 0^+ states will be discussed. In a search for the Giant monopole excitation, data from proton and ^{3}He scattering experiments on ^{208}Pb will be presented. A monopole state is found at 9.11 MeV which exhausts about 7% of the energy weighted monopole sum rule strength.

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

Status Report on Superconducting Cyclotron Magnet.* H.G. BLOSSER, Mich. State Univ.--A full-scale prototype magnet for a superconducting cyclotron is under construction. Design calculations indicate this magnet will be able to bend ions with $E \leq 500\ (Q^2/A)$ MeV and will be able to focus ions with $E/A \leq 160\ (Q/A)$ MeV. The superconducting main coil will be fabricated from 120,000 feet of 770 ampere, cryogenically-stabilized NbTi conductor. Delivery of conductor is now scheduled for April 1976. The pole base and the "pill box" return yoke will be fabricated from 1020 steel castings; the first casting has been poured and the remaining four are scheduled to follow at approximately two-week intervals. The fully machined pole bases and yoke are scheduled for delivery in June, along with a removable central plug so that the magnet can be configured both with a central hole as appropriate for a post accelerator and with a central cone as needed for a stand-alone, internal-source cyclotron. Allowing for coil winding, cryostat installation, installation of median plane penetrations etc., it appears marginally possible to be ready for first magnetic measurements in December 1976, which would be two months in advance of the originally anticipated schedule.

*Work supported by the National Science Foundation.

Magnetic Dipole Moments of sd-shell Nuclei.* W. CHUNG and B.H. WILDENTHAL, Mich. State Univ.--We have used shell-model wave functions generated in the full $d_{5/2}$-$s_{1/2}$-$d_{3/2}$ space from empirical Hamiltonians in the calculation of magnetic dipole moments of ground and excited states of sd-shell nuclei. Predictions have been obtained both from the assumptions of the bare-nucleon values of the single-particle matrix elements and from values obtained by a fit to available precise experimental values. For A=17-25 nuclei, good agreement with experiment is obtained with either M1 operator. For A=29-39, however, the results from the bare-nucleon operator agree less well with experiment than those from the fitted operator.

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

Mass of ^{44}Ar.* G.M. CRAWLEY,+ J.N. BISHOP, W.F. STEELE,** P.A. SMITH, and S. MARIPUU++ Mich. State Univ.--The mass of ^{44}Ar was remeasured using the ^{48}Ca(^{3}He,^{7}Be) reaction at 70 MeV. The ^{7}Be particles were detected with a resistive wire proportional counter in the focal plane of an Enge split-pole spectrograph. Particle discrimination was accomplished using a time of flight measurement through the spectrograph. Impurity peaks which previously partially obscured the ^{44}Ar ground state were reduced using blocking pins in the impurity focal plane. The preliminary result for the mass excess is $-32.27 \pm .02$ MeV which is .49 MeV heavier than the Garvey-Kelson prediction. ^{44}Ar excited states are seen at $.75 \pm .03$, $1.61 \pm .03$, $3.48 \pm .03$, $3.98 \pm .05$ and $4.43 \pm .04$ MeV.

*Supported by U.S. National Science Foundation.
+Present address: NSF, Washington, DC.
**Present address: U. of California, Berkeley
++Present address: Duke University.

The Heaviest-Known T=1/2 Mirror Pair, ^{47}Cr-^{47}V.* M.D. EDMISTON, R.A. WARNER, and WM. C. McHARRIS, Mich. State Univ.--Measurements of the half-lives for the mirror-decays in the $f_{7/2}$ shell are desirable especially since the masses for these nuclei are now known.[1] However, these half-lives are hard to measure because production cross sections are small, cluttered with unwanted products, and the half-lives are short (<1 sec.). By utilizing our on-line mass identifier, SIEGFRIED, we have unambiguously found a mass-47 isotope with a half-life of about 0.5 sec. It was produced by the ^{46}Ti(^{3}He,2n) and ^{46}Ti(α,3n) reactions and could be identified as ^{47}Cr. Preliminary measurements of its half-life yield the value 0.46 ± 0.02 sec. Taken with the Q value, measured from particle-transfer experiments, this yields a log ft=3.63.

[1]D. Mueller, E. Kashy, W. Benenson, and H. Nann, Phys. Rev. C 12, 51(1975).
*Supported by the U.S. National Science Foundation.

Inelastic Proton Scattering From ^{176}Yb and ^{154}Sm.* J.E. FINCK, G.M. CRAWLEY,† and J.A. NOLEN, JR., Mich. State Univ.--Because of the complementary nature of (e,e') and (p,p') in probing proton and neutron transition densities and because there are existing (e,e') data on ^{154}Sm and ^{176}Yb,[1] measurements of the (p,p') reaction on these nuclei was carried out with 35 and 40 MeV proton beams from the MSU Cyclotron. The protons were detected both with a delay line counter and with nuclear emulsions in the focal plane of the Enge spectrometer. States up to 8^+ in the ground state band of both nuclei were observed and many levels in other bands were also seen. Angular distributions have been measured from 20° to 80°. Calculations of the angular distributions will be presented.

*Submitted by H. McMANUS.
†Supported by the U.S. National Science Foundation.
†Present address: National Science Foundation, 1820 G street, Washington, D.C.
[1]W. Bertozzi, "High Energy Physics and Nuclear Structure", Santa Fe, 1975, AIP Conference Proceedings No. 26, p. 409.

An Explanation of the Anomalous ^{22}Na ε/β^+ Decay Branching Ratio.* R.B. FIRESTONE, WM. C. McHARRIS, and W.H. KELLY, Mich. State Univ.--The ^{22}Na ε/β^+ decay branching ratio differs from theoretical calculations by 7.9±0.4%. This accurately measured value has been used as evidence for the absence of Fierz interference; however, the noted discrepancy has never been satisfactorily explained. The inclusion of "second forbidden" terms in the calculated ratio can be shown to account for this discrepancy if the weak magnetism $\int \vec{\alpha} x r$ matrix element is an order of magnitude larger than that predicted by the intrinsic magnetic moments of the proton and neutron alone. This possibility is realistic because the decay is severely hindered with a logft=7.40, making the $\int \vec{\sigma}$ matrix element small.

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

Observation of Highly Neutron-Rich ^{43}Cl.* E. KASHY, W. BENENSON, D. MUELLER, H. NANN and L. ROBINSON, Mich. State Univ.--We have observed the previously unknown T_z=9/2 isotope of chlorine in the 5-nucleon pickup reaction ^{48}Ca(^{3}He,^{8}B)^{43}Cl. The targets consisted of ^{48}Ca evaporated unto either C or Ag foils, and the method was the same as used earlier in the observation of ^{59}Mn.[1] The very negative Q-value of the reaction increased the difficulty of the measurement considerably since peaks from the ^{12}C contaminant on the target fell in the region of interest. A yield of about 25 nb/sr was measured at angles from 8° to 10°. A preliminary value for the mass excess of ^{43}Cl is -23.14±.06 MeV, thus indicating that ^{43}Cl is significantly less bound than semi-empirical predictions indicated.[2]

*Supported by the U.S. National Science Foundation.
[1]E. Kashy, W. Benenson, D. Mueller, H. Nann and L. Robinson, BAPS 20 1164(1975).
[2]N.A. Jelley, J. Cerny. D.P. Stahel and K.H. Wilcox, Phys. Rev. C11 2049(1975).

High-Spin, Multi-quasiparticles Yrast Traps in ^{176}Hf.* T.L. KHOO, F.M. BERNTHAL, R.G.H. ROBERTSON and R.A. WARNER, Mich. State Univ.--We have employed the (α,4n) reaction and a variety of γ-ray and conversion electron spectroscopic techniques to study the high spin structure of ^{176}Hf in the region between 2.5 and 5 MeV. In addition to a 4-quasiparticle (qp) $K^\pi=15^+$ state 4-qp rotational bands based on a 401-μsec $K^\pi=14$ isomer[1] and a $K^\pi=16^+$ state have been observed up to spin 20. We have also located three 6-qp states near 5 MeV; two of these, with $K^\pi=22^-$ and 19^+, have half-lives of 40 μsec and 84 nsec, respectively. The third 6-qp state has $K^\pi 20^-$. The yrast line changes from the g.s.b. to the $K^\pi=22^-$ structure at I=22. The multi-qp structures thus serve as yrast traps. The relationship to yrast traps which are predicted[2] to occur when some nuclei become oblate at much higher spin will be discussed.

*Supported by the U.S. National Science Foundation.
[1]T.L. Khoo, et al., Phys. Rev. Lett. 35, 1256(1975).
[2]A. Bohr and B.R. Mottelson, Nuclear Structure v.2 (Benjamin 1975).

A Study of the Even Platinum Nuclides Using the (p,t) Reaction.* C.H. KING, P.T. DEASON, F.M. BERNTHAL, T.L. KHOO, and J.A. NOLEN, JR., Mich. State Univ.--The vibrational model has frequently been successful in describing nuclear properties in the transitional region between closed-shell and well-deformed nuclides. However, the Pt nuclides would not seem to fit into this model, since no known 0^+ states are low enough in energy to be appropriate candidates for the 0^+ member of the two-phonon triplet. To search for the states we measured the ^{194,196,198}Pt(p,t) reactions using 35-MeV protons and targets of 96% isotopic enrichment. Triton angular distributions were measured for transitions to states below 1.5-MeV excitation energy, and no excited 0^+ states were observed below 1 MeV. This suggests that another model, such as the triaxial rotor model,[1] is perhaps more appropriate for the Pt nuclides.

*Supported by the U.S. National Science Foundation.
[1]J. Meter-ter-Vehn, Nucl. Phys. A249, 111 and 141 (1975); and T.L. Khoo, et al., Phys. Lett. in press.

Structural Changes in the Yrast Levels of ^{178}Hf.* G. LOVHOIDEN, Univ. of Bergen and McMaster Univ. and T.L. Khoo, Mich. State Univ. and McMaster Univ.--The high spin level structure of ^{178}Hf has been investigated using the (α,2n) reaction, with experiments performed both with the McMaster FN Tandem Accelerator and the MSU Cyclotron. The ground band has been observed to $I=14^+$. Two $K^\pi=8^-$ bands of mixed proton and neutron 2-quasiparticle (qp) structure have also been identified to spin 14. The yrast sequence changes from the ground band to the lower $K^\pi=8^-$ band at I=12, and again to a $K^\pi=16^+$ four-qp state for $I\geq16$. Thus, in this nucleus the yrast structure at high spin corresponds to motion of a few quasiparticles around the nuclear symmetry axis. Similar behaviour is predicted[2] to occur in ultra high-spin states in some nuclei.

*Partially supported by the U.S. National Science Foundation, U.S. ERDA and NRC, Canada.
[1]R.G. Helmer and C.W. Reich, Nucl. Phys. A114, 649 (1968).
[2]A. Bohr and B.R. Mottelson, Nuclear Structure v.2 (Benjamin, 1975).

Proton Hole States in ^{119,121}Sb.* R.G. MARKHAM, R.K. BHOWMIK, P.A. SMITH, J.A. NOLEN, JR. and M.A.M. SHAHABUDDIN, Mich. State Univ.--The ^{122,124}Te(p,α) ^{119,121}Sb reactions have been studied at 35 MeV. Similar levels are populated in both final nuclei. Comparison to proton pickup data[1] shows that mainly proton hole states are populated in ^{121}Sb. DWBA calculations further support this conclusion. The identification of the 0.970, 1.487 and 1.676 MeV levels as the principal $g_{9/2}$, $p_{1/2}$ and $0_{3/2}$ hole states of ^{119}Sb is then established by their similar angular distributions. No apparent rotational structures were seen; however, a tentative $J^{\pi}=5/2^-$ seniority three state was observed in both final nuclei.

*Supported by the National Seience Foundation.
[1]M. Conjeaud, S. Harar, M. Caballero and N. Cindro, Nucl. Phys. A215 (1973)383.

Fine Structure in the Region of Giant Resonances in ^{208}Pb.* H.P. MORSCH, P. DECOWSKI and W. BENENSON, Mich. State Univ.--High Resolution spectra of 45 MeV protons scattered inelastically from ^{208}Pb show very rich structure even at excitations as high as 8-11 MeV. There are many resolvable peaks, and their angular distributions indicate excitations of different multipolarities: dipole, quadrupole and octupole. A peak was found at 9.11 MeV which has an L=0 angular distribution. Its strength, which exhausts 7% of energy weighted monopole sum rule, suggests that it is a part of the giant monopole resonance. The concentration of L=1 strength in peaks from 7 to 8.5 MeV is discussed. Above 8.5 MeV, the majority of the peaks show L=2 angular distributions in agreement with the localization of the giant quadrupole resonance in the excitation region around 10 MeV.

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

Levels in ^{47}Cr and ^{51}Fe.* D. MUELLER, E. KASHY, and W. BENENSON, Mich. State Univ.--The (^{3}He,^{6}He) reaction has been employed to observe and measure excited levels in ^{47}Cr and ^{51}Fe. A beam of 70 MeV ^{3}He particles from the MSU Cyclotron induced the reaction. The reaction products were analyzed in an Enge split-pole spectrograph as has been previously described.[1] The ground and first excited states of ^{47}Cr have been resolved thereby improving the accuracy of the mass measurement. A preliminary value of -34.618±.025 MeV has been determined for the mass excess of ^{47}Cr. Despite the low cross sections (.1 to 1.0 μb/sr) angular distributions have been taken as far back as 27°. Comparisons of the Coulomb displacement energies for the lowest lying $7/2^-$, $5/2^-$, $3/2^+$ and $1/2^+$ levels have been made, and systematics of the Coulomb displacement energies will be presented.

*Supported by the U.S. National Science Foundation.
[1]E. Kashy, W. Benenson, I.D. Proctor, P. Hauge and G. Bertsch, Phys. Rev. C7 2251(1973).

(p,t) and (p,^{3}He) on T_z=1/2 Nuclei in the 2s-1d Shell.* H. NANN and B.H. WILDENTHAL, Mich. State Univ.--Angular distributions of the (p,t) and (p,^{3}He) reaction on all T_z=1/2 nuclei in the 2s-1d shell have been measured at 40 MeV proton energy. These data have been analyzed with the DWBA utilizing multiconfiguration shell-model wave functions. The results for the ground state transitions are systematically anomalous for the (p,^{3}He) reaction in that the (S=0,T=1) component of the predicted transfer strength, normalized to the mirror (p,t) cross section magnitude, accounts for all of the strength observed. This has the consequence that the additional contributions of the (S=1,T=0) terms yield a consistent overprediction of the (p,^{3}He) cross sections. The (p,t) and (p,^{3}He) cross sections to the T=3/2 states are correctly dealt with, which indicates that the anomaly does not lie in simple aspects of the DWBA description.

*Supported by the National Science Foundation.

Study of the ^{51}V(p,t)^{49}V and ^{50}Ti(p,t)^{48}Ti Reactions and the Weak Coupling Core-Excitation Model.* A. SAHA, K.K. SETH, Northwestern Univ., and H. NANN, Mich. State Univ.--The ^{51}V(p,t)^{49}V and ^{50}Ti(p,t)^{48}Ti reactions have been studied with the MSU cyclotron at incident proton energy of 40 MeV. States in ^{48}Ti up to 5 MeV excitation energy and in ^{49}V up to 4.3 MeV excitation energy were observed with an energy resolution of 15-20 keV (FWHM). Spin and parity values were determined from the shapes of the measured angular distributions taken in the angular range of 6° to 55°. The weak-coupling model has been explored as an alternative empirical explanation for the structure of the odd-parity states of ^{49}V. In this model, a $f_{7/2}$ proton coupled to the strong 0^+ levels (g.s. and 2999 KeV) and 2^+ levels (985 keV, 2416 keV, 3363 keV) in a ^{48}Ti "core" (states observed with the ^{50}Ti(p,t)^{48}Ti reaction) can give rise to weak-coupling negative parity multiplets in ^{49}V.

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

Study of ^{85}Sr and ^{86}Sr with the (p,t) Reaction and the Weak-Coupling Core-Excitation Model.* K.K. SETH, A. SAHA, Northwestern Univ. and H. NANN, Mich. State Univ.--The ^{88,87}Sr(p,t) ^{86,85}Sr reactions have been studied with 40 MeV protons from the MSU cyclotron. States in ^{86}Sr up to 4.5 MeV excitation energy and in ^{85}Sr up to 2.7 MeV excitation energy were obtained with an energy resolution of 15-20 keV (FWHM). Many new states in both nuclei were observed and from the shapes of the measured angular distributions (taken in the angular range 3° to 55°), spin and parity values were assigned. The weak-coupling core-excitation model has been invoked to classify the states in ^{85}Sr. In this model, a $g_{9/2}$ neutron hole coupled to strong collective states in a ^{86}Sr "core" (observed with the ^{88}Sr(p,t)^{86}Sr reactions) give rise to weak-coupling multiplets in ^{85}Sr.

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Γπ/Γ for the 7.65 MeV 0^+ State in ^{12}C and the 3α Reaction Rate,* R.G.H. ROBERTSON, R.A. WARNER and SAM M. AUSTIN, Mich. State Univ.--The rate at which three α particles fuse to form ^{12}C in helium burning stars is inversely proportional to Γπ/Γ for the 7.65 MeV state. Only a single measurement ($\Gamma\pi/\Gamma=(6.9\pm2.1)\times10^{-6}$ is available[1] and its uncertainty now limits the accuracy of the predicted rate. We have populated the 7.65 MeV state by $^{12}C(p,p')$ at 10.54 MeV and counted the decay e^+-e^- pairs in coincidence with the inelastic proton group. The ratio Γπ/Γ is obtained by dividing the number of coincidences of protons and pairs by the number of inelastic events. Pairs are detected in a 7 cm diameter plastic scintillator which surrounds the target (∿4π geometry) and which is segmented into an inner and outer region to reduce sensitivity to γ rays. Our preliminary result is consistent with Alburger's measurement[1] and has an uncertainty of about 15%.

*Supported by the National Science Foundation.
[1]D. Alburger, Phys. Rev. 118, 235(1960); A.W. Obst et al., Phys. Rev. C5, 738(1972).

Features of the (p,α) Reaction as Seen in the $^{52}Cr(p,\alpha)^{49}V$ Reaction.* P.A. SMITH, R.G. MARKHAM, M.A.M. SHAHABUDDIN, J.A. NOLEN,JR., Mich. State Univ.--We have studied the $^{52}Cr(p,\alpha)$ reaction at a bombarding energy of 35 MeV. The strongest states are the $7/2^-$ ground state and the $3/2^+$ and $1/2^+$ sd-shell hole states. A large number of weaker, more complicated seniority three transfers are also observed. In the excitation region from 6 to 9 MeV we have observed the analogs of the hole states in ^{49}Ti. A comparison with $^{51}V(p,t)$[1] and $^{50}Cr(t,\alpha)$[2] results will be presented. Some states seen with significant strength in the (p,t) data are virtually absent from the (p,α) spectra. DWBA calculations employing microscopic Woods-Saxon form factors will be compared with the data. Relative spectroscopic factors for both $T_<$ and $T_>$ hole states have been extracted assuming simple seniority wavefunctions. Coulomb energies for the analog states will also be given.

[1]A. Saha, H. Nann, K.K. Seth, to be published.
[2]D. Bachner, et al., Nucl. Phys. A106(1968) 577.
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Optimum Coupling of a Tandem Injector to a Superconducting Heavy Ion Cyclotron.* J.N. BISHOP, Mich. State Univ.--The optimum choice of charge states has been studied for the coupling of Tandems of 13 and 25 MV maximum voltage to the prototype superconducting cyclotron magnet being built at MSU. The optimum choice results from maximizing $P_1(Q_1)P_2(Q_2)$, the product of the probabilities for stripping to charge states Q_1 in the tandem and Q_2 in the cyclotron. For a wide range of ions and energies a lower than equilibrium charge state from the tandem stripper must be chosen in order to make the injection orbit sufficiently rigid to reach the central region of the cyclotron. This can be produced by a very low pressure gas cell. Further restriction in the allowed range of injection orbit rigidity is necessary to fit the injection paths into the confined space in the median plane. Results of calculations of injection paths and optimum charge states will be shown.

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A 0.5-sec ($\nu i_{13/2}^{-2}$, $\nu f_{5/2}^{-1}$) $J^\pi=29/2^-$ Isomer in ^{203}Pb.* H. HELPPI, S.K. SAHA, P.J. DALY, Purdue Univ. and S.R. FABER, T.L. KHOO, F.M. BERNTHAL, Mich. State Univ.--The level structures of light odd-A Pb nuclei are being studied by (α,xn) in-beam γ-ray spectroscopy using the MSU cyclotron. A pulsed beam $^{202}Hg(\alpha,3n\gamma)$ experiment has revealed a ^{203}Pb isomer with $t_{1/2}=0.48\pm0.04$ sec, which de-excites through high-spin positive parity levels to the known 6.2 sec $13/2^+$ isomer at 825 keV. From γ-γ coincidence data and transition multipolarities based on intensity balance requirements, the isomeric decay scheme has been established. The 0.5-sec isomeric state is assigned $J^\pi=29/2^-$, and a dominant configuration of ($\nu i_{13/2}^{-2}$ $f_{5/2}^{-1}$) is proposed. The high-spin level structure of ^{203}Pb will be discussed with reference to $^{199-206}Pb$ level systematics, including new results of ours for ^{199}Pb and ^{201}Pb.

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$\nu i_{13/2}$ and $\nu h_{9/2}$ Isomers in Odd-A Pt nuclei.* S.K. SAHA, M. PIIPARINEN, P.J. DALY, Purdue Univ. and C.L. DORS, F.M. BERNTHAL, T.L. KHOO, Mich. State Univ.--$13/2^+$ isomers with half-lives of 311 ± 15, 143 ± 5 and 95 ± 5 μs in ^{187}Pt, ^{189}Pt and ^{191}Pt, respectively, have been observed in Os (α,3nγ) reactions. Levels of ^{191}Pt populated in the decay of 3.2 h ^{191}Au have also been studied and a rather complete ^{191}Au decay scheme, which differs radically from earlier versions, has been established. On the basis of the combined ^{191}Au decay and (α,3nγ) results, and those obtained in an earlier study of ^{189}Au decay[1], it is proposed that the $^{187,189,191}Pt$ $13/2^+$ isomers de-excite by M2 transitions to $9/2^-$ intrinsic states of $\nu h_{9/2}$ character. Isomeric decay schemes will be presented for ^{189}Pt and ^{191}Pt; in these nuclei, the $9/2^-$ states are also isomeric with half-lives of 0.46 μs[1] and >1 μs. The corresponding $9/2^-$ levels in A ≥ 193 Pt nuclei must lie above the known long-lived $\nu i_{13/2}$ isomers. Other aspects of the odd-A Pt level spectra will also be discussed.

*Work supported by the USERDA and the NSF.
[1]M. Finger et al., CERN Report No. 70-29 (1970).

Evidence for a Five-Quasiparticle Isomer in ^{177}Ta. L. BUJA-BIJUNAS, J.C. WADDINGTON, McMaste Univ. and T.L. KHOO, Mich. State Univ.--Recent interest in the study of many-quasiparticle states in ^{176}Hf has prompted a similar study of high-spin states in ^{177}Ta. Experiments at McMaster and Michigan State Universities using the ^{170}Er(^{11}B, 4n) and ^{176}Lu(α,3n) reactions have located a high spin isomer at 2826.9 keV. This isomer decays with a half life of approximately 70ns by 555 and 790 keV transitions to previously identified 3 quasiparticle states.[1] Delayed and prompt γ-γ techniques were used to isolate the γ-rays feeding and de-exciting this isomer.

[1]D. Barneoud, S. Andre and C. Foin, Phys. Lett. 55B, 443 (1974).

Search for $(f_{7/2})^{-3}$ Configuration States in ^{45}Ca.* H. NANN, E. KASHY and D. MUELLER, Mich. State Univ.--Angular distributions of the ^{48}Ca(^{3}He,^{6}He)^{45}Ca reaction have been measured at 70 MeV bombarding energy. Several states in ^{45}Ca up to an excitation energy of 4.5 MeV are strongly excited. Since, except for the 7/2$^-$ state the $(f_{7/2})^{-3}$ configurations have seniority 3, these states are not strongly excited in single-nucleon transfer reactions, but are expected to be strong in the three-neutron pick up reaction. A comparison with states observed in the ^{44}Ca(d,p)^{45}Ca reaction[1] gives evidence for the $(f_{7/2})^{-3}$ configuration of these states.

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

[1]Rapaport, Dorenbusch and Belote, Phys. Rev. 156, 1255(1967).