

SECTION IV
ABSTRACTS OF PAPERS IN PRESS
(after June 30, 1973)

G. F. Bertsch[†]
 Department of Physics, Cyclotron Laboratory
 East Lansing, Michigan 48823

Isobaric Mass Quartets in the Mass-21
 and Mass-37 Nuclei^{*}

W. Benenson, E. Kashy and I. D. Proctor[†]
 Cyclotron Laboratory, Michigan State University
 East Lansing, Michigan 48823

ABSTRACT

A fast numerical method for calculating nuclear excitation properties with δ -type interactions is described. The method is applied to Pb^{208} , and we find properties of the nucleus as: (i) the quadrupole strength has two main pieces, one a low state and one identifiable as the giant quadrupole; (ii) excitations with $L > 2$ do not seem to have high-energy collective parts; (iii) the giant dipole $L=1$ $T=1$ is too low unless the interaction has a strong momentum dependence.

[†]Supported in part by the National Science Foundation.

ISOSPIN MIXING FROM THE EFFECTIVE
 NUCLEON INTERACTION^{*}

G. F. Bertsch and B. H. Wildenthal
 Cyclotron Laboratory, Department of Physics
 Michigan State University, East Lansing, Michigan 48823

ABSTRACT

Effective interactions determined from closed-shell-plus-two-particle spectra have a charge dependence which predicts isospin mixing for more complicated nuclei. We infer the isospin mixing in $A=44, 46, 48$ and 52 on the basis of the observed $A=42$ spectra. Agreement is reasonable in 4 out of 6 cases; the best example is ^{44}Sc , where we verify that the n - p effective residual interaction is stronger than the n - n interaction. We also compare predictions for $A=20$ and 24 , from the charge dependence seen in the $A=18$ spectrum.

^{*}Supported by the National Science Foundation.

ABSTRACT

The $^{40}Ca(^3He, ^6He)^{37}Ca$ reaction has been used to measure the mass of ^{37}Ca in its ground and first excited states. The mass of ^{37}Ar and ^{37}K in their lowest $T=3/2$ states were also measured. The $^{24}Mg(^3He, ^6He)^{21}Mg$ reaction was used as a calibration, and consequently the energies of several excited states of ^{21}Mg were measured. The mass-37 measurements give new precision values for the coefficients of the isobaric multiplet mass equation, and the excited states in ^{21}Mg are members of quartets in the mass-21 nuclei.

^{*} Work supported by the National Science Foundation.

[†] Present address: Lawrence Livermore Laboratory, Livermore, Calif.

A High Resolution Study of $^{48}Ca(p,t)^{46}Ca$ at $E_p=39$ MeV^{*}

G.M. Crawley and P.S. Miller
 Cyclotron Laboratory and Physics Department
 Michigan State University, East Lansing, Michigan 48823

and

G.J. Igo and J. Kulleck
 Physics Department, University of California
 Los Angeles, California

ABSTRACT

The ^{46}Ca nucleus was studied using the (p,t) reaction. A number of spin-parity assignments are clarified for the low-lying states. Many new energy levels are reported up to an excitation energy of 6.3 MeV including an additional 0^+ state at 4.76 MeV. Distorted wave calculations with f - p shell wave functions give reasonable agreement for the first $0^+, 2^+, 4^+$, and 6^+ states and for two weak 0^+ states near 5.5 MeV which were strongly excited in the $^{44}Ca(t,p)$ reaction.

^{*}Supported in part by the National Science Foundation and the U.S. Atomic Energy Commission.

A Determination of the Mass and Some
Energy Levels of the Nuclide ^{44}Ar *

W. F. Steele, G. M. Crawley, and S. Maripuu

Cyclotron Laboratory and Physics Department
Michigan State University, East Lansing, Michigan 48824

ABSTRACT

The mass and some energy levels of the nuclide ^{44}Ar have been determined from the $^{48}\text{Ca}(^3\text{He}, ^7\text{Be})^{44}\text{Ar}$ reaction.

The lifetime of the nucleus ^{44}Ar has been reported [1,2] but until now its mass and energy levels were unknown. This letter reports the mass of ^{44}Ar and the excitation energies of several of its excited states as determined from the $^{48}\text{Ca}(^3\text{He}, ^7\text{Be})^{44}\text{Ar}$ reaction at 70 MeV ^3He bombarding energy.

The ^3He beam was produced by the MSU variable energy sector focused cyclotron. The reaction products were analyzed by an Enge split-pole magnetic spectrograph [3]. Detection of ions in the focal plane of the spectrometer was accomplished by means of a system composed of a plastic scintillator photo-multiplier unit behind a 25 cm single wire charge division gas

*Work supported by the National Science Foundation.

Excitation of Giant Resonances by Inelastic
 ^3He Scattering*

A. Moalem, W. Benenson, and G.M. Crawley

Physics Department and Cyclotron Laboratory
Michigan State University, East Lansing, Michigan 48823

ABSTRACT

Inelastic ^3He scattering at 71 MeV on 12 nuclei ranging from ^{27}Al to ^{209}Bi shows an enhancement of the continuum very similar to that observed in electron and proton scattering. The effect is ascribed to a giant multipole state. The strength of the excitation indicates an E2 character for the state.

*Supported by the National Science Foundation.

35 MeV Proton Inelastic Scattering from Low-Lying
States in ^{207}Pb *

W.T. Wagner, G.R. Hammerstein, G.M. Crawley, and J.R. Borysowicz

Cyclotron Laboratory and Physics Department
Michigan State University, East Lansing, Michigan 48823

and

F. Petrovich

Lawrence Radiation Laboratory, University of California
Berkeley, California 94720

ABSTRACT

Differential cross sections for the excitation of the first four excited states in ^{207}Pb via the inelastic scattering of 35 MeV protons have been compared with microscopic model predictions. Contributions from non-central forces are important in a valence orbital model and the effects of exchange and core polarization have been investigated. Addition of an imaginary part to the microscopic form factor was also investigated and gave the best predictions of observed transition strengths.

*Supported in part by the National Science Foundation.

Measuring Nuclear Excitation Energies and Q-Values
With a Cyclotron-Magnetic Spectrograph System.*

J.A. Nolen, Jr., G. Hamilton, E. Kashy
and I. D. Proctor⁺

Cyclotron Laboratory, Physics Department,
Michigan State University, East Lansing, Michigan 48823, USA

ABSTRACT

Nuclear excitation energies and reaction Q-values have been measured with the M.S.U. cyclotron-magnetic spectrograph system with uncertainties on the order of 1 keV or less. The method involves a spectrograph calibration procedure which utilizes a combination of momentum-matching and kinematics techniques. The calibration lines used in the present work are independent of any previous spectrograph based on the $^{210}\text{Po}(\alpha)$ energy scale. The present work is also largely independent of Ge(Li) gamma detector measurements, and provides independent consistency checks on previous measurements at the 1 keV uncertainty level. Sample results include checks on the excitation energies of the first excited state of ^{12}C and the third excited state of ^{24}Mg . The excitation energy of the first excited state of ^{11}C and the Q-values for the reactions $^{24}\text{Mg}(p,d)^{23}\text{Mg}$ and $^{24}\text{Mg}(p,t)^{22}\text{Mg}$ are also presented.

*Supported by the National Science Foundation.

⁺Present address: Physics Division E, L-313, Lawrence Livermore Lab.
Livermore, California.

R.R. Doering,** A.I. Galonsky, and R.A. Hinrichs

Cyclotron Laboratory, Department of Physics
Michigan State University, East Lansing, Michigan 48823

ABSTRACT

Small differential cross sections, such as those measured at back angles for 70 MeV ^3He elastic scattering (typically below 10^{-4} mb/sr past 130°), are difficult to calculate accurately when they result from considerable cancellation in the partial-wave sum. The codes GENOA, GIBELUMP, SNOOPY3, and DWUCK differ by as much as 2-1/2 orders of magnitude on $\sigma(\theta)$ for an optical-model potential describing $^{60}\text{Ni}(^3\text{He}, ^3\text{He})^{60}\text{Ni}$ scattering at 71 MeV. This calculation is repeated with a modified version of GIBELUMP for wide ranges of the parameters affecting numerical accuracy. A study of errors in scattering matrix elements and cross sections, as functions of these parameters, reveals that criteria commonly used to determine the matching radius and number of partial waves employed in optical-model calculations yield insufficient values in this case.

* Research supported by the National Science Foundation.

** NSF Trainee.

Mass of ^{31}S *

A. Moalem and B.H. Wildenthal

Cyclotron Laboratory, Michigan State University
East Lansing, Michigan 48823

ABSTRACT

A high-resolution study of the $^{32}\text{S}(p,d)^{31}\text{S}$ reaction shows a discrepancy with the current table of mass values. The $^{32}\text{S}(p,d)^{31}\text{S}$ reaction Q-value is found to be -12817.8 ± 1.5 keV, 45.6 keV more positive than the published value, which carried an 11-keV uncertainty. Similar studies of the (p,d) reaction on ^{23}Na , ^{27}Al , ^{33}S , ^{34}S , ^{35}Cl , and ^{37}Cl indicate no discrepancies with the Q-values (of 1 to 2 keV accuracy) tabulated for these nuclei. Possible sources for the sulfur discrepancy are discussed.

NUCLEAR REACTIONS ^{23}Na , ^{27}Al , $^{32,33,34}\text{S}$, $^{35,37}\text{Cl}(p,d)$,
E=35 MeV, measured Q, deduced new value for the mass of ^{31}S .

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

R.G.H. Robertson and B.H. Wildenthal

Cyclotron Laboratory and Physics Department
Michigan State University, East Lansing, Michigan 48823

ABSTRACT

Shell-model calculations for the A=24, T=2 system are presented which use an empirically modified version of Kuo's realistic two-body interaction and a large, but truncated, sd-shell basis space. Using the same two-body matrix elements, single-particle energies and effective charges that were found to be successful in the full sd space for A=19-22, good agreement with experimental measurements is obtained for ^{24}Ne levels and other members of the A=24, T=2 system. Some predictions are made for the unreported isotope ^{24}Si .

* Work supported by the National Science Foundation.

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FAST AQUEOUS CHEMISTRY ON-LINE WITH CYCLOTRON-PRODUCED ACTIVITIES

USING A HELIUM-JET RECOIL-TRANSPORT SYSTEM

K. L. Kosanke, Wm. C. McHarris*, and R. A. Warner
Department of Chemistry†, Cyclotron Laboratory†,
and Department of Physics

and

W. H. Kelly

Cyclotron Laboratory† and Department of Physics
Michigan State University
East Lansing, Michigan 48823, U. S. A.

Abstract:

A relatively simple system is described that can be used to perform fast on-line chemical separations (sl sec) on activities transported to low background areas in the relatively short times provided by a helium-jet recoil-transport system. The helium-jet recoil-transport system is run with its low-pressure end at atmospheric pressure, thereby eliminating the need for vacuum pumps and their associated apparatus.

ENERGY LEVELS IN ^{142}Nd

S. RAMAN

Oak Ridge National Laboratory,* Oak Ridge, Tennessee 37830, USA

J.L. FOSTER, Jr.†

Laboratoire de Physique Nucléaire, Université de Montréal,* Quebec, Canada
and the
University of Pittsburgh,* Pittsburgh, Pennsylvania 15213, USA

O. DIETZSCH‡ and D. SPALDING**

University of Pittsburgh,* Pittsburgh, Pennsylvania 15213, USA

L. BIMBOT††

Laboratoire de Physique Nucléaire, Université de Montréal,* Quebec, Canada
and

B.H. WILDENTHAL

Cyclotron Laboratory, Michigan State University,* East Lansing, Michigan 48823, USA

Abstract: The excited states of ^{142}Nd were studied by means of the decay of 40 sec ^{142}Pm and the $^{142}\text{Nd}(p,p')$ reaction via isobaric analog resonances. Approximately sixty levels of ^{142}Nd were observed below 5.3 MeV excitation, including several neutron particle-hole states excited strongly in (p,p')

*Research jointly sponsored by the U.S. Atomic Energy Commission under contract with the Union Carbide Corporation and by the National Research Council of Canada and the U.S. National Science Foundation. Preliminary results were reported previously³⁶.

†Present address: Université de Montréal, Quebec, Canada.

‡Present address: Universidade de Sao Paulo, Brazil.

**Present address: Analytic Services Corp., Falls Church, Virginia.

††On leave of absence from I.P.N., Orsay, France.

An Experimental Demonstration of Backbending

from a Band-Crossing in ^{154}Cd *

T. L. Khoo, F. M. Bernthal, J. S. Boyno and R. A. Warner

Cyclotron Laboratory, Depts. of Physics and Chemistry,
Michigan State University, East Lansing, Michigan 48824

ABSTRACT

The members of the ground- and β -bands in ^{154}Cd have been identified to spin 18. Plots of $2J/\hbar^2$ vs ω^2 yield backbending curves for both the β - and yrast states. It is shown that the backbending in the yrast sequence results from a band-crossing and it is speculated that the twin backbending may arise from the intersection of the ground- and β - bands by a third "intersecting band."

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

The $^{207}\text{Pb}(p,d)^{206}\text{Pb}$ Reaction and Some

Matrix Elements of the Effective Interaction.*

W. A. Lanford and G. M. Crawley

Cyclotron Laboratory and Department of Physics
Michigan State University, East Lansing, Michigan 48824

ABSTRACT

The cross-sections for the $^{207}\text{Pb}(p,d)^{206}\text{Pb}$ reaction have been measured relative to the cross-sections for the $^{208}\text{Pb}(p,d)^{207}\text{Pb}$ reaction to the single neutron hole states in ^{207}Pb . The reactions were studied with 35 MeV protons and a final deuteron resolution of 5 keV (FWHM). By making the same assumptions as are usually made in model calculations of ^{206}Pb , the matrix elements of the effective interaction of a $p_{1/2}$ neutron with neutrons in other orbits are derived from the experimental results.

*Work supported by the National Science Foundation.

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LBL-1626

ELECTRON AND PROTON INELASTIC SCATTERING FROM ^{40}Ca , ^{120}Sn , AND ^{208}Pb †

G. R. Hammerstein and R. H. Howell*
Cyclotron Laboratory and Physics Department
Michigan State University
East Lansing, Michigan 48823

and

F. Petrovich
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

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Abstract

Theoretical (e,e') form factors and (p,p') differential cross sections for the first 3^- and 5^- excitation in ^{40}Ca , the first 3^- excitation in ^{208}Pb , and the first 2^+ and 3^- excitations in ^{120}Sn are presented and compared with experiment. Results are also presented which test the hypothesis that the proton and neutron transition densities for these transitions are related by the condition $\rho_n = (N/Z)\rho_p$. A simple modified Born approximation has been used in the electron scattering calculations. The long range part of the Kallio-Kolltveit potential has been used for the projectile-target interaction in the proton scattering calculations and "knock-on" exchange contributions have been included approximately.

†Supported in part by U. S. Atomic Energy Commission and NSF.

* Present address: Lawrence Livermore Laboratory, Livermore, California.

G.M. Crawley, E. Kashy, W. Lanford, and H.G. Blosser

Cyclotron Laboratory, Department of Physics
Michigan State University, East Lansing, Michigan 48823

by C. Peter Wolk

MSU/AEC Plant Research Laboratory

and

ABSTRACT

Sam M. Austin, John Bortins* and Aaron Galonsky

Cyclotron Laboratory and Department of Physics,

Michigan State University, E. Lansing, Mich. 48823

Particle-hole multiplets in ^{208}Bi corresponding to the coupling of the $h_{9/2}$ proton with neutron-holes in the $p_{1/2}$, $f_{5/2}$, $p_{3/2}$, $i_{13/2}$, $f_{7/2}$, and $h_{9/2}$ shells have been observed by the $^{209}\text{Bi}(p,d)^{208}\text{Bi}$ reaction at 35 MeV with an overall resolution of 5 keV in the deuteron spectra. The results generally show excellent agreement with the weak coupling model except for the $h_{9/2}$ hole states. However the observed $h_{9/2}$ multiplet states do contain a large fraction of the strength. There is also substantial agreement with earlier (d,t) work except for some spin assignments and in the location of the 2^- member of the $h_{9/2}, v^{-1}i_{13/2}$ multiplet.

Summary

^{13}N , generated by proton bombardment of ^{13}C powder, is rapidly and easily converted to $^{13}\text{N-N}_2$, 0.01 atm pressure, ca. 10 mC/ml, by automated Dumas combustion. ^{13}N fixed (as $^{13}\text{N-N}$) by algal filaments was localized by an autoradiographic technique which permits track autoradiography with isotopes having short half-lives. The results show that if $t/x^2 \geq 5$ s, where t would be the time of diffusion of precursor-pool nitrogenous products along filaments of *Anabaena cylindrica* if those products were not immobilized by metabolism, and x is distance measured in number of vegetative cells, it is far less probable that heterocysts account for all of the nitrogen fixation by filaments than that they account for only about 25% of the total fixation of nitrogen. Arguments are presented that t/x^2 exceeds 5 s. Our findings support biochemical demonstrations that ca. 25% of the N_2 -fixation by aerobically grown *A. cylindrica* is carried out by the heterocysts.

*Work supported by the National Science Foundation.

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LBL-1692

CONFIGURATION MIXING OF TWO-QUASI-PARTICLE

STATES IN EVEN-EVEN DEFORMED NUCLEI*

H. Massmann† and J. O. Rasmussen†,
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720P. E. Haustein
Department of Chemistry and
Heavy Ion Accelerator Laboratory
Yale University
New Haven, Connecticut 06520T. E. Ward
Cyclotron Laboratory
Indiana University
Bloomington, Indiana 47401F. M. Bernthal
Departments of Chemistry and Physics
and Cyclotron Laboratory
Michigan State University
E. Lansing, Michigan 48873

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ABSTRACT

Evidence of configuration mixing of higher K bands in deformed even nuclei is surveyed. A general formulation for configuration mixing due to a two-body neutron-proton force is developed. A fit to the energy-splittings of Gallagher-Moszkowski pairs in odd-odd nuclei is made to obtain an effective Gaussian, central force except for the undetermined Wigner component. With this force, off-diagonal band-mixing matrix elements are calculated for various configurations in ^{176}Hf , ^{178}Hf , and ^{174}Yb . By solving BCS equations, the relevant occupation amplitudes are calculated. The effective n-p Wigner force component is fixed to give best over-all agreement to experimental band-mixing information. The resulting force is compared with the Anantaraman Schiffer force for spherical nuclei.

Inelastic Proton Scattering from ^{138}Ba and ^{144}Sm at 30 MeV*

Duane Larson, Sam M. Austin, and B.H. Wildenthal

Cyclotron Laboratory, Physics Department
Michigan State University
East Lansing, Michigan 48823

ABSTRACT

Measurements of the inelastic scattering of 30 MeV protons from ^{138}Ba and ^{144}Sm have been carried out with better than 10 keV energy resolution. Differential cross sections were measured for levels up through 3.4 MeV excitation energy. Spin and parity assignments are suggested for most of these states on the basis of angular distributions distinctly characteristic of angular momentum transfer $L=2,3,4$, or 6.

*Research supported by the National Science Foundation.

R. A. Warner, F. M. Bernthal, J. S. Boyno, and T. L. Khoo

Cyclotron Laboratory and Departments of
Chemistry and Physics
Michigan State University
East Lansing, Michigan 48823

and

G. Sletten
The Niels Bohr Institute
University of Copenhagen
Denmark

Abstract:

The yrast levels have been determined to spin 16 or 18 in $^{182,184,186}\text{Os}$ and to spin 12 in ^{188}Os from γ -ray excitation functions, anisotropies, and coincidence data from $^{182,184,186}\text{W}(\alpha,4n)$ and $^{186}\text{W}(\alpha,2n)$ reactions. A fork is observed in the ^{186}Os yrast band at spin 12. Above spin 12 the J vs. ω^2 curves for $^{182,184,186}\text{Os}$ display "backbending" behavior. Such behavior has not been reported for any other nuclei with more than 96 neutrons.

* Work supported in part by the U. S. Atomic Energy Commission and in part by the U. S. National Science Foundation.

SHELL-MODEL CALCULATIONS FOR A=6-14
NUCLEI WITH A REALISTIC INTERACTION

P. Hauge* and S. Maripuu*

Cyclotron Laboratory, Physics Department
Michigan State University, East Lansing, Michigan 48823

ABSTRACT

Shell model calculations are performed on the normal parity states of Op shell nuclei with A=6-14. The Hamiltonian is diagonalized in the full Op basis, and the effective two-body interaction is computed from the Sussex relative harmonic oscillator matrix elements. The second-order corrections to the two-body matrix elements are calculated for all intermediate states up to $2\hbar\omega$ excitation energy. The harmonic oscillator size parameter is taken to be constant at 1.7 fm for all nuclei, and the $p_{3/2} - p_{1/2}$ single particle energy splitting is determined for each mass number by a least-squares rms fitting to the experimental spectrum. Static and dynamic properties of the energy levels are calculated and found to be usually in good agreement with experiment.

* Part of this work was performed while the authors were NAS-NRC Research Associates at the Aerospace Research Laboratories of Wright Patterson AFB, Ohio 45433.

Helmut Laumer,** Sam M. Austin, Lolo M. Panggabean, and Cary N. Davids***

Cyclotron Laboratory, Physics Department
Michigan State University
East Lansing, Michigan 48823

Abstract

Astrophysically interesting cross sections for the production of isotopes of lithium, beryllium and boron in the proton-induced spallation of ^{14}N were measured for proton energies between 17 and 42 MeV. A time-of-flight method was used for mass identification, supplemented at one energy by radioactivity analysis. Gas targets were used throughout. The astrophysical significance of the results is discussed.

* Research supported in part by the National Science Foundation.

** Present address: Department of Physics, Kansas State University, Manhattan, Kansas 66502.

*** Present address: Center for Nuclear Studies, University of Texas, Austin, Texas 78712.

SECTION V

PH.D. THESIS TITLES

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