

SECTION IV
ABSTRACTS OF PAPERS IN PRESS
(after June 30, 1974)

FAST CALIBRATION OF LARGE Si(Li) ELECTRON DETECTORS
FROM 511.0 TO 4564.0 KEV USING DOUBLE-ESCAPE
PEAKS AND COMPTON EDGES FROM ^{66}Ga

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Study of the (p, ^3He) and (p,t) Reactions on ^{29}Si [†]

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ABSTRACT

Differential cross sections of the $^{29}\text{Si}(p,^3\text{He})^{27}\text{Al}$ and $^{29}\text{Si}(p,t)^{27}\text{Si}$ reactions between $\theta_L=4^\circ$ and 60° have been measured at 40.1 MeV bombarding energy. Assignments of the L-transfers on the basis of comparisons to DWBA calculations yield several new spin and parity assignments for states in ^{27}Si . The experimental differential cross sections of the transitions to several of the low-lying mirror pairs of final states in ^{27}Al and ^{27}Si are compared to the results of microscopic DWBA calculations in order to study the spin-isospin dependence of the interaction potential in the two-nucleon transfer reaction and to test current shell-model wave functions for the nuclear states involved.

NUCLEAR REACTIONS: $^{29}\text{Si}(p,t)^{27}\text{Si}$, $^{29}\text{Si}(p,^3\text{He})^{27}\text{Al}$, $E_p=40.1$ MeV; Measured $\sigma(E_t, E_{^3\text{He}}, \theta)$; Enriched target; deduced energies, L-values, normalization factors for states of ^{27}Al and ^{27}Si .

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

^{††}On leave of absence from Institut für Kernphysik der J.W. Goethe Universität, Frankfurt/M, Germany.

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Abstract:

Double-escape peaks and Compton edges from the γ -rays of 9.5-h ^{66}Ga have been used to allow fast, precise calibration of Si(Li) electron detectors. They allow a direct calibration up to 4564.0 keV, and the calibration curve is linear enough that it can probably be extrapolated safely to even higher energies.

*Alfred P. Sloan Fellow, 1972-1974

[†]Work supported in part by the U.S. Atomic Energy Commission

[‡]Work supported in part by the U.S. National Science Foundation

Decay of ^{177}Ta to Levels in ^{177}Hf

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Abstract:

The locations of 13 energy levels have been deduced from γ -ray singles and γ - γ coincidence measurements on the EC- β^+ decay of ^{177}Ta to ^{177}Hf . Four energy levels and fourteen γ -rays associated with ^{177}Ta decay were unknown from the previous NaI(Tl) work. The $\log ft$ values have been assigned to ^{177}Ta EC- β^+ decay, and multipolarities of several transitions have been determined with use of earlier conversion electron data.

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[†]Supported in part by the U.S. Atomic Energy Commission.

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

Study of the $^{30}\text{Si}(^3\text{He},\text{p})^{32}\text{P}$ Reaction

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ABSTRACT

The $^{30}\text{Si}(^3\text{He},\text{p})^{32}\text{P}$ reaction was studied at an incident energy of 28 MeV, and angular distributions were measured for states in ^{32}P up to 3.00 MeV of excitation energy. Comparison of the experimental differential cross sections with two-nucleon transfer distorted-wave Born approximation (DWBA) calculations was made to test different sets of wave functions, which were calculated in the same configuration space but with different treatments of the effective residual interaction.

E NUCLEAR REACTION: $^{30}\text{Si}(^3\text{He},\text{p})^{32}\text{P}$, E=28 MeV, measured $\sigma(\theta)$; enriched target; DWBA-analysis.

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^{*} Research supported in part by the Bundesministerium für Forschung und Technologie of the Federal Republic of Germany.

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A Study of the Nuclear Structure of ^{36}Cl with the (p,d) Reaction[‡]

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NUCLEAR REACTIONS: $^{37}\text{Cl}(p,d)^{36}\text{Cl}$, $E_p=35$ MeV; measured $\sigma(E_d, \theta)$; deduced excitation energies, ℓ_n -values and spectroscopic factors for states of ^{36}Cl . Enriched target.

The $^{37}\text{Cl}(p,d)^{36}\text{Cl}$ reaction, at $E_p=35$ MeV, was employed to study properties of the levels of ^{36}Cl . Excitation energies of levels up to 8.2 MeV were obtained by high-resolution magnetic analysis of the emitted deuterons. Angular distributions for the states observed in this span were measured over the angular range $\theta_L=3^\circ-55^\circ$. These data were analyzed with the DWBA theory to obtain values of ℓ_n and C^2S_ℓ . The results are compared to the previously extant experimental picture for this nucleus and to predictions of current nuclear structure theory.

[‡] Research supported in part by the U.S. National Science Foundation.
^{**} Supported in part by the Research Corporation.

A High Resolution Study of ^{208}Pb with
35 MeV Protons*

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The $^{39}\text{K}(p,d)^{38}\text{K}$ Reaction at $E_p = 35$ MeV

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NUCLEAR REACTIONS: $^{39}\text{K}(p,d)^{38}\text{K}$, $E_p = 35$ MeV; measured $\sigma(E_d, \theta)$; deduced Q-value, excitation energies, l_n -values, and spectroscopic factors for states of ^{38}K . Natural target.

ABSTRACT

The $^{39}\text{K}(p,d)^{38}\text{K}$ reaction at $E_p = 35$ MeV has been used to study the properties of states in ^{38}K up to an excitation energy of 6 MeV. An experimental resolution of 10 keV (FWHM) made it possible to detect many heretofore unobserved states. Excitation energies of observed states are determined to an accuracy of 1-4 keV. Angular distributions were measured for many of the transitions, and for these states assignment of l_n -values and extraction of spectroscopic factors is made. The results are compared to previous experiments and to current shell-model calculations.

* Work supported by the National Science Foundation.

** Work supported in part by the Research Corporation.

ABSTRACT

Angular distributions of states in ^{208}Pb excited by 35 MeV protons have been measured with a resolution of 5-8 keV. Collective model calculations enabled the l -transfers of many states to be identified. The possibility of excitation of 1^+ states is discussed. Microscopic model calculations were made with both phenomenological and theoretical information. The large number of observed unnatural parity states permitted the role of non-central forces in these transitions to be investigated.

* Supported in part by the National Science Foundation.

A High Resolution Study of ^{40}Ca Via Inelastic
Proton Scattering at 35 MeV*

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ABSTRACT

Spectra of inelastic proton scattering on ^{40}Ca have been obtained with 4.5 keV resolution at a bombarding energy of 35 MeV. Cross sections for the excitation of several previously unresolved particle-hole states have been measured. Nearly all known energy levels plus nine new levels have been observed up to an excitation energy of 9.3 MeV, slightly above the proton separation energy, and accurate excitation energies have been determined for these states.

NUCLEAR REACTIONS: $^{40}\text{Ca}(p,p')$, $E = 35.2$ MeV; measured $\sigma(15^\circ, E_p)$, $\sigma(30^\circ, E_p)$; deduced excitation energies; resolution 4.5 keV.

* Research supported in part by the National Science Foundation.

Study of ^{173}Hf Levels Populated in the
Decay of ^{173}Ta

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Abstract

The decay of ^{173}Ta was studied using high resolution Ge(Li), Si(Li) and Si surface barrier detectors in singles and coincidence modes. The ^{173}Ta activity was produced via the reaction $^{165}\text{Ho}(^{12}\text{C}, 4n)^{173}\text{Ta}$, at a carbon beam energy of 6.3-6.9 MeV per nucleon. All spectra were obtained from chemically separated Ta sources. Besides the previously known energy levels of ^{173}Hf , the following levels in keV were determined: 255.5, 451.9, 508.9, 635.8, 775.5, 785.3, 811.7, 872.6, 927.5, 942.5, 1020.3, 1111.4, 1127.0, 1192.8, 1248.3, 1450.0, 1574.2, 1655.6, 1667.1, 1694.3, 2263.3. Rotational bands based on the $1/2^- [521]$ (G.S.), $5/2^- [512]$ (107.2 keV), and $7/2^+ [633]$ (197.5 keV) Nilsson states were observed. From measurement of the β^+ end-point energy, the mass difference between ^{173}Ta and ^{173}Hf was determined to be 3670 ± 150 keV.

* Supported by the U.S. Atomic Energy Commission.

† Supported by the U.S. Atomic Energy Commission.

‡ Supported by the National Science Foundation.

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STATES IN $N=81$ ^{141}Nd POPULATED BY THE DECAY OF ^{141}Pm

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Abstract:

The decay of 20.90-min ^{141}Pm has been studied with Ge(Li) and NaI(Tl) γ -ray detectors in a variety of singles and coincidence configurations, including Ge(Li)-Ge(Li) two-parameter "megachannel" coincidence experiments, anticoincidence experiments, and pair (γ^{\pm} - γ) experiments to determine the relative β^+ feedings. Fifty γ rays were identified from this decay, and 44 of these (>99% of the γ intensity) were placed in a decay scheme containing 25 levels in ^{141}Nd . J^{π} assignments or limits were made for all of the states. The structures of the lower-lying states in ^{141}Nd are discussed in terms of the shell model, and possible structures are also suggested for many of the higher-lying states. We compare our results with those of previous studies and also with particle-transfer experiments.

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§ Work supported in part by the U.S. Atomic Energy Commission.

NUCLEAR ISOMERS AND WHAT

THEY CAN TEACH US

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Abstract:

A survey of nuclear isomers and how they arise is given. High-multipolarity, large spin-change γ -ray transitions are analyzed, and it is shown how these "forbidden" transitions come about in nuclei. The kinds of nuclear isomers, especially those occurring below closed shells and in odd-odd nuclei, are discussed, and some of the structures are analyzed in terms of shell-model states. Examples are given of specific nuclear isomers that reveal a wealth of information about nuclear structure, and future and applied applications of nuclear isomers are considered.

* Alfred P. Sloan Fellow, 1972 - 1974

[†] Supported in part by the U.S. Atomic Energy Commission

[‡] Supported in part by the U.S. National Science Foundation

An Energy-Dependent, Lane-Model, Nucleon-Nucleus
Optical Potential*

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ABSTRACT

A global, energy-dependent, Lane-model, nucleon-nucleus optical potential has been determined by fitting (p,n)-IAS angular distributions between 25 and 45 MeV while maintaining the fit obtained by Becchetti and Greenlees to proton elastic-scattering data. The potential so determined is successful in reproducing neutron elastic-scattering data over a wide mass and energy range, thus firmly establishing the essential validity of the Lane model for nucleon-nucleus optical potentials.

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

A Study of the Nuclear Continuum in ^{16}O by Inelastic ^3He Scattering[†]

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ABSTRACT

Inelastic scattering of 71 MeV ^3He -particles from ^{16}O shows an enhancement and structure of the continuum consistent with the assumption of a giant quadrupole resonance. Completely microscopic model calculations indicate that the excitation of $1^-(T=1)$ and $0^+(T=0)$ states may account for only ~10% of the total cross sections of the excitation region 17-27 MeV.

NUCLEAR REACTION $^{16}\text{O}(^3\text{He}, ^3\text{He}')$, $E_x = 0-35$ MeV
 $E_{^3\text{He}} = 71$ MeV; measured $\sigma(E_x, \theta)$, deduced E2 strength.

[†] Supported by the National Science Foundation.

A Microscopic Description of IAS Transitions Induced by 25-, 35-, and 45-MeV Protons*

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ABSTRACT

Differential cross sections have been measured for (p,n) reactions to the isobaric analogs of the targets ^{48}Ca , ^{90}Zr , ^{120}Sn , and ^{208}Pb at proton bombarding energies of 25, 35, and 45 MeV. The isospin-flip strength of a phenomenological nucleon-nucleon force has been determined with microscopic DWBA calculations including the "knockon" exchange amplitude. At the higher proton energies a realistic G-matrix effective interaction also provides a reasonable account of the observed angular distributions.

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

BASIC ORBIT PROPERTIES OF IONS IN A MIGMA FUSION DEVICE*

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ABSTRACT

The "Migma Cell" designed by Maglich is aimed at producing useful fusion power by storing deuterons in precessing, self-colliding orbits in a suitable magnetic field.¹ We have undertaken a more thorough analysis of the basic orbit properties in such a device. Using equilibrium orbit and transfer matrix techniques, we have developed a computer code which calculates all the important properties of median plane orbits and of vertical focusing in the given magnetic field as a function of momentum. Our results show that inherent alternating-gradient effects increase the vertical focusing, but beyond a critical momentum value, the vertical oscillations become unstable because of over-focusing. Moreover, the longer precession periods required for successful beam injection are generally correlated with weaker vertical focusing, and hence, lower space charge limits. In terms of orbit dynamics, our results also suggest that the particular magnet parameters chosen by Maglich may not be suitable.

*Work supported by the National Science Foundation.

AN ULTRA-THIN-WINDOW GAS CELL*

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A gas cell has been developed for which the total areal density encountered by outgoing reaction products can be as low as 50 $\mu\text{g}/\text{cm}^2$ at 25 torr gas pressure.

*Research supported in part by the National Science Foundation.

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Cross Sections for the Production of Mass-6 and Mass-7 Nuclides in the Proton-Induced Spallation of ^{20}Ne [†]

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ABSTRACT

Cross sections for proton induced spallation of ^{20}Ne leading to nuclides with mass 6 or mass 7 were measured at proton energies between 30 and 40 MeV. Time-of-flight techniques were used for mass identification.

NUCLEAR REACTIONS: $^{20}\text{Ne}+p$; $E=30.0, 35.0, 40.0$ MeV; measured spallation σ for producing masses 6,7; gas targets. Discuss astrophysical significance.

[†]Research supported in part by the National Science Foundation.

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First Excited A=9 Isospin Quartet*

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ABSTRACT

The first excited state of ^9C and its analog in ^9B have been observed, and their mass excesses and widths have been measured. This completes a new mass quartet which differs from the predictions of the isobaric multiple mass equation less significantly than the ground state A=9 quartet.

NUCLEAR REACTIONS: $^{12}\text{C}(^3\text{He}, ^6\text{He})$, $E=74$ MeV measured Ex of ^9C first excited state. $^{11}\text{B}(p,t)$, $E=46.5$ MeV, measured Ex of second T=3/2 level in ^9B . Deduced coefficient of multiplet mass equation for first excited A=9 quartet.

*Work supported by the National Science Foundation.

DECAYS OF THE $f_{7/2}$ ISOMERS, ^{53g}Fe AND ^{53m}Fe

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Techniques for the Study of Short-Lived Nuclei

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The decays of 8.5-min ^{53g}Fe and 2.5-min ^{53m}Fe have been studied with a variety of γ and β^+ detectors in many different singles and coincidence configurations. States in ^{53}Mn populated by ^{53g}Fe decay were found to lie at 0 ($J^\pi=7/2^-$), 377.9 ($5/2^-$), 1288.0 ($3/2^-$), 1619.9 ($9/2^-$), 2273.5 ($5/2^-$), 2685.6 ($7/2^-$), 2946.6 ($9/2^-$), 3126.7 ($9/2^-$, $7/2^-$, $5/2^-$), and 3248.0 keV ($[9/2^-]$). States in ^{53}Fe populated by 3040.6-keV ($19/2^-$) ^{53m}Fe decay were confirmed at 0 ($7/2^-$), 1328.1 ($9/2^-$), and 2339.6 keV ($11/2^-$). In addition, a 3040.6-keV $E6$ and a 1712.6-keV $M5$ transition were found to compete with the 701.1-keV $E4$ isomeric transition in deexciting ^{53}Fe , this being the first observation of such high multipolarities. The $E6$ has an intensity of 6.0×10^{-4} and the $M5$ an intensity of 1.3×10^{-2} relative to the $E4$ transition. The $E4$, $M5$, and $E6$ transitions are retarded by respective factors of 7.6, 4.2, and 4.3 with respect to single-particle estimates and by somewhat larger factors with respect to simple shell-model estimates.

RADIOACTIVITY $^{53g,m}\text{Fe}$ [from $^{53}\text{Mn}(p,3n)$]; measured $E_\gamma I_\gamma$, γ - γ coin, E_β^+ , I_β^+ , γ - β^+ coin; calculated $\log ft$; ^{53}Fe , ^{53}Mn deduced levels J^π ; calculated shell-model wave functions, γ transition probabilities.

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‡Work supported in part by the U.S. Atomic Energy Commission.

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FOCUSING PROPERTIES OF SUPERCONDUCTING CYCLOTRON MAGNETS[‡]

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ABSTRACT

Superconducting main coils combined with conventional sectorized iron pole tips constitute a promising design configuration for a new generation of compact, low-cost heavy-ion cyclotrons. This paper gives results of focusing strength calculations for such cyclotrons for a variety of possible pole tips. The focusing is found to be highly sensitive to the average strength of the magnetic field, moderately sensitive to the magnet gap in the hills, and relatively independent of the number of sectors, the relative width of hill and valley and the magnet gap in the valleys. Spiraling of the magnet pole tips increases the focusing but substantially less than expected. Several of these properties are strikingly different from the corresponding properties of conventional low field magnets. The focusing limit of high field magnets leads to a linear dependence of the energy per nucleon on the charge to mass ratio of the ion over much of the operating range which contrasts with the usual quadratic dependence.

‡Work supported by the National Science Foundation.

A Note on Discrepancies Between (p,n) and (p,n \bar{p}) Reactions
on Nuclei near A = 208[†]

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ABSTRACT

The (p,n) and (p,n \bar{p}) reactions on nuclei near A=208 were compared. No discrepancy in cross sections were observed but the width anomaly remains.

[NUCLEAR REACTIONS: $^{208}\text{Pb}(p,n)$ and $^{208}\text{Pb}(p,n\bar{p})$, $E_p=21-35$ MeV] measured σ .

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

HEXADECAPOLE DEFORMATIONS IN W AND OS NUCLEI FROM PERTURBED ROTATIONAL
BAND STRUCTURE^{*}

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ABSTRACT

The spectroscopic data for even-parity rotational and intrinsic states in ^{181}W and ^{187}Os are shown to be incompatible with very large static nuclear hexadecapole deformations ($\epsilon_4 \cong 0.2$) implied by conventional analysis of recent Coulomb excitation measurements of E4 transition moments in ^{182}W and $^{186,188}\text{Os}$.

ROTATIONAL BAND STRUCTURE IN N=105 AND 107 ISOTONES:

I. EVIDENCE FOR THE TRANSITION TO $|II_J\rangle$
COUPLING AT HIGH SPINS IN ^{179}W .^{*}

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ABSTRACT

The $^{177}\text{Hf}(\alpha,2n\gamma)$ and $^{181}\text{Ta}(p,3n\gamma)$ reactions have been employed in a study of the ^{179}W rotational band structure. Attention is focused on the unique-parity $9/2^+$ [624] band and its highly-perturbed rotational structure. The higher spin members of the even-parity band in ^{179}W are not well-characterized by a single K quantum-number and are better represented in the $|IR_J\rangle$ coupling scheme. Limits are placed on the hexadecapole deformation consistent with the rotational band structure in ^{179}W . The relevance of the even-parity band structure in ^{179}W to back-bending in neighboring even-A nuclei is discussed.

J-Dependence Observed in $^{61,62}\text{Ni}(p,d)$ Reactions at 40 MeV^{*}

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ABSTRACT

Several $l=3$ transitions observed in both $^{61,62}\text{Ni}(p,d)$ reactions demonstrate a very stable j-dependence of shape over a range of intensities and excitation energy.

*Supported in part by the National Science Foundation.

[†]Supported by C.N.R.S. (France), on leave from the Institut des Sciences Nucleaires, Grenoble, France.

Failure of the Allowed Assumption in the ϵ/β^+ Decays of ^{145}Gd and ^{143}Sm —Experimental Evidence for Interference Effects in Nuclear β Decay

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(Received 8 April 1974)

Anomalous ϵ/β^+ decay branching ratios for “hindered allowed” transitions (measured by $\gamma^+-\gamma$ and $x-\gamma$ coincidence techniques) have been found in $^{145}\text{Gd} \rightarrow ^{145}\text{Eu}$ (808.5-keV state) and $^{143}\text{Sm} \rightarrow ^{143}\text{Pm}$ (1173.2-keV state). These ratios exceed theoretical predictions by factors of 24 and 5, respectively. Thirteen additional ratios from these nuclei and ^{143}Eu agree with the predictions. This is the first conclusive evidence of the failure of the allowed assumption in nuclear β decay and of the presence of interference effects.

PHYSICAL REVIEW C

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Classical view of the application of sum rules to inelastic form factors*

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(Received 15 April 1974)

Classical arguments are given to show why the Tassie model of form factors can be derived from a doorway hypothesis.

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Discovery of the Missing Two-Particle, Two-Hole 0^+ States in ^{40}Ca

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(Received 25 March 1974)

A good-resolution study of the reaction $^{42}\text{Ca}(p,t)^{40}\text{Ca}$ has revealed the existence of three new 0^+ states in ^{40}Ca at 7698, 8284, and 8438 keV excitation. Arguments are presented to show that these states are indeed the long sought-after 0^+ , $T=0$ states with predominantly two-particle, two-hole configurations.

Study of the Structure of ^{62}Zn and ^{64}Zn
Through (p,t) Reactions at 35 MeV*

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ABSTRACT

Energy levels in ^{62}Zn and ^{64}Zn have been investigated via the (p,t) reaction at 35 MeV. Many new levels are reported up to an excitation energy of 5.3 MeV, with spin and parity assignments determined for most levels, including the 0^+ member of the two phonon triplet at 2.33 MeV. A comparison between the states populated in these two reactions is made. Standard distorted-wave calculations give reasonable agreement with the data. However, 3^- and 4^+ states cannot be unambiguously distinguished.

[NUCLEAR REACTIONS ^{64}Zn (p,t) ^{62}Zn , $E = 35$ MeV,
 ^{62}Zn (p,t) ^{64}Zn , $E = 35$ MeV; measured $\sigma(E_t, \theta)$;
 ^{62}Zn , ^{64}Zn deduced levels, J, π .]

*Work supported in part by the National Science Foundation.

Two-body short-range correlations and Coulomb matrix elements*

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Correlated Coulomb matrix elements are calculated by evaluating the appropriate G matrices G_{N+C} and G_N which correspond to $V_N + V_C$ (nuclear + Coulomb) and V_N potentials, respectively. Including the effect of the Pauli operator, we confirm the recent report by McCarthy and Walker that the effect of the two-body short-range correlations is small.

Levels of $^{56}\text{Ni}^{\#}$

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ABSTRACT

The $^{58}\text{Ni}(p,t)^{56}\text{Ni}$ reaction was studied at 40 and 45 MeV beam energy. An energy resolution of 10-25 keV permitted observation of 60 levels with excitation energy up to 10.5 MeV. Spin and parity are assigned to levels which were excited with characteristic angular distributions. These include 0^+ states at 3.95, 5.00, 6.44, 7.91, 9.92, 9.99 and 10.02 MeV.

NUCLEAR REACTIONS: $^{58}\text{Ni}(p,t)^{56}\text{Ni}$, $E_p = 40.0$ and 45.5 MeV; measured $\sigma(E_t, 0)$; enriched target. ^{56}Ni deduced levels, L, J, π .

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High Resolution (p,p') on ^{207}Pb and $^{209}\text{Bi}^{\#}$

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ABSTRACT

The inelastic scattering of protons from ^{207}Pb and ^{209}Bi has been measured with energy resolution on the order of 1/5000. Many states were observed and a number of weak coupling multiplets were identified. Use of the collective model and weak coupling theory enabled spin and parity assignments to be made. Calculations for the observed single particle states with non-central forces and with core polarization are presented.

NUCLEAR REACTIONS. $^{207}\text{Pb}(p,p')$, $^{209}\text{Bi}(p,p')$, $E=35$ MeV; measured $\sigma(\theta)$, $\theta=10-100^\circ$. Deduced L, B_L ; microscopic DWBA analysis.

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