SECTION II

ABSTRACTS OF TALKS AT MEETINGS

(July 1973-June 1974)

Levels of ^{199}Hg Populated in ^{199}Tl Decay.* G.J. MATHEWS† and F.M. BERNTHAL, Michigan State University--Sources of ^{199}Tl have been produced by an (α,2n) reaction on ^{197}Au at the Michigan State University Cyclotron Laboratory. Analysis of the gamma ray singles and coincidence spectra indicate 18 new transitions in addition to those previously reported, and supports the following level assignments in ^{199}Hg: 158.36(5/2$^-$), 208.20(3/2$^-$), 403.50(3/2$^-$), 413.85(5/2$^-$), 455.46(1/2$^-$), 492.30(3/2$^-$), 750.41(3/2$^-$), 1221.21(1/2,5/2$^-$). These levels are compared with the transfer reaction data obtained by R.A. Moyer and discussed in terms of an extended core excitation model as proposed by Kalish and Gal.

*Supported by the U.S. Atomic Energy Commission and the National Science Foundation.
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Study of Giant Resonances in ^{16}O by ^{3}He Scattering.* A. MOALEM, W. BENENSON and G.M. CRAWLEY, Mich. State Univ.--Energy spectra of ^{3}He particles scattered from Oxygen-16 have been measured at incident energy of 71 MeV. The Giant Dipole Resonance region exhibits fine structure similar to that observed in the ^{12}C(α,γ)^{16}O reaction.[1] In particular in the region 15 to 21 MeV several peaks previously identified as $J^\pi=2^+$ and 1^- resonances were noted. In the region 21 to 25 MeV there is indication of broad structure similar to that observed in previous (p,γ) studies[2] but there is no clear enhancement of $J^\pi=1^-$ states previously ascribed to 1p-1h configurations. The interpretation of the $J^\pi=2^+$ states as evidence for a giant quadrupole resonance will be discussed.

*Work supported by the National Science Foundation.
[1]M. Suffert and W. Feldman, Phys. Lett. 24B, 579(1967).
[2]N.W. Tanner, G.C. Thomas and E.D. Earle, Nucl. Phys. 52, 45(1964).

The (^{3}He,^{6}He) Reaction on Light Nuclei.* W. BENENSON, E KASHY, A. MOALEM, and H. NANN, Mich. State Univ.--The nuclei ^{6}Be, ^{10}C and ^{11}N have been studied with the (^{3}He,^{6}He) reaction at 70 MeV. In the case of ^{6}Be, a search for excited states was made for excitation energies up to 15 MeV, and no new states were found. The region of astrophysical interest near the breakup energy into two ^{3}He-particles (~11.48 MeV) was searched particularly carefully; and there was no evidence whatsoever for a narrow state. In the case of ^{10}C the region from 6 MeV to 25 MeV was searched and, three levels near 10 MeV were observed. One at 10.72 MeV was very strong. The region where a T=2 state should lie in ^{10}C (~22 MeV) showed no enhancement of the cross section or peak. The ^{14}N(^{3}He,^{6}He)^{11}N reaction at 8° produced a ~1.5 MeV wide peak located near the mass excess estimate in the 1971 mass tables. This peak will be reexamined at other angles to ascertain that it has the required kinematics.

*Work supported by the National Science Foundation.

Helium Jet Recoil Transport Utilizing Plasma Chemistry.* K.L. KOSANKE, M. SLAUGHTER, M. EDMISTON, WM. C. MCHARRIS, Mich. State Univ.--Evidence will be presented supporting the possibility that the chemical nature of the bond between recoil and cluster molecule in the helium jet recoil transport (HeJRT) system can be used to achieve chemical separation. There are two aspects of this type of chemical separation that made it quite attractive. The first is that it could be accomplished in the extremely short time required for recoil atoms to attach to cluster molecules in the HeJRT target assembly. The second is that it should be compatible with isotope separators, thus allowing both isotopic and isobaric separation of activities.

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

Recent Experience with Momentum Matching and Dispersion Matching Techniques in the MSU Magnetic Spectrograph.* R.J. GLEITSMANN, G. HAMILTON, and J.A. NOLEN, JR., Mich. State Univ.--The current practical limitations and procedures associated with the momentum matching[1] and dispersion matching techniques[2] used with the MSU cyclotron-magnetic spectrograph system will be presented. The spectrograph calibration procedure[3] which utilizes momentum matching methods will also be discussed. Recent ^{40}Ca(p,p') spectra recorded on nuclear emulsions at 35 MeV yielded a resolution of 4.5 keV FWHM and elastic peak height to background ratio of 3×10^{6}:1. A comparison will be made between new excitation energies extracted from these data and previous assignments based on γ-ray work.

*Work supported by the National Science Foundation.
[1]G.F. Trentelman, and E. Kashy, Nucl. Inst. & Meth. 82 304(1970).
[2]H.G. Blosser, et al, Nucl. Inst. & Meth. 91 61(1971).
[3]J.A. Nolen, Jr., G. Hamilton, E. Kashy and I.D. Proctor, Nucl. Inst. & Meth., in press.

Lane Model Consistent Macroscopic Analysis of (p,n) Reactions to the Isobaric Analog States of ^{48}Ca, ^{90}Zr, ^{120}Sn, and ^{208}Pb at 25, 35, and 45 MeV.* D.M. PATTERSON, R.R. DOERING, and A.I. GALONSKY, Mich. State Univ.--In the Lane model of the Nucleon-nucleus optical potential, the potential consists of an isospin-independent part, U_o, and an isospin-dependent part, U_1. We have measured the differential cross section for quasi-elastic (p,n) scattering from ^{48}Ca, ^{90}Zr, ^{120}Sn, and ^{208}Pb with 25, 35, and 45 MeV protons in order to determine U_1. U_o was taken from the elastic proton scattering analysis of Becchetti and Greenlees.[2] A linear energy dependence was assumed for U_1. The parameters were optimized by fitting the data with a search routine using a modified version of the DWBA program DWUCK. All of the potentials used in the macroscopic calculations were obtained from U_o and U_1 using the Lane model.[1]

*Supported by the National Science Foundation and the Office of Naval Research.
[1]A.M. Lane, Phys. Rev. Lett. 8, 171(1962).
[2]F.D. Becchetti and G.W. Greenlees, Phys. Rev. 182, 1190(1969).

^{40}Ca(p,p') at 35 MeV.* J.A. NOLEN, JR., R.J. GLEITSMANN, G. HAMILTON, A. MOALEM, and T. UDAGAWA,† Michigan State Univ.--New higher resolution data on the ^{40}Ca(p,p') reaction have been recorded in order to resolve some questions raised in a recent microscopic analysis of the reaction.[1] A resolution of 4.5 keV FWHM was obtained at a bombarding energy of 35 MeV with the MSU cyclotron-magnetic spectrograph system. In particular, the 4^-(T=0) and 4^-(T=1) particle-hole states at 5.615 and 7.655 MeV excitation energies have been clearly resolved from nearby energy levels. The predicted yields to these unnatural parity levels are very sensitive to the details of the tensor and spin-orbit parts of the nucleon-nucleon force used in the microscopic analysis. The new data indicate that the excitation of these levels is experimentally ∿2-5X stronger than predicted by reference 1. Coupled channel calculations show that indirect processes should be included in the analysis of some of the T=0 levels.

*Work supported by the National Science Foundation.
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[1]F. Petrovich, et al., to be published.

A Measurement of the Excitation Energy of the 7.65 MeV Level of ^{12}C.* G. HAMILTON, J.A. NOLEN, JR., and D. TODY, Mich. State Univ.--The 3α→^{12}C reaction rate in stellar interiors is very sensitive to the excitation energy of the 7.65 MeV energy level in ^{12}C. The current uncertainty of ∿2 keV in the energy of this level[1,2] implies an uncertainty of ∿20% in the reaction rate. In the present measurement this level was opulated via the ^{12}C(p,p') reaction at 35 MeV. The spectra were recorded on nuclear emulsions and a simultaneous momentum matching-spectrograph calibration procedure[3] was used. Well known levels in ^{16}O and ^{40}Ca were used in the calibration. The resulting uncertainty in the excitation energy of the 7.65 MeV level in ^{12}C should be <1 keV.

*Work supported by the National Science Foundation.
[1]S.M. Austin, G.F. Trentelman and E. Kashy, Astro. J. 163 179(1971).
[2]H. Stocker, A.A. Rollefson, and C.P. Browne, Phys. Rev. C4 1028(1971).
[3]J.A. Nolen, Jr., G. Hamilton, I.D. Proctor, and E. Kashy, Nucl. Instr. & Meth. in press.

Energy Dependence of the Isospin-Exchange Term of the Effective Two-Nucleon Interaction.* R.R. DOERING, D.M. PATTERSON, and AARON GALONSKY, Mich. State Univ.--Angular distributions have been taken for (p,n) reactions to the isobaric analogs of ^{48}Ca, ^{90}Zn, ^{120}Sn, and ^{208}Pb target ground states. Proton energies of 25, 35, and 45 MeV were used. Microscopic DWBA calculations, with and without exchange amplitudes, have been compared with the measured cross sections to determine the strength of the term in the effective two-nucleon interaction proportional to $\vec{\tau}_j \cdot \vec{\tau}_j$.

*Supported by the National Science Foundation and the Office of Naval Research.

Levels of ^{187}Os Populated in the ^{186}W(α,3n) Reaction.* J.S. BOYNO, F.M. BERNTHAL, T.L. KHOO and R.A. WARNER, Mich. State Univ.--The γ-ray spectra following the ^{186}W(α,3n) reaction have been studied with 35 MeV α-particles obtained from the MSU cyclotron. Anisotropies from γ-singles measurements, as well as γ-γ coincidence data, have been used in determining the cascade relationships. Direct lifetime measurements have also been performed. From a preliminary analysis, the members of the yrast [615↑] band have been identified up to spin 21/2 (tentatively to 27/2). The [512↓] band has been identified through the spin 15/2 member. Other γ-rays indicate the population of the [510↑], [503↑] and [624↑] bands.

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

Recoil Effects in Single-Nucleon Transfer Reactions.* P. HAUGE and G. BERTSCH, Mich. State Univ.--A formalism is developed for approximately treating the recoil of the projectile in single-nucleon transfer reactions. Following earlier calculations, we neglect the recoil of the target, translate the scattered wavefunction of the heavier projectile to a coordinate system centered about the lighter mass projectile, and make a plane-wave approximation to the translation operator. No further approximations are made. The "no-recoil" term is evaluated exactly by rotating the functions of the "form-factor" integral to a coordinate system where the lighter projectile lies along the z axis relative to the target nucleus. The integral can then be rapidly evaluated by numerical means. Recoil terms are constructed by expanding the plane wave in terms of spherical harmonics, and they can again be evaluated exactly. The theory is then applied to light-ion reactions. It is found that although the first-order recoil term may be large, higher order terms become much less important, and convergence is always easily obtained.

*Work supported by the National Science Foundation.

Progress Report on the MSU Automated Plate Scanner.* R.G.H. ROBERTSON and J.A. NOLEN, JR., Mich. State Univ.--An automated scanner for nuclear track plates which is based on a new simple design is in preliminary stages of operation at MSU. The scanner is intended to scan thin (25 μm or 10 μm) emulsions in order to handle the higher track densities which are a consequence of our small line widths (∿0.1-0.2 mm FWHM). Both the scanning, done with a commercial motorized stage, and track identification are computer independent. The optical track detector is a monolithic array of silicon photodiodes in the focal plane of a microscope. A 10 watt point source light illuminates the plate in the bright field mode. Overall optical-electrical resolution for nuclear tracks is 1-2 μm. Preliminary results with good plates indicate slowly changing counting efficiency and spurious counts of ∿1 track/25 μm strip. The scanner is presently useful for fine scanning (25 μm steps) to resolve closely spaced doublets, which is very hard to do by hand, and very accurate peak centroid determinations for precision excitation energy and Q-value measurements.

*Work supported by the National Science Foundation.

^{40}Ar(p,n) Reaction to the Isobaric Analog State (IAS) and Anti-Analog State (AAS) in ^{40}K.* AARON GALONSKY, J.G. BRANSON, R.R. DOERING, and D.M. PATTERSON, Mich. State Univ.--Using 24-MeV protons and a neutron flight path of 11.5 meters we resolved the AAS group, $E_x(^{40}K)$=1.65 MeV, with our time-of-flight apparatus. The cross section ratio of AAS to IAS was ∿0.03 in the angular range, 10°-35°, covered in our experiment. In (^{3}He,t) excitation[1] of the same AAS state it was found necessary to include a two-step amplitude[2] in order to fit both the magnitude and shape of the angular distribution. In contrast to that case, we have good one-step microscopic fits to both the AAS at 24 MeV and the IAS at 22.8 MeV[3] with reasonable values for the parameters of the 2-nucleon effective interaction. The code DWBA-70 of J. Raynal and R. Schaeffer, which includes direct and exchange amplitudes, was used in the computation.

*Work supported by the National Science Foundation and the Office of Naval Research.
[1]R.A. Hinrichs et al., Phys. Rev. Lett. 25 829(1970)
[2]R. Schaeffer & G. Bertsch, Phys. Lett. 38B 159(1972).
[3]R.F. Bentley et al., Phys. Rev. Lett. 27 1081(1971).

New Orbit Codes for the Indiana Cyclotron.* M.M. GORDON and D.A. JOHNSON, Mich. State Univ.--Two new orbit codes have been developed which integrate the equations of motion for ions moving in the symmetric magnetic field of the Indiana cyclotron. Measured median plane fields are stored in a polar grid, from which field components on and off the median plane are calculated as needed. These codes are a very accurate and efficient (Milne-Reynolds) integration routine with 0.5 deg integration steps. One code "Symeon" calculates as a function of energy all the pertinent equilibrium orbit properties including the focusing oscillation frequencies, ν_r and ν_z; this basic code runs about 100 times faster than the previous Indiana code. The second code "Indigo" calculates accelerated orbits assuming delta function electric gaps. This code serves to investigate non-linear effects in the radial and axial oscillations, as well as coupling effects between the radial, axial, and longitudinal motions. Preliminary results indicate that these effects are all unimportant except for the radial-longitudinal coupling. This coupling produces a significant phase compression effect because of the large increase in the dee voltage with radius.

*Supported by the National Science Foundation, partly at Indiana University.

Backbending and Forking in ^{182}W.* B.D. JELTEMA and F.M. BERNTHAL, Michigan State Univ.--Levels of ^{182}W were studied using in-beam γ-ray spectroscopy. γ-ray singles and γ-γ coincidence data were collected using Ge(Li) detectors, and levels in ^{182}W were populated via the ^{180}Hf(α,2n)^{182}W reaction using a self supporting target and a beam of 26-MeV α particles produced by the MSU sector focused cyclotron. Levels in the ground band of ^{182}W were seen up to spin 12, at which point backbending and forking are exhibited. Energies for the 10^+, 12^+, and $12^{+'}$ levels are 1712, 2230, and 2372 keV, respectively.

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

Study of the ^{29}Si(p,t)^{27}Si and ^{29}Si(p,^{3}He)^{27}Al Reaction.* H. NANN, W. BENENSON and W.A. LANFORD, Mich. State Univ.--The (p,t) and (p,^{3}He) reactions on ^{29}Si have been studied at E_p=40 MeV. The reaction products were detected in a position sensitive proportional counter backed by a plastic scintillation counter on the focal plane of a split-pole magnetic spectrograph. An energy resolution of about 30 keV was obtained. Differential cross sections were measured between 6° and 55° for mirror transitions to states up to 5 MeV excitation energy in the final nuclei and were compared to microscopic DWBA calculations based on shell-model wave functions of Wildenthal and McGrory.[1] Since the (p,^{3}He) reaction permits an S=0, T=1 and an S=1, T=0 spin-isospin transfer of a proton-neutron pair, whereas the (p,t) reaction allows only an S=0, T=1 transfer of two neutrons, different parts of the wave function of the target and the final nucleus are being tested.

*Work supported by the National Science Foundation.
[1]B.H. Wildenthal & J.B. McGrory, Phys. Rev. C7 714(1973).

Levels of ^{182}Re.* M.F. SLAUGHTER, R.A. WARNER, W.H. KELLY, and WM. C McHARRIS, Mich. State Univ.--In-beam γ-ray studies of ^{182}Re have been performed with a 37.5 MeV α beam and a Ta target. γ-γ coincidence and γ-ray lifetime measurements have been completed. Analysis of the coincidence data shows two prominent rotational bands, with the bandheads displaced from the energies proposed by Hjorth et al.[1] Higher states than were previously reported have also been observed. Levels have been located in the lower band at 154.1, 339.4, 552.0, 789.7, 1049.8, 1331.6, and (1634.7) keV and in the upper band at 433.3, 625.1, 834.4, 1069.4, .328.4, 1609.4, and (1912.5) keV. The upper band is fed with a 94±5 nsec half-life.

*Work supported in part by the U.S. Atomic Energy Commission and the National Science Foundation.
[1]S.A. Hjorth, H. Ryde, and B. Skanberg, Arkiv for Fysik 38 29(1968).

AMERICAN PHYS. SOC. CHICAGO MEETING, FEB. 1974

Structure of ^{32}S from ^{33}S(p,d)^{32}S.* D.L. SHOW, A.S. MOALEM, and B.H. WILDENTHAL, Mich. State Univ.--We have studied the states of ^{32}S in the region of excitation from 0-10 MeV by means of the ^{33}S(p,d)^{32}S reaction at E_p=35 MeV. Angular distributions from θ_L 4° to 40° were measured by recording deuteron spectra on nuclear emulsions in a split-pole spectrograph with an energy resolution of ∿10 keV. The target was a thin layer of elemental sulfur, enriched to 83% ^{33}S, sandwiched between carbon foils.[1] The experimental angular distributions were analyzed with the DWBA in a fashion consistent with procedures thoroughly verified in studies of (p,d) reactions on neighboring nuclei. The spectroscopic factors are in consistently good accord with the predictions of the FPSDI shell-model wave functions.

*Work supported by the National Science Foundation.
[1]The target was generously loaned to us by J.P. Schiffer and D.J. Crozier.

The Level Structure of ^{174}Hf from (α,xn) Reactions.* T.L. KHOO, F.M. BERNTHAL, J.S. BOYNO, and R.A. WARNER, Mich. State Univ.--The levels of ^{174}Hf have been studied by observing both in-beam and delayed γ-rays from the (α,2n) and (α,4n) reactions. Prompt and delayed γ-γ coincidence measurements have been performed. Three isomers ($T_{\frac{1}{2}}$>1μsec.) have been observed, with K values of 6^+,(8^-) and 12^+; the $K=12^+$ isomer is a 4-quasiparticle state whose decay populates members of the $K=6^+$ and (8^-) bands. Although analysis of the data is still in progress, the following states have been identified: the ground band (to spin 20), the β-band (to spin 16), a $K=6^+$ band (to spin 12) and a $K=(8^-)$ band (to spin 12). The structure of the high K states will be discussed, with emphasis on neutron-proton configuration mixing, a phenomenon previously observed in the neighboring nucleus ^{176}Hf (T.L. Khoo, et al., Phys. Rev. Letts. 28, 1717(1972)).

*Work supported by US Atomic Energy Commission and National Science Foundation.

Proton Rich Exotic Nuclei.* W. BENENSON, Mich. State Univ.--Multinucleon transfer reactions have been used to measure the mass and energy levels of exotic nuclei with Z>N. The (^{3}He,^{6}He) reaction, for example, has yielded masses and energy levels with 10-50 keV accuracy of ten nuclei from ^{9}C to ^{55}Ni. This reaction has a very negaitve Q-value (-20 to -40 MeV) and a very low yield (of the order of 1 ub/sr). A spectrograph time-of-flight combination is used for particle identification and energy measurement. Recent results have completed new mass quartets and yielded information on the Isobaric Multiplet Mass Equation and Coulomb energies.

*Work supported by the National Science Foundation.

AMERICAN PHYS. SOC. WASHINGTON, D.C. MEETING, April. 1974

High Spin Level Structure in ^{192}Pt.* P.J. DALY, J.C. CUNNANE, M. PIIPARINEN, Purdue Univ. and F.M. BERNTHAL, C.L. DORS, T.L. KHOO, Mich. State Univ.--Levels of ^{192}Pt have been studied by the ^{192}Os (α,4n) reaction using the MSU cyclotron. γ-ray singles, γ-γ coincidence, angular distribution and excitation function measurements have been performed. The 784.5 keV 4^+ state in ^{192}Pt is populated by two strong de-excitation branches of approximately equal intensity, one involving high spin negative parity levels,[1] and the other positive parity levels. These positive parity levels exhibit highly unusual energy spacings; the proposed 14^+ state at 2998 keV decays to ground by the following sequence of stretched E2 transitions: 374.5, 104.7, 500.6, 653.0, 580.9, 468.1 and 316.5 keV. Additional branches feeding into the positive parity yrast sequence at spins ≥ 10 have also been identified. Implications of the results will be discussed.

*Work supported by the US Atomic Energy Commission and the National Science Foundation.
[1]Yates, Cunnane, Hochel, Daly, Nucl. Phys. to be published.

A=9 Isospin Quartet.* E. KASHY, W. BENENSON and J.A. NOLEN, JR., Mich. State Univ.--New measurements of the mass excess of the lowest T=3/2 levels of ^{9}Be and ^{9}B give values of 25.7406±.0017 and 27.0711±.0023 MeV respectively indicate a definite cubic dependence for the masses of the A=9 quartet which includes ^{9}Li and ^{9}C in their ground states. A value of 7.6±1.7 keV is obtained for the coefficient of the T_z^3 term. The magnitude of this term now clearly exceeds the current theoretical estimates. Precise values of excitation energy of levels in ^{10}B and ^{11}B have been obtained as part of these measurements. The methods and results will be presented.

*Work supported by the National Science Foundation.

Levels of ^{56}Ni.* W. BENENSON and H. NANN, Mich. State Univ.--The ^{58}Ni(p,t)^{56}Ni reaction at 40 MeV has been used to resolve discrepancies in the spin and parity of levels found in previous experiments which used the ^{54}Fe(^{3}He,n)^{56}Ni and ^{58}Ni(p,t)^{56}Ni reactions. A resolution of 8 keV reveals that the level scheme contains many doublets. The shapes of angular distributions which correspond to the different ℓ-values were taken from ^{56}Fe(p,t)^{54}Fe to levels of known spin and parity. There is a 4^+-0^+ doublet at 3.923-3.952 MeV and a 3^+-0^+ doublet at 4.937-5.007 MeV. The J^π of other doublets at 5.22 and 5.99 MeV are not as well determined. Many of the higher lying levels have strange angular distributions indicating perhaps even more unresolved states.

*Work supported by the National Science Foundation.

Super Conducting Magnets for Heavy-Ion Cyclotrons.* H.G. BLOSSER, M.M. GORDON and D.A. JOHNSON, Mich. State Univ.--Recently completed NAL bubble chamber coils[1] demonstrate that fields with great bending capability can be obtained at relatively low cost. In a pioneering study[2] of a $500(Z^2/A)$ MeV heavy ion cyclotron, Fraser and coworkers conclude that such coils yield >50% cost savings as compared with conventional techniques. Interesting design questions arise in providing the field flutter required for stable axial motion in a CW cyclotron. Iron structures can provide both flutter and a confined magnetic path for return flux. This iron operates however, in an extreme saturation limit and design techniques appropriate for this situation must be employed. Using such techniques a series of initial calculations have been carried out to define optimum ranges for the major magnet parameters, namely average field, flutter and spiral.

*Work supported by the National Science Foundation.
[1]Purcell, Desportes, and Jones ANL/NEL 7215(1973).
[2]Bigham, Fraser and Schneider AECL-4654(1973).

Elasticity and Nuclear Vibrations.* G.F. BERTSCH, Mich. State Univ.--We derive from Thouless's RPA variational principle and the Fermi gas model the following formula for vibrational energies of spherical nuclei:

$$\hbar\omega = \frac{\hbar^2}{m}\sqrt{\frac{k_F^2(L-1)(2L-1)\langle r^{2L-4}\rangle}{5\langle r^{2L-2}\rangle}}$$

where L is the multipolarity, k_F is the Fermi momentum, and $\langle r^n\rangle$ and expectation values of r^n in the ground state. Numerically, the formula gives an energy for the giant quadrupole 30% lower than the empirical. An identical formula can be obtained classically for an elastic sphere from Rayleigh's variational principle, suggesting that the macroscopic properties of nuclei require elasticaity as well as fluidity.

*Supported by the National Science Foundation.

Four Quasiparticle States in ^{174}Hf and ^{176}Hf.* T.L. KHOO, F.M. BERNTHAL, J.S. BOYNO, and R.A. WARNER, Mich. State Univ.--The occurrence of high-Ω orbitals near the Fermi level in ^{174}Hf and ^{176}Hf gives rise to the formation of low-lying high-K two quasiparticle states.[1] There should also exist high-K ($\geq$12) four quasiparticle states and the intent of this study is to identify them. Prompt and delayed γ-rays from the (α,4n) reaction at 48 MeV have been observed and angular distribution, excitation function, and prompt and delayed γ-γ coincidence experiments were performed. In ^{174}Hf, two isomers were seen, one at 3269 keV with K=12$^+$ and another at 3312 keV [K=(14$^-$)], which decay to the 11$^+$ and 12$^+$ members of a K=6$^+$ band. In ^{176}Hf, preliminary analysis indicates a four quasiparticle isomer at 2827 keV which decays to the 11$^-$ and 12$^-$ members of two previously known K=8$^-$ bands. Structure of the four quasiparticle states will be discussed and their energies compared with those deduced from the energies of the two quasiparticle states.

*Work supported by the US Atomic Energy Commission and the National Science Foundation.
[1]T.L. Khoo, et al., Can. J. Phys. 51 2307(1973) and Mich. State U. Cyclotron Lab. Annual Report 1972-73.

The Excitation of Multipole Resonances with Electron and Hadron Scattering.* G.R. HAMMERSTEIN, H. MCMANUS and A. MOALEM, Mich. State Univ.--Calculations are presented for the excitation of multipole states in ^{40}Ca by inelastic scattering of electrons, protons, alphas and ^{3}He particles. Using microscopic shell-model vectors, a resonance-like structure largely due to dipole and/or quadrupole states is predicted in the giant dipole resonance region. The cross-sections are in good agreement with those obtained from simple phenomenological collective models. Using the spreading width of the states as a parameter, cross-sections are in fair agreement with available experimental data.

*Work supported by the National Science Foundation.

Evidence for Rotational Structure in ^{48}V.* L.E. SAMUELSON, F.M. BERNTHAL, W.H. KELLY, and Wm. C. McHARRIS, Mich. State Univ.--Identification of two odd-parity bands in ^{48}V (an odd-odd-nucleus in the middle of the $f_{7/2}$ shell) has been made using the ^{46}Ti(α,pnγ)^{48}V reaction at E_α=30 MeV. The level energies in keV and tentative spins and parities for the two bands are 519 [1$^-$], 745 [2$^-$], 1056 [3$^-$], 1558 [4$^-$], 2062 [(5$^-$)], 2780 [(6$^-$)], 3423 [(7$^-$)], and 1099 [4$^-$], 1685 [5$^-$], 2400 [(6$^-$)], 3177 [(7$^-$)], 3982 [(8$^-$)], (4882) [(9$^-$)]. Both bands exhibit spacing consistent with a rotational model interpretation. In this picture, the two band-head configurations can be viewed as the triplet and singlet coupling of a 5/2$^-$[312] neutron with a 3/2$^+$[202] proton to give the observed $I^\pi K=1^-1$ and 4^-4 states at 518.8 and 1099.3 keV, respectively. The band structure will be discussed in the light of the Nilsson model.

*Work supported by the US Atomic Energy Commission and the National Science Foundation.

The Decay of ^{199m}Pb.* M.W. JOHNSON, Wm. C. McHARRIS,+ R.A. WARNER, and W.H. KELLY, Mich. State Univ.--12.7-min. ^{199m}Pb was produced via the ^{198}Hg(α,3n) and ^{200}Hg(^{3}He,4n) reactions with beams from the MSU Cyclotron. In addition to the known[1] 424.7-keV isomeric transition, at least 29 γ transitions have been observed using Ge(Li) detectors in singles and γ-γ coincidence modes. The transitions have been placed among 18 levels, some previously known from ^{199g}Pb decay[2] or from the ^{197}Au(α,2nγ) reaction.[3] New levels are observed at 1012.5, 1826.4, 2042.4, 2397.1, and possibly 2751.9 keV. Systematics of the odd-A Tl nuclei will be discussed, also conjectures concerning the structures of the 9/2$^-$ isomeric states and the three-quasiparticle states in ^{199}Tl that receive most of the ^{199m}Pb β decay.

*Work supported in part by the U.S. Atomic Energy Commission and the National Science Foundation.
+Alfred P. Sloan Fellow, 1972-4.
[1]R. Stockendal et al., Ark. Fys. 11, 165(1956).
[2]R.W. Doebler, PH.D. Thesis, Mich. State Univ. COO-1779-42(1970).
[3]J. Newton et al., Nucl. Phys. A184, 593(1970).

Rotational Bands in ^{183}Os.* C.L. DORS, F.M. BERNTHAL, B.D. JELTEMA, and R.A. WARNER, Mich. State Univ.--An investigation of the rotational band structure of ^{183}Os has been carried out via in-beam γ-ray spectroscopy. The levels in ^{183}Os are populated by the (α,3nγ) reaction on ^{182}W and by (p,3nγ) on ^{185}Re. Prompt and delayed γ-ray singles, γ-γ coincidence, angular distribution, and excitation function data have been used to characterize the ^{183}Os band structure. The 9/2$^+$[624] ground band has been identified up to spin 33/2, and members of the 7/2$^-$[514] (393-keV) band are proposed to spin 17/2. A third band which is populated more strongly in the (p,3nγ) reaction has tentatively been identified as the 1/2$^-$[510] (170.7-keV) band. The data for the lower-spin members of this third band seem consistent with preliminary data from the decay of ^{183}Ir.[1]

*Work supported by the U.S. Atomic Energy Commission and the National Science Foundation.
[1]I.-M. Ladenbauer-Bellis, private communication.

The Odd-Odd Nucleus ^{116}Sb: State Energies and Spins,* 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 ^{116}Sn(p,nγ) and ^{118}Sn(p,3nγ) reactions have been used to identify the energy levels of ^{116}Sb below 1500 keV. Over one hundred γ rays appear to belong to the de-excitation of ^{116}Sb. More than half of these have been placed in a tentative decay scheme which incorporates 42 levels. Gamma-ray angular distribution measurements have been made with the (p,nγ) reaction at beam energies of 5.95, 6.25, and 6.65 MeV. Spin assignments based upon the angular distributions of 24 γ rays and upon the measured excitation functions will be discussed.

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The Low-Lying Levels and an Isomeric State of ^{118}Sb.* W.B. CHAFFEE, C.B. MORGAN, R.A. WARNER, Wm. C. McHARRIS, W.H. KELLY, Mich. State Univ., E.M. BERNSTEIN, and R. SHAMU, Western Mich. Univ.--Gamma rays from the reaction ^{118}Sn(p,nγ)^{118}Sb, in conjunction with (p,nγγ) coincidence experiments have been used to construct a tentative energy level diagram of ^{118}Sb for levels below 1200 keV of excitation. Delayed timing experiments have identified a 13.2 ns isomeric state. The level scheme is split into three parts with a total of 38 energy levels. 118 gamma rays have been identified in the (p,nγ) experiments as being probably associated with the de-excitation of ^{118}Sb. 75 of them have been placed in the decay scheme.

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Multistep Processes in ^{186}W(p,d) at 35 MeV.* C.H. KING, F.M. BERNTHAL, T.L. KHOO and J.A. NOLEN, JR., Mich. State Univ.--Angular distributions have been obtained for the reaction ^{186}W(p,d) at an incident proton energy of 35 MeV. Significant differences are observed among the angular distributions for the three ℓ=1 transitions to the 3/2$^-$(g.s.), 1/2$^-$(24 keV), and 3/2$^-$(94 keV) states. Similar differences observed in the same reaction at E_p=18 MeV were explained[1] in the coupled-channel Born approximation (CCBA) as resulting from the presence of multistep processes. The anomalous angular distributions from the 35 MeV data indicate that the multistep effects persist in higher energy reactions, but a comparison between the data at the two energies shows that there is considerable energy dependence in the character of the effects. CCBA calculations and a discussion of the energy dependence of multistep processes will be presented.

*Work supported by the National Science Foundation.

[1]R.J. Ascuitto, C.H. King and L.J. McVay, Phys. Rev. Lett. 29, 1106(1972).

^{12}C, ^{24}Mg(α,^{6}Li) at 46 MeV.* R.G. MARKHAM, Mich. State Univ.--The above reactions were induced by a 46 MeV, alpha beam from the MSU cyclotron with the outgoing ^{6}Li ions detected in a position sensitive proportional counter in the focal plane of a split-pole spectrograph. Adequate identification of the ^{6}Li ions relative to ^{6}He and ^{7}Li was possible by energy loss information. Angular distributions were measured over the angular range of 6° to 60° c.m. in 4° steps. These distributions were forward peaked and well structured. For the ^{24}Mg experiment, data taken at 120° cm indicated a much smaller cross section than at 60°. Thus, it appears the reaction proceeds via a direct mechanism.

*Work supported by the National Science Foundation.

Comparisons of the Mirror Reactions ^{6}Li(d,p_1)^{7}Li*--^{6}Li(d,p_1)^{7}Be* and ^{16}O(d,p_1)^{17}O*--^{16}O(d,n_1)^{17}F*. S.M. AUSTIN, R.L. HERSHBERGER, F. RIESS and R.S. SIMON, University of Munich.--A comparison of the total cross sections for the above pairs of mirror reactions has been made by observing the isotropic γ rays from the decays of the first-excited J=1/2 states of the product nuclei. A target consisting of a layer of ^{6}Li metal plus a layer of $^6Li_2O$(^{6}Li enrichment of 99.32%) was bombarded by 7-17 MeV deuterons from the Munich MP tandem and the γ rays were counted in Ge(Li) detectors at 90° to the beam. If nuclear forces are charge symmetric the ratio R=σ(d,n_1)/σ(d,p_1) should be unity. The measured R has an average value of 1.1(0.7) for the ^{6}Li+d(^{16}O+d) reactions and decreases slowly with increasing energy. DWBA calculations including the trivial differences in the mirror reactions (Q values, binding energies and Coulomb barriers) account for at least the bulk of the observed deviations from R=1.

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Fast Chemistry On-Line with a Helium-Jet Recoil-Transport System.* K.L. KOSANKE, M. EDMISTON, M. SLAUGHTER, Wm. C. McHARRIS, and W.H. KELLY, Mich. State Univ.-- In recent months we have come upon several techniques for performing fast chemistry on line with the helium-jet recoil-transport system. One is a fast method (≲1 second) involving conventional chemical separation in an aqueous phase at atmospheric pressure. Results for a series of experiments demonstrating this technique will be presented. The other method is an ultra-fast method (≲100 msec) involving chemical enrichments resulting from the preferential attachment of nuclear recoils to clusters in the transport process. High recoil transmission through long jet systems is the result of the nuclear recoils, generated from a target, attaching themselves to large macromolecules before entering the capillary. Accordingly, if through controlling the chemical nature of the cluster molecules chemically different recoils have differing degrees of success in attaching themselves to the clusters, a chemical separation will result. Results from a series of experiments supporting this approach will be presented.

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The $^{154}Sm(^{4}He,^{6}He)^{152}Sm$ Reaction.* J.S. BOYNO, W. BENENSON, T.L. KHOO, C.H. KING, Wm. C. McHARRIS and R.A. WARNER, Mich. State Univ.--An investigation of the applicability of the ($^{4}He,^{6}He$) reaction as a spectroscopic tool in the study of rare earth nuclei is in progress. This reaction is more closely momentum matched than the parallel (p,t) reaction, and this difference may be helpful in extracting spectroscopic data from two nucleon transfer reactions. The first reaction studied is $^{154}Sm(^{4}He,^{6}He)^{152}Sm$. Many of the states excited in this process are known from a (p,t) study (W. McLatchie, et al. Nucl. Phys. A159, 615(1970), and spin assignments are easily made. Initial runs were performed using 50 MeV alpha particles from the MSU cyclotron. A single-wire gas-filled proportional counter was used. A plastic scintillator placed behind the counter gave time-of-flight information used to isolate tritons and ^{6}He particles from other products. Further particle identification by $\Delta E/X$ measurements separated the abundant tirtons from the ^{6}He particles. The resolution obtained was ≃45 keV. The absolute cross sections are smaller than in (p,t). At 20°, the ($^{4}He,^{6}He$) cross sections for $I^{\pi} = 0^{+}$ states are 1-2 orders of magnitude less than the same states in (p,t). Our preliminary results at forward angles indicate that the relative intensities and angular distributions of the ground state rotational band members are quite different than those seen in the (p,t) reaction.

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

Progress on the MSU ON-Line Mass Identification System.* K.L. KOSANKE, M. EDMISTON, Wm. C. McHARRIS and W.H. KELLY, Mich. State Univ.--The Michigan State University on-line Time-Of-Flight Spectrometer and Helium-Impurity Transport System is patterned after R.D. Macfarlane's MAGGIE system (R.D. Macfarlane, D.F. Torgerson, Y. Fares, A. Hassel, accepted for publication in Nucl. Instr. and Methods), with the exception that provision is made for locating up to two gamma or x-ray detectors near the collection surface of the helium transport system. The helium-impurity transport system will transport cyclotron produced activities to a collecting surface in the TOF system in times as short as a few hundred milliseconds. As the activities on the collecting surface β decay, a fraction of the nuclei will recoil from the collecting surface and become ionized by shake-off. These ions will be accelerated and pass down a flight line to a positive ion detector. The detection of the β particle and the positive ion will provide the start and stop times for the TOF system and will be used to characterize the mass of the recoil. The mass information and the coincident gamma signals will be stored on magnetic tape. When the tape is played back, gating on the appropriate mass peaks, gamma spectra corresponding to those peaks will result. Initial testing of the system is planned for early 1974. The results of these experiments will be presented.

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