

Argonne National Laboratory

**UNCLASSIFIED QUARTERLY PROGRESS REPORT
ON PHYSICAL SCIENCES**

February, March, April 1962

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ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
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UNCLASSIFIED QUARTERLY PROGRESS REPORT
ON PHYSICAL SCIENCES

February, March, April 1962

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TABLE OF CONTENTS

	<u>Page</u>
FOREWORD	3
PHYSICS DIVISION	5
Theoretical Physics	5
Experimental Physics	7
PARTICLE ACCELERATOR DIVISION	15
APPLIED MATHEMATICS DIVISION	17
CHEMISTRY DIVISION	19
Nuclear Chemistry	19
Effects of Radiation	24
Inorganic and Physical Chemistry	27
Analytical Chemistry	34
Miscellaneous	36
SOLID STATE SCIENCE DIVISION	39
CHEMICAL ENGINEERING DIVISION	47
METALLURGY DIVISION	51

UNCLASSIFIED QUARTERLY PROGRESS REPORT
ON PHYSICAL SCIENCES

May 1962

This report presents briefly the unclassified accomplishments in the basic physical science program (5000 Program) of the Laboratory. It is a collection of abstracts of papers on work in the physical sciences published or accepted for publication since February 1962.

Research activities which have not yet reached the state of accepted journal publications are not covered. Neither is classified work covered; this will be reported in a series of supplementary reports which will be issued at less frequent intervals.

PHYSICS DIVISION

Theoretical Physics

FLUX QUANTIZATION AND TIME-REVERSAL DEGENERACY

Murray Peshkin and W. Tobocman*

Phys. Rev., in press

It is shown on the basis of very general considerations that the observed quantization of the magnetic flux enclosed by a ring superconductor in units of $\pi\hbar c/e$ implies time-reversal degeneracy of the states of the superconductor. This degeneracy results in vanishing electron current density at thermodynamic equilibrium, which is required for consistency with the Meissner effect. On the basis of our general arguments alone, it is not possible to show that vanishing current requires flux quantization. The quantization of flux is also used to shed some light on the applicability of the BCS approximation in the presence of an enclosed magnetic field.

FLUX QUANTIZATION AND THE CURRENT-CARRYING STATE IN A SUPERCONDUCTING CYLINDER

H. J. Lipkin, Murray Peshkin and L. J. Tassie

Phys. Rev. 126 116-117 (April 1, 1962)

London's phenomenological theory is modified to include quantization of angular momentum in the boson gas model of a superconductor. The modified London equation is solved in ring geometry to find the magnetic field in the penetration region. The unit of flux quantization is obtained for all thicknesses of the superconductor. The relation between angular momentum and kinetic energy in the current-carrying state is discussed briefly.

TIME REVERSAL AND SUPERSELECTION

Hans Ekstein

Nuovo Cimento 23 (3) 606-615 (1962)

Abstract in ANL-6493, p. 5

*Case Institute of Technology, Cleveland.

THE PION-PION EFFECT ON LOW-ENERGY PION-NUCLEON
SCATTERING

M. Marinaro* and Katsumi Tanaka
Nuovo Cimento 23 (3) 537-546 (1962)

Abstract in ANL-6493, p. 5

TOTAL CROSS SECTIONS AT HIGH ENERGIES

Kichiro Hiida, Michitoshi Soga and Katsumi Tanaka
Phys. Rev. Letters 4 187-190 (February 15, 1962)

Abstract in ANL-6493, p. 6

ELASTIC NUCLEON-NUCLEON SCATTERING AT HIGH ENERGIES
AND SMALL ANGLES

Kichiro Hiida
Phys. Rev. Letters 8 148-150 (February 1, 1962)

Abstract in ANL-6493, p. 6

NUCLEAR MODELS, THRESHOLD STATES AND
REARRANGEMENT ENERGY

D. R. Inglis
Nuclear Phys. 30 (1) 1-29 (February 1962)

Abstract in ANL-6493, p. 8

*University of Naples.

SPIN AND STATISTICS WITH AN INDEFINITE METRIC

Richard Spitzer

Nuclear Phys., in press

A theory of spin- $\frac{1}{2}$ bosons and spin-0 fermions formulated with an indefinite metric for physical states is considered. The requirement that squares of S-matrix elements be interpretable as probabilities in the usual sense is formulated in terms of a symmetry principle as a consequence of which states with positive norms become separated from those with negative norms by a superselection law. The symmetry transformation, called metric conjugation, is induced by the metric operator and is nonlocal. An example of an interaction invariant under metric conjugation is shown to lead to a unitary S matrix and to a theory that admits a causal interpretation in the sense of Stueckelberg. Some consequences of the assumption that the muon is a spin- $\frac{1}{2}$ boson are discussed. The theory then provides a physical basis for the absence of the decays $\mu \rightarrow e + \gamma$, $\mu \rightarrow 3e$ in the sense that the conservation law which leads to these selection rules is the one required for the theory to admit a physical interpretation. The same conservation law forbids muon pair production.

Experimental Physics

HIGH-FREQUENCY PLASMOIDS

A. J. Hatch

Proc. 5th Intern. Conf. on Ionization Phenomena in Gases, Munich, Aug. 28-Sept. 1, 1961, ed. H. Maecker. Amsterdam: North-Holland Publishing Co., 1962. pp. 748-755

Abstract in ANL-6445, p. 7

GEOMETRICAL CONSIDERATIONS IN THE MEASUREMENT OF THE RATIO L/R IN THE SCATTERING OF POLARIZED NUCLEONS

J. E. Monahan and A. J. Elwyn

Nuclear Instr. and Methods 14 (3) 348-350 (January 1962)

Abstract in ANL-6493, p. 15

POLARIZATION AND DIFFERENTIAL CROSS SECTION FOR NEUTRONS SCATTERED FROM DEUTERIUM

R. O. Lane, A. J. Elwyn and A. S. Langsdorf, Jr.

Bull. Am. Phys. Soc. 7 333 (April 1962)

Abstract

The scattering of polarized neutrons by deuterium has been measured at five laboratory angles (22° , 48° , 80° , 100° , 150°) and three neutron energies. The neutrons were emitted at an angle of 51° to the proton beam incident on a lithium target. Results for n-d scattering were obtained from measurements on deuteriated polyethylene by subtraction of the scattering by carbon. Polarization was measured by determining the differences in the scattered intensities, first without a magnetic field and then by passing the incident neutrons through the transverse field of an electromagnet set to precess their spins by 180° . Preliminary results indicate that the polarizations are $\leq 2.5\%$ at a neutron energy of 0.5 Mev and $< 2\%$ at 1.0 Mev at all measured angles. At an energy of 1.95 Mev, an apparent polarization of about 3% was found in the vicinity of 90° (Laboratory). The unpolarized differential-scattering cross section appears to be considerably larger than previous results had indicated at the two largest angles, but is in agreement at the smaller angles at all three of the energies.

DOUBLE-OVEN EXPERIMENTS WITH LITHIUM HALIDE VAPORS

Joseph Berkowitz, H. A. Tasman and W. A. Chupka

J. Chem. Phys., in press

Abstract in ANL-6493, p. 26

(d,He³) REACTIONS ON F¹⁹ AND Al²⁷

T. H. Braid and Benjamin Zeidman

Bull. Am. Phys. Soc. 7 300 (April 1962)

Abstract

The 21.6-Mev deuteron beam from the Argonne 60-in. cyclotron has been used to initiate (d,He³) reactions in F¹⁹ and Al²⁷. The reaction products were detected by means of a solid-state EdE/dx system. The spectra have been measured over a range of angles between 9° and 40° in the laboratory system. From the F¹⁹ target, we observed strong transitions to the ground state of O¹⁸ and to the first-excited state at 1.98 Mev. The angular distributions for these states correspond to $\ell = 0$ and $\ell = 2$, respectively. This indicates the presence of configuration mixing. For Al²⁷, we observed strong transitions to the ground state and 1.83-Mev first-excited state of Mg²⁶. Weaker transitions to the state at 2.97 Mev and a group at approximately 4 Mev were seen. All angular distributions correspond to $\ell = 2$ transitions.

HIGH-ENERGY GAMMA RAYS FROM Na^{24}

J. E. Monahan, Sol Raboy and C. C. Trail
Nuclear Phys., in press

The gamma-ray spectrum from Na^{24} has been studied with a scintillation spectrometer with an anticoincidence annulus of NaI(Tl) . Gamma rays with energies of 3.85 Mev and 4.1 Mev are observed in addition to the well-known gamma rays with energies of 2.753 Mev and 1.3686 Mev. The intensities of the 3.85-Mev gamma ray and the 4.1-Mev gamma ray relative to the 2.75-Mev gamma ray are measured to be $(7.5 \pm 2) \times 10^{-4}$ and $(8 \pm 3) \times 10^{-5}$, respectively. An upper limit of 7×10^{-6} is placed upon the intensity of a 5.5-Mev gamma ray relative to the 2.75-Mev line.

POLARIZATION AND DIFFERENTIAL CROSS SECTION FOR NEUTRON SCATTERING FROM SILICON

R. O. Lane, A. J. Elwyn and A. S. Langsdorf, Jr.
Phys. Rev., in press

The polarization of neutrons scattered from Si and the unpolarized differential cross section for the process are measured at 5 angles and at neutron energies from 0.2 to 0.7 Mev. The differential cross sections in the present work, together with previously measured cross sections, are analyzed in terms of the properties of the resonance levels seen in Si^{29} ($\text{Si}^{28} + n$) by means of the R-function formalism of Lane and Thomas. The levels in Si^{29} at neutron energies of 0.536 Mev and 0.571 Mev are assigned to be $D_{5/2}$ and $P_{3/2}$, respectively. The phase shifts obtained from this analysis are used to predict the polarization in the scattering from Si^{28} . The predicted values agree well with the measured polarization in scattering from natural Si. However, the rapid variation of the polarization with energy limits the usefulness of Si as an analyzer near the resonance energies. At neutron energies below 0.4 Mev and above 0.65 Mev the polarization is practically zero. The agreement between calculated and measured polarizations gives added confirmation of previous measurements of the polarization of the neutrons in the $\text{Li}^7(p,n)\text{Be}^7$ reaction, which has been used as the neutron source in the present study.

ELECTRIC QUADRUPOLE MOMENT OF THE 14.4 kev STATE OF Fe^{57}

C. E. Johnson,* W. Marshall* and G. J. Perlow
Phys. Rev., in press

From a measurement of the Mössbauer absorption spectrum of ferrous fluosilicate for polarized 14.4-kev radiation the quadrupole moment of the first excited state of Fe^{57} is deduced to be +0.12 barn. This value is subject to a small correction due to the internal Sternheimer effect for the Fe^{++} ion.

*A.E.R.E., Harwell.

MÖSSBAUER EFFECT OF Fe^{57} AS AN IMPURITY IN VARIOUS ALLOYS

Juergen Heberle, P. N. Parks and J. P. Schiffer

Bull. Am. Phys. Soc. 7 350 (April 1962)

Abstract

Sources of Co^{57} have been prepared by diffusing the activity into Cu, W, and Pt. Measurements were made with these sources at 82° , 298° , and 425°K with a metallic iron absorber above the Curie point. The Mössbauer line was narrower than three natural linewidths in all cases. Effective Debye temperatures were deduced (a) from the temperature shift neglecting a possible temperature-dependent isomer shift, and (b) from the change in Mössbauer f as the source temperature is changed. The simple expectation for low temperatures that

$$\theta_{\text{eff}} = (M_{\text{lattice}}/M_{\text{impurity}})^{\frac{1}{2}} \theta_{\text{lattice}}$$

seems to be correct for Cu and Be, but does not hold for W and Pt.

(d,t) REACTIONS ON NUCLEI NEAR $N = 28$

Benjamin Zeidman and T. H. Braid

Bull. Am. Phys. Soc. 7 315 (April 1962)

Abstract

The (d,t) reactions on targets of V, Cr, Mn, Fe^{54} , Fe^{56} , and Ni^{58} have been studied over a range of forward angles with 21.6-Mev deuterons from the Argonne 60-in. cyclotron. The detection system consisted of a $E - dE/dx$ telescope composed of solid-state detectors. The system was capable of observing (d,t) reactions having negative Q values up to about 12.5 Mev. Many groups were observed in all targets. The most prominent groups in nuclei having 28 neutrons all showed $\ell = 3$ angular distributions, but weaker $\ell = 1$ angular distributions also appear. For nuclei having 30 neutrons, the $\ell = 1$ angular distributions predominate, the $\ell = 3$ contributions are observed up to excitations of 5 Mev. The transition to the 933-keV level in Fe^{55} is evident. It has an $\ell = 3$ angular distribution and a cross section approximately 10% of that of the 1.3-Mev group.

ELASTIC AND INELASTIC SCATTERING OF 43-Mev ALPHA PARTICLES BY Ni^{58} AND Ni^{60}

H. W. Broek, T. H. Braid, J. L. Yntema and Benjamin Zeidman
Phys. Rev., in press

Inelastic scattering and elastic scattering of 43-Mev α particles have been studied over the angular range from 17° to 53° c.m. The angular distributions of the prominent group from the 2^+ first excited level and the 3^- "anomalous" group are fitted well by calculations based on the distorted-wave Born approximation. The angular distribution of the 4^+ group at 5.5 Mev in Ni^{58} also agrees well with the calculations. Groups at low excitation, with angular distributions in phase with elastic scattering, were found at 2.2 and 2.50 Mev in Ni^{60} and at 2.47 Mev in Ni^{58} . These groups violate the phase rule from Fraunhofer diffraction theory, and hence are believed to be due to two-phonon excitations. Other groups with angular distributions in phase with elastic scattering were found at 4.45, 6.8 and 7.1 Mev in Ni^{58} and at 4.05, 5.6, 6.2, and 7.0 Mev in Ni^{60} . Groups with angular distributions out of phase with elastic scattering were found at 1.45, 3.3, 5.5, and 5.9 Mev in Ni^{58} and at 1.33, 3.2 and 5.1 Mev in Ni^{60} .

DIRECT OBSERVATION OF RESONANT p-WAVE NEUTRON CAPTURE

H. E. Jackson

Bull. Am. Phys. Soc. 7 289 (April 1962)

Abstract

Although much effort has recently been devoted to the measurement of average cross sections for p-wave neutron capture, no p-wave resonances have been specifically identified below 20 kev. However, a direct measurement of individual p-wave resonance parameters is of interest in determining the degree to which the latter depend on the spin and parity of the captured neutron. In particular, Cameron has pointed out that the total radiation width may be considerably different for s- and p-wave resonant capture. Hence, the capture γ -ray spectra for resonant capture in Mo and Zr have been measured in an effort to observe p-wave resonances directly. Preliminary results indicate the presence of a resonance in Mo^{95} at 107 ev with an anomalously strong ground-state transition. The strength of this line is inconsistent with s-wave capture. Consequently, the resonance must be due to capture of a p-wave neutron, the transition must be $E1$, and the capture state must be 1^- .

Sm¹⁴⁹ (n, γ) Sm¹⁵⁰ AND THE ASSOCIATED ENERGY LEVELS IN Sm¹⁵⁰

R. K. Smither

Bull. Am. Phys. Soc. 7 316 (April 1962)

Abstract

The capture γ -ray spectrum of Sm¹⁴⁹(n, γ) Sm¹⁵⁰ was investigated with the Argonne 7.7-m bent-crystal spectrometer. The observed spectrum consisted of 215 γ -rays with energies below 2.2 Mev. These precision energy measurements were used to modify and extend the level scheme of Sm¹⁵⁰. The extended scheme consists of 12 levels of excitation (above the 0⁺ ground state). Of particular interest is the increased level structure in the region of the second 2⁺ level. Four levels appear to be bunched in this region at 711.85 kev ((2)); 737.10 kev ((2)); 740.62 kev (0⁺); 773.53 kev (2⁺). The double parentheses indicate uncertainty in the spin assignments. For these levels, the probable error in the energy relative to the ground state is about 0.6 Mev. Many of the low-energy γ -ray transitions between the upper levels are observed. Their role in the determinations of the spins and parities of the upper levels is discussed.

SPUTTERING EXPERIMENTS IN THE RUTHERFORD COLLISION REGION

Manfred Kaminsky

Bull. Am. Phys. Soc. 7 346 (April 1962)

Abstract

Phys. Rev., in press

Sputtering experiments have been conducted by bombarding the (110) plane and the (100) plane of single crystals of copper by deuterons incident normally with energies from 0.8 to 2.5 Mev from a Van de Graaff accelerator. Electron micrographs showed that surface etch pits were formed by bombardment, even at these high energies. Measurements of optical transmission of the sputtered film collected on a quartz tube indicated a deviation from a cosine distribution in the energy range investigated. For 800-kev deuterons bombarding a (100) plane in Cu, the absolute value of the sputtering ratio was $S = 1.1 \times 10^{-3}$ atom/ion at 25° with respect to the surface normal and 5.8×10^{-4} at angles larger than 40°; and $S < 0.9 \times 10^{-3}$ atom/ion at 25° for 1.5-Mev deuterons. For 0.80- and 2.5-Mev deuterons bombarding a (110) plane, $S < 5 \times 10^{-2}$ atom/ion. These data agree with the calculations of Goldman and Simon and of Pease within a factor of two, but disagree with those reported by Pleshivtsev by 2-4 orders of magnitude. The sputtering ratio was found to decrease with increasing ion energy, in qualitative agreement with the theoretical predictions but contrary to the findings of Pleshivtsev.

EFFECT OF STYRENE MONOMER ON THE FLUORESCENCE PROPERTIES OF POLYSTYRENE

L. J. Basile

J. Chem. Phys., in press

Fluorescent spectra and lifetimes have been studied for polystyrene having different average molecular weights and different concentrations of residual monomer. The residual styrene monomer is fluorescent and acts as a typical fluorescent solute in a rigid medium. The fluorescent properties of polystyrene were found to be dependent on both the concentration of residual styrene monomer and, to a lesser extent, the average molecular weight.

ON THE FLUORESCENCE SPECTRUM AND DECAY TIME OF NAPHTHALENE

I. B. Berlman* and Arye Weinreb

Mol. Phys., in press

In her study on the dependence of the fluorescent intensity of naphthalene on its concentration in n-hexane Dammers-de Klerk explained her results on the assumption that at higher concentrations naphthalene dimers are formed by interaction between excited and unexcited molecules. In this paper the authors report measurement of the decay time of naphthalene under various conditions. Their results indicate the existence of at least two decay rates of approximately 70 nsec and 0.6 μ sec. These values are for deaerated naphthalene solutions excited with electrons and for concentrations from 1 to 50 g/liter. The decay-time measurements and other experiments do not support the assumption of dimer formation at low and medium concentrations. The absence of a relative change in the shape and magnitude of the emission spectrum upon changing the solvent or varying the temperature and/or the concentration up to 20 g/liter suggests that there is no appreciable dimerization effect in solutions of naphthalene at these concentrations. The absence of a change in the decay time upon changing concentrations supports this contention. Since the decay has two components, one might be tempted to ascribe the long-lived component to dimers. The long-lived component is much more quenched by oxygen than the short-lived component. At low concentrations the dimer concentration should be low and the long-lived component should then be absent or very small. One would then expect the quenching action of oxygen on the fluorescent intensity to decrease with decreasing concentration. This is not the case.

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FLUORESCENCE ENERGY TRANSFER AND OXYGEN QUENCHING IN
SOLUTIONS OF DIPHENYLOXAZOLE IN CYCLOHEXANE

Arye Weinreb

J. Chem. Phys. 36 890-894 (February 15, 1962)

Abstract in ANL-6445, p. 17

THE ARGONNE 60-IN. SCATTERING CHAMBER

J. L. Yntema and H. W. Ostrander

Nuclear Instr. and Methods, in press

Abstract in ANL-6394, p. 14

PARTICLE ACCELERATOR DIVISION

A HIGH CURRENT RADIO FREQUENCY PROTON SOURCE WITH RADIAL EXTRACTION

M. E. Abdelaziz

IRE Trans. NS-9 (2) 1-10 (April 1962)

A theory outlining the mechanism of the low pressure hydrogen plasma used in radio frequency proton sources is given. Taking into account secondary emission from surfaces of plasma vessel it is shown that the electron density is maximum at the tube's center. This is confirmed experimentally, and a source is designed with its extraction electrode positioned radially near the plasma center.

Compared with axial extraction used in conventional rf sources, radial extraction yields beam currents over 20% higher, and allows the application of higher extraction voltages. Beam currents up to 150 ma can be extracted, of which more than 85% is proton current. Two methods are used for the measurement of the emittance of the accelerated beam.

FEASIBILITY OF ACCELERATING POLARIZED PROTONS WITH THE ARGONNE ZGS

David Cohen

Rev. Sci. Instr. 33 161-169 (February 1962)

Abstract in ANL-6493, p. 29

A STABLE ELECTRONIC INTEGRATOR SWITCH

R. E. Daniels

Rev. Sci. Instr. 33 487-488 (April 1962)

Note

The techniques described in the literature for clamping and unclamping an electronic integrator for use with a monopolar signal have excessive drift or jump or are slow in operating. A switch has been developed that is extremely stable and reliable.

STUDY OF A FOCUSED BEAM FROM THE DUOPLASMATRON PROTON SOURCE

R. P. McKeever and Akihiko Yokosawa

Bull. Am. Phys. Soc. 7 276 (April 1962)

Abstract

The aberrations of the preaccelerator focusing electrodes were studied experimentally by obtaining the emittance diagrams of the beam of 38, 60, and 75 ma. The aberrations observed were similar to those obtained from the previous ray-tracing calculations. According to the analysis, the cause of aberrations is improper distribution of the radial field in the exit portion of the lens. More distortion of the phase-space diagram was observed for the higher beam current than the lower one. The observed emittance area increased by more than a factor of two when the beam current was doubled. This fact may raise a serious problem in the beam matching (for instance, preaccelerator to linac) for a high current, say, above 70 ma, even if aberrations were entirely eliminated. A technique for measuring the emittance of the beam at 200 kv was developed, and the details are described.

SEPARATION SCHEME FOR HIGH ENERGY PARTICLES BY DIFFERENTIAL ENERGY LOSS AND MOMENTUM ANALYSIS

S. M. Marcowitz and L. G. Ratner

Rev. Sci. Instr., in press

A simple, low cost separation scheme using differential energy loss is described. The expected parameters of the ANL-ZGS secondary beams provide a framework for the design of a \bar{P} , K^- beam at 6 Bev/c for bubble chamber use. Magnet stabilities of the order of 0.01% are required. The π^- , \bar{P} , K^- ratio at the chamber is about 1:8:8 with $3.2\bar{P}$ and $3.0K^-$ per pulse for a $\pm 0.25\%$ initial momentum bite. A calculation is also made for a 50-Bev/c beam to show that it seems feasible to use this method at energies higher than any that have hitherto been produced.

APPLIED MATHEMATICS DIVISION

THE APPROACH TO STEADY STATE OF SOLUTIONS OF EXTERIOR
BOUNDARY VALUE PROBLEMS FOR THE WAVE EQUATION

R. N. Buchal

J. Math. and Mech., in press

A recent paper by C. S. Morawetz discusses the decay of solutions of the initial-boundary value problem for the wave equation when the initial data have compact support. A similar problem is obtained when a forcing term $\rho(x, y, z) \exp(-i\omega t)$ is added to the wave equation, with a corresponding term in the boundary condition. In this case it is shown that the solution decays to the steady state solution at least as fast as $1/\sqrt{t}$. The proof is obtained by generalizing Morawetz's technique to complex functions and using an expansion theorem for the steady state function to prove that certain integrals involved in the proof are bounded.

A NUMERICAL STUDY OF THE RELATIVE CLASS NUMBERS OF REAL
QUADRATIC INTEGRAL DOMAINS

Harvey Cohn

Math. Computation 16 (78) 127-140 (April 1962)

In 1856 Dirichlet gave some applications of a formula for the ratio of the class number of a quadratic integral domain in a real field to the class number of the whole integral domain, with the principal objective of showing that this ratio takes many values infinitely often for the real case, in support of a conjecture of Gauss.

The object of this paper is to give Dirichlet's results briefly, together with some theorems and illustrations immediately deducible from them. The main object of the paper is to offer various tables of relative class numbers. The problem was programmed for the GEORGE computer.

AN ANALOG COMPUTER MODEL OF A MULTIPLE-REGION REACTOR
L. C. Just, C. N. Kelber* and N. F. Morehouse, Jr.
ANL-6482 (February 1962)

This paper presents a technique for solving the time-space-dependent diffusion equation for a multiple-region reactor on an analog computer. The technique was applied to a reactor problem involving fuel burnup and poison buildup, while constant power was maintained by the introduction of control poison.

Diffusion across boundaries is computed by putting the interregion neutron diffusion into the form of a surface integral. This method allows a good flux plot to be made by means of only six spatial points.

A sample problem was worked by this technique and compared to a digital solution. All computations, circuits, and operating information necessary to duplicate the experiment are given. Also, results are included and compared with a digital computation.

EFFECT OF VIRTUAL EXCITATION OF THE $2s$ STATE ON THE ELASTIC SCATTERING OF ELECTRONS BY ATOMIC HYDROGEN

Kenneth Smith, R. P. McEachran** and P. A. Fraser**
Phys. Rev. 125 553-558 (January 15, 1962)

Abstract in ANL-6493, p. 36

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CHEMISTRY DIVISION

Nuclear ChemistryTHEORETICAL REACTION CROSS SECTIONS FOR ALPHA PARTICLES
WITH AN OPTICAL MODEL

J. R. Huizenga and G. Igo

Nuclear Phys. 29(3) 462-473 (January 1962)

Abstract in ANL-6493, p. 39

FISSION FRAGMENT ANGULAR DISTRIBUTIONS AND SADDLE
DEFORMATIONS

Ramesh Chaudhry, Robert Vandenbosch and J.R. Huizenga

Phys. Rev. 126 220-227 (April 1, 1962)

The fission fragment angular distributions have been measured with solid-state detectors for helium-ion-induced fission of bismuth, lead-206, thallium, and gold. The measurements were made at several helium-ion-projectile energies between 30 and 43 Mev. With 42.8-Mev helium ions the relative differential fission cross sections for gold and bismuth targets were measured at ten angles between 90° and 180° and the resulting angular distributions fitted by a least-squares method with Legendre polynomials. The $W(174.5^\circ)/W(90^\circ)$ ratios for 42.8-Mev helium-ion-induced fission of bismuth, lead, lead-206, thallium, and gold are 2.26 ± 0.07 , 2.47 ± 0.08 , 2.46 ± 0.08 , 2.53 ± 0.08 , and 2.62 ± 0.08 , respectively. The relative fission cross sections at 174.5° and 90° were also measured at several lower helium-ion energies for all targets except natural lead. These data are utilized in the calculation of the energy dependence of K_0 , the standard deviation of the distribution in the angular-momentum projection on the nuclear symmetry axis at the saddle point. The energy dependence of K_0 , deduced from the experimental anisotropy measurements, is similar to the predicted energy dependence from statistical theory if the nuclear temperature at the saddle point is proportional to the square root of the excitation energy. These results indicate that the effective moment of inertia is independent of excitation energy and they differ from heavy element (uranium region) results where it was found that at low excitation energies the experimental K_0 values were much reduced from statistical theory presumably due to pairing effects. With the assumption that the effective moment of inertia at the saddle-point deformation (which is deduced for each target from the anisotropy measurement at the highest energy) is the rigid-body value, the stretching at the saddle point is calculated for various simple geometric configurations. For a saddle configuration of two equal tangent spheroids, the stretchings necessary to reproduce the observed effective moments of inertia are in good agreement with the liquid-drop model calculations of Cohen and Swiatecki. Some comments are made on previous analyses of heavy-ion-induced fission of elements in the vicinity of gold.

HALF-LIFE OF NICKEL-63

D. L. Horrocks and A. L. Harkness*

Phys. Rev. 125 1619-1620 (March 1, 1962)

Abstract in ANL-6493, p. 42

PHOTOEXCITATION OF THE ISOMERIC STATES OF Cd^{111} AND In^{115} WITH MONOENERGETIC GAMMA RAYS

J. R. Huizenga and Robert Vandenbosch

Nuclear Phys., in press

The cross sections for photoexcitation of $\text{Cd}^{111\text{m}}$ and $\text{In}^{115\text{m}}$ with gamma rays from the $\text{F}^{19}(\text{p}, \alpha\gamma)\text{O}^{16}$ reaction have been measured. For a gamma-ray beam in which the gamma-ray intensity ratio $(I_{6.91} + I_{7.11})/I_{6.14} = 6.7$, the $\text{Cd}^{111}(\gamma, \gamma')\text{Cd}^{111\text{m}}$ and $\text{In}^{115}(\gamma, \gamma')\text{In}^{115\text{m}}$ cross sections are 0.4 and 1.6 mbs, respectively.

PROPERTIES OF Gd^{146} , Gd^{147} , Gd^{148} , Eu^{145} , Eu^{146} , Eu^{147}

A. M. Friedman and John Milsted

Bull. Am. Phys. Soc. 7 352 (April 1962) Abstract

Targets of Sm^{144} and Sm^{146} oxides were bombarded with the He beam of the Argonne cyclotron. The resulting Gd and Eu products were chemically purified, and then the isotopes of each elemental fraction were separated on the mass separator. The decay of each isotope was studied.

*Special Materials Division

ANISOTROPY OF SELECTED FRAGMENTS IN HELIUM-ION-INDUCED FISSION OF Pb^{206} AND Bi^{209}

K. F. Flynn, L. E. Glendenin and J. R. Huizenga

Bull. Am. Phys. Soc. 7 303 (April 1962)

Abstract

Fission fragments from 42-Mev helium-ion-induced fission of Pb^{206} and Bi^{209} were collected in thin aluminum catcher foils at center-of-mass angles 90° and 165° . Several elements were chemically separated from the foils and were purified by standard radiochemical procedures. The differential cross-section ratios $W(165^\circ)/W(90^\circ)$ for ruthenium (Ru^{105}), palladium ($\text{Pd}^{109, 111, 112}$), silver ($\text{Ag}^{111, 112, 113}$), strontium ($\text{Sr}^{91, 92}$), and molybdenum (Mo^{99}) were measured and found to be constant for each target. The average values of $W(165^\circ)/W(90^\circ)$, determined in these experiments by the radiochemical technique are 2.3 and 2.0 for Pb^{206} and Bi^{209} , respectively, in excellent agreement with results obtained with solid-state counters. Since second-chance fission is negligible for each of these targets, the constancy of the fission-fragment anisotropy as a function of mass split (A_1/A_2 varying from 1.0 to 1.3) is interpreted to mean that the saddle points of the various mass splits for a particular target have a similar deformation.

HELIUM-ION INDUCED FISSION OF Bi, Pb, Tl AND Au

J. R. Huizenga, Ramesh Chaudhry and Robert Vandebosch

Phys. Rev. 126 210-219 (April 1, 1962)

The fission cross sections have been measured with solid-state detectors for helium-ion-induced fission of bismuth, lead-206, thallium, and gold. The measurements were made at several helium-ion projectile energies between 30 and 43 Mev. The fission cross sections of bismuth, lead-206, thallium, and gold with 42.8-Mev helium ions are 7.3, 1.8, 0.65, and 0.28 mb, respectively, and the cross sections decrease rapidly with reduced-energy projectiles. The competition between fission and neutron emission as a function of excitation energy is compared with theoretical predictions of Γ_f/Γ_n and some comments are made on the effect of nuclear deformation on the Fermi-gas level density parameter a . Fission thresholds for At^{213} , Po^{210} , $\text{Bi}^{207, 209}$, and Tl^{201} of 15.8 ± 2.0 , 18.6 ± 2.0 , 20.6 ± 2.0 , and 19.9 ± 2.0 Mev are derived. The saddle-point masses of these nuclei relative to Cameron's reference mass surface lie on a smooth curve with the heavy element data, indicating that the shell structure is completely destroyed during the distortion from equilibrium to saddle-point deformation. An empirical equation for fission thresholds is deduced from the saddle-point mass surface which is thought to be valid for nuclei with Z^2/A between 32 and 40.

STUDIES OF COINCIDENT FRAGMENTS IN THE HELIUM-ION-INDUCED FISSION OF Bi^{209} AND U^{238}

John Unik, G. L. Bate and J. R. Huizenga
Bull. Am. Phys. Soc. 7 303 (April 1962)

Abstract

A study has been made of helium-ion-induced fission of Bi^{209} and U^{238} with thin targets and back-to-back gold surface-barrier semiconductor detectors. The data were collected and recorded with the Argonne three-parameter multichannel (each parameter consisting of 256 channels) analyzer, and the system was calibrated with a Cf^{252} source. An average total kinetic energy of 150 ± 4 Mev was determined for 42-Mev helium-ion-induced fission of Bi^{209} , and a full-width at half-maximum height of 16 ± 1 Mev was obtained for the kinetic-energy distribution for all mass divisions. The mass distribution for Bi^{209} is symmetric with a full-width at half-maximum of 21 ± 2 mass units. The widths of the mass distributions for fission leading to particular values of the total kinetic energy become narrower with increasing total kinetic energy. The fission of U^{238} was studied at helium-ion energies of 29 and 42 Mev. With 29-Mev projectiles, the total kinetic energy is 171 ± 5 Mev, and the full-width at half-maximum of the total kinetic-energy distribution for all mass divisions is 24 ± 1 Mev. The mass distribution at 29-Mev is asymmetric with a peak-to-valley ratio of about 2.6 and a full-width at half-maximum of 49 ± 2 mass units in good agreement with radiochemical data.

NUCLEAR FISSION OF RADIUM

J. E. Gindler, G. L. Bate and J. R. Huizenga
Bull. Am. Phys. Soc. 7 303 (April 1962)

Abstract

The dependence of the angular distributions on projectile energy for proton-, deuteron-, and helium-ion induced fission of Ra^{226} has been investigated with gold surface-barrier semiconductor detectors. The measurements were made in steps of approximately 1 Mev or less for deuterons between 10 and 21 Mev and for helium ions between 20 and 43 Mev. For protons, a measurement was made at only 10.5 Mev. The differential-fission cross-section ratios $W(174^\circ)/W(90^\circ)$ for 42.5-Mev helium ions, 21.3-Mev deuterons, and 10.5-Mev protons are 2.42, 1.30, and 1.13, respectively. With the helium-ion projectiles, the anisotropy varies strongly with energy, and reaches a maximum value of 2.44 with 27-Mev helium ions. These results can be interpreted in terms of multiple-chance fission. Cross sections for the fission of Ra^{226} with various projectiles have been determined as a function of projectile energy. The fission cross sections for 42.5-Mev helium ions, 21.3-Mev deuterons, and 10.5-Mev protons are 1130, 150, and 4 mb, respectively. The fission-fragment kinetic-energy spectra change markedly with angle, bombarding energy, and projectile. When the helium-ion bombarding energy has been reduced to about 27 Mev, the peak-to-valley ratios of the kinetic energy spectra observed in the 174° and 90° counters are approximately 4 and 2.5, respectively.

THE DECAY SCHEME OF 10.1-HOUR Am^{244}

S. E. Vandenbosch and P. P. Day

Nuclear Phys. 30 177-190 (February 1962)

A new 10.1-hour beta-emitter produced by neutron irradiation of enriched (99.97%) Am^{243} was chemically identified as an isotope of americium and is assigned to an isomer of Am^{244} . The decay scheme was studied using a beta spectrometer in addition to gamma-gamma and gamma-beta coincidence scintillation counting techniques. A single beta group with an end-point energy of 387 ± 1 kev ($\log ft = 5.7$) populates a 1042-kev level in Cm^{244} . This 1042-kev level decays to the 4+, 6+, and 8+ members of the ground state rotational band by highly retarded E2 transitions suggesting that it is a (6, 6+) particle level. Rotational levels were observed at 0(0, 0+), 42.9 (0, 2+), 142.3(0, 4+), 296(0, 6+), and 502(0, 8+) kev. The 26-minute isomer of Am^{244} decays by beta emission principally to the ground state of Cm^{244} with an energy of 1498 ± 10 kev ($\log ft = 6.3$). Spin assignments of 6- to the 10.1-hour ground state and 1- to the 26-minute isomer were obtained by couplings of the odd neutron and odd proton Nilsson orbitals. These assignments are consistent with the data.

PHOTOFISSION CROSS SECTIONS OF SEVERAL NUCLEI WITH MONO-ENERGETIC GAMMA RAYS

J. R. Huizenga, K. M. Clarke, J. E. Gindler and Robert Vandenbosch

Nuclear Phys., in press

Gamma rays of 6.14, 6.91 and 7.12 Mev produced by the $\text{F}^{19}(\text{p}, \alpha\gamma)\text{O}^{16}$ reaction were used to induce heavy element fission. The photofission cross sections of Th^{232} , U^{238} , U^{236} , U^{235} , U^{234} , U^{233} and Np^{237} for a 7.0-Mev average gamma ray energy (a mixture of the 6.91- and 7.12-Mev gamma rays) are 9, 15, 28, 33, 52, 44 and 45 mb, respectively. The cross section for producing Mo^{99} from U^{238} with 7.0-Mev gamma rays is 1.1 mb. The 7.0-Mev photon absorption cross section of heavy nuclei is determined to be 60 ± 20 mb. From this cross section one deduces that the gamma-ray strength function $\bar{\Gamma}_0/D$ for heavy nuclei at 7.0 Mev is $(2.5 \pm 0.8) \times 10^{-4}$. The variation in the photofission cross sections with 6.14-Mev photons for nuclei in which photoneutron emission is energetically forbidden is interpreted in terms of resonance absorption. This results from the line width of the 6.14-Mev photons (O^{16} recoils stopped prior to the emission of the 6.14-Mev γ ray) being of the same order of magnitude as the average spacing between levels of the same spin in the compound nucleus.

α DECAY OF Bk²⁴⁹

John Milsted and A. M. Friedman

Bull. Am. Phys. Soc. 7 353 (April 1962)

Abstract

The α decay of Bk²⁴⁹ was studied with silicon surface barrier detectors using a magnetic field to deflect away the interfering β particles. α - γ coincidences were also studied. Four main α groups were found at 5.087, 5.326, 5.376, and 5.395 Mev. A tentative decay scheme is presented.

STUDY OF TRIPLE FISSION IN Fm²⁵⁴

E. N. Sloth and A. M. Friedman

Bull. Am. Phys. Soc. 7 304 (April 1962)

Abstract

A sample of Fm²⁵⁴ was absorbed into 100- μ -thick Kodak NTB2 emulsion and allowed to decay. The processed plates were scanned for 3-pronged stars. A fraction of these was shown to be true triple-fission events. The relative frequencies of binary and triple fission were estimated, and the energies and angular distributions tabulated for the events observed.

A NON-INTERCEPTING ACCELERATOR BEAM POSITION SENSOR

K. W. Johnson, T. E. Klippert and W. J. Ramler

Nuclear Instr. and Methods 14 (2) 125-130 (December 1961)

Abstract in ANL-6493, p. 45

Effects of Radiation

ABSOLUTE RATE CONSTANT FOR THE REACTION OF HYDROXYL RADICALS WITH BENZENE IN WATER

L. M. Dorfman, R. E. Bühler and I. A. Taub

J. Chem. Phys. 36 549-550 (January 15, 1962)

Letter

Abstract in ANL-6493, p. 48

PULSE RADIOLYSIS STUDIES. I. TRANSIENT SPECTRA AND REACTION RATE CONSTANTS IN IRRADIATED AQUEOUS SOLUTIONS OF BENZENE

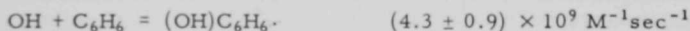
L. M. Dorfman, I. A. Taub and R. E. Buhler

J. Chem. Phys., in press

The radiation chemistry of aqueous benzene solutions has been studied by the electron pulse radiolysis technique. Ultraviolet absorption spectra of some of the transient species have been recorded by synchronized flash absorption spectroscopy. The elementary reactions occurring have been observed by fast photoelectric recording of the transient optical density.

A transient spectrum having a broad absorption with a strong maximum at $313\text{ m}\mu$ has been observed. On the basis of both spectrographic and kinetic evidence this spectrum is assigned to the hydroxycyclohexadienyl radical, $(\text{OH})\text{C}_6\text{H}_6\cdot$. The molar extinction coefficient is estimated to be $\epsilon_{3130} = 3500 \pm 800\text{ M}^{-1}\text{cm}^{-1}$. A number of substituted cyclohexadienyl radicals have been observed in aqueous solution as well as in pure benzene and chlorobenzene. A second transient observed in oxygenated aqueous benzene solution shows an absorption shifted to lower wavelength. This is attributed to the hydroxycyclohexadienyl peroxy radical, $(\text{OH})\text{C}_6\text{H}_6\text{O}_2\cdot$.

Absolute rate constants have been determined at 23°C for the following reactions:



The yield of phenol in oxygenated solution was found to decrease continuously with increasing pulse intensity. At the highest intensity used, $G(\text{C}_6\text{H}_5\text{OH}) = 0.19\text{ molec./100ev}$. At the lowest pulse intensity used, $G(\text{C}_6\text{H}_5\text{OH}) = 1.9\text{ molec./100ev}$, which approaches the values found in steady irradiations. Some additional phenol is formed in slow postirradiation reactions. Diphenyl was identified as a product in the deaerated system by gas chromatographic analysis. Its formation is largely the result of postirradiation reactions, the initial yield being substantially lower than previously reported.

The mechanism of the radiation chemical reaction in both deaerated and oxygenated solutions is discussed on the basis of our conclusion that the hydroxyl radical enters the ring to form the hydroxycyclohexadienyl radical.

RADIATION CHEMISTRY OF IONIC SOLIDS. II. FREE RADICALS
DETECTED IN IRRADIATED POTASSIUM NITRATE BY ELECTRON
PARAMAGNETIC RESONANCE

Joseph Cunningham

J. Phys. Chem., in press

Crystals of $K^{14}NO_3$ and $K^{15}NO_3$ have been irradiated and studied at 4 and 77°K. Six distinct species were indicated by the electron paramagnetic resonance spectra. Tentative identification of individual patterns with radical species in fixed orientations is attempted. The magnetic parameters of patterns assigned to $(NO_2^-)^{\cdot-}$, NO_2 , $(NO_3^-)^{\cdot-}$, NO_3 , NO , and O_2^- radicals are shown to be not inconsistent with previous results and with orbital representation. Results are described on optical removal of the signals. The relationship of radical formation and orientation to the radiation chemistry of nitrates is considered.

PHOTOCHEMICAL PRIMARY PROCESS IN BIACETYL VAPOR AT 4358 Å

W. A. Noyes, Jr., W. A. Mulac and M. S. Matheson

J. Chem. Phys. 36 880-886 (February 15, 1962)

Abstract in ANL-6493, p. 49

THE RADIOLYSIS OF ETHYLENE: DETAILS OF THE FORMATION OF
DECOMPOSITION PRODUCTS

M. C. Sauer, Jr., and L. M. Dorfman

J. Phys. Chem. 66 322-325 (February 1962)

Abstract in ANL-6445, p. 29

Inorganic and Physical Chemistry

NEUTRON DIFFRACTION STUDIES OF HIGHER CARBIDES OF HEAVY METALS

Masao Atoji

J. Phys. Soc. Japan, in press

The neutron diffraction and paramagnetic scattering analysis of the CaC_2 type carbides (CaC_2 , YC_2 , LaC_2 , CeC_2 , TbC_2 , YbC_2 , LuC_2 , UC_2) and the Pu_2C_3 type carbides (La_2C_3 , Ce_2C_3 , Pr_2C_3 , Tb_2C_3) show strong correlations between the interatomic distances and the metal valency. These correlations and the vanishing Knight shift of YC_2 can reasonably be interpreted from the following postulations. The conduction band wave functions of MC_2 are composed only of the metal d-orbitals and the $\text{C}_2 - \pi_g 2p$ anti-bonding orbitals. The $\text{C}_2 - \pi_g 2p$ contribution to the conduction band is smaller in M_2C_3 than in MC_2 . The conduction band of M_2C_3 is also associated with the metal s-orbital.

RAMAN SPECTROSCOPY WITH SOLIDS

J. R. Ferraro, J. Ziomek* and G. Mack

Carygraph 2(1) (Spring 1962), Applied Physics Corp. Publ.

For materials which are generally insoluble or can change in dissolution in solvents (e.g., depolymerization, solute-solvent interaction), it is advantageous to obtain Raman spectra with the material in the solid state. In addition, solid-state spectra are particularly helpful in studying such problems as solid crystal defects, solid solutions, surface reactions and solid catalysts.

In the past, experimental techniques employed in obtaining Raman spectra of solids have been beset by numerous problems. Long exposure times were necessary, and other problems were involved in using photographic plates. With the availability of a commercial recording Raman spectrophotometer (Cary Model 81) the problem of exposure times has been reduced, and the problem of photographic plates eliminated. Formerly, it was also necessary to realign the optics and change the source and the filters in the spectrophotometer in going from liquid operation to solid operation.

Various sample tubes (7 mm and 19 mm diameter) were used, including one which could be used at liquid nitrogen temperatures. The effects of crystal size, sample thickness, sample position and method of solid preparation are discussed. In all cases satisfactory and useful spectra were obtained in periods of exposure of about 1 hour, despite a high background of scattered radiation for some samples with the 7-mm sample tube. The results agreed with published reports whenever these were available for comparison.

*DePaul University, Chicago

ABSORPTION SPECTRA OF THE D-STATE IONS TiCl_6^{-3} , TiCl_4^- , CrCl_4^{-2} , FeCl_4^{-2} AND CuCl_4^{-2} IN CHLORIDE MELTS

D. M. Gruen and R. L. McBeth

Nature, in press

Letter

The absorption spectra of dilute solutions of the ions TiCl_6^{-3} , TiCl_4^- , CrCl_4^{-2} , FeCl_4^{-2} and CuCl_4^{-2} in chloride melts have been obtained. Of particular interest is the magnitude of Dq , the crystal field splitting parameter, deduced from the locations of the near-infrared absorption bands. In the present communication a detailed discussion of the spectra and their interpretation in terms of distortions of the complexes has been omitted. Only the salient results of the investigation are listed (electronic configuration, energy at absorption maxima, width at half-maxima, transition and Dq). This constitutes the first report of the tetrahedral spectra of a number of these ions.

STRUCTURE OF THE BAND SPECTRUM OF CuCl MOLECULES.

II. ROTATIONAL STRUCTURE OF THE F-X BAND SYSTEM OF $\text{Cu}^{65}\text{Cl}^{35}$

P. R. Rao, J. K. Brody and R. K. Asundi

Canad. J. Phys., in press

The F-X band system of $\text{Cu}^{65}\text{Cl}^{35}$ extending from 3700 to 4200 \AA has been photographed in emission under high resolution. Rotational analysis of the (3,0), (2,0), (1,0), (0,0), (0,1) and (0,2) bands of the system has been made. The electronic transition involved is found to be $^1\Pi - ^1\Sigma$. The Λ -type doubling in the $^1\Pi$ state is negligible. The principal molecular constants obtained are as follows (cm^{-1} units):

$$F^1\Pi \text{ State: } T_e = 25285.30 \quad ; \quad B_e = 0.1608 \quad ; \quad \alpha_e = 9.1 \times 10^{-4} \quad ;$$

$$D_e = 1.2 \times 10^{-7} \quad ; \quad \omega_e = 384.94 \quad ; \quad \omega_e x_e = 1.65 \quad ;$$

$$X^1\Sigma \text{ State: } B_e = 0.1764 \quad ; \quad \alpha_e = 10.0 \times 10^{-4} \quad ;$$

$$D_e = 1.3 \times 10^{-7} \quad ; \quad \omega_e = 415.29 \quad ; \quad \omega_e x_e = 1.58 \quad .$$

STRUCTURE OF THE BAND SPECTRUM OF CuCl MOLECULES.

III. ROTATIONAL STRUCTURE OF THE B AND C SYSTEMS OF $\text{Cu}^{65}\text{Cl}^{35}$

P. R. Rao, J. K. Brody and R. K. Asundi

Canad. J. Phys., in press

The B and C band systems of $\text{Cu}^{65}\text{Cl}^{35}$ lying in the region $4600\text{--}5200\text{\AA}$ have been photographed in emission under high resolution. Rotational analysis of the (1,0), (0,0) and (0,1) bands of each system has been made. The analysis shows that the B and C systems involve transitions ${}^1\Pi (B^1\Pi) - X^1\Sigma$ and ${}^1\Sigma (C^1\Sigma) - X^1\Sigma$ respectively. Due to the influence of the close-by $C^1\Sigma$ state, the $B^1\Pi$ state shows appreciable Λ -type doubling. It is found that the $B^1\Pi$ and $C^1\Sigma$ states provide an instance closely resembling the case of Van Vleck's "pure precession". The principal molecular constants obtained for the initial states of the B and C systems of $\text{Cu}^{65}\text{Cl}^{35}$ are as follows (cm^{-1} units):

$$\begin{aligned} B^1\Pi \text{ State: } T_e &= 20484.0 \quad ; \quad B_e = 0.1688 \quad ; \\ \alpha_e &= 9.2 \times 10^{-4} \quad ; \quad D_e = 1.2 \times 10^{-7} \quad ; \\ q_0 &= -8.7 \times 10^{-4} \quad ; \end{aligned}$$

$$\begin{aligned} C^1\Sigma \text{ State: } T_e &= 20630.8 \quad ; \quad B_e = 0.1700 \quad ; \\ \alpha_e &= 8.9 \times 10^{-4} \quad ; \quad D_e = 1.2 \times 10^{-7} \end{aligned}$$

A RAMAN-SPECTRAL STUDY OF SOME GALLIUM (III) CHLORIDE SYSTEMS

Kenneth Schug and L. I. Katzin

J. Phys. Chem., in press

Raman spectral observations and related chemical studies have been employed to investigate the nature of the species present in diisopropyl ether-aqueous extraction systems of gallium (III)-chloride and in certain other gallium chloride solutions. Evidence is presented that tetrahedral GaCl_3OH_2 is an important species in the ethereal phase when the molar ratio of chloride-to-gallium is low and/or in the absence of a cation capable of accompanying the species GaCl_4^- in the ether phase.

HEATS OF FORMATION OF BROMINE FLUORIDES

Lawrence Stein

J. Phys. Chem. 66 288-291 (February 1962)

Abstract in ANL-6493, p. 56

VIBRATIONAL SPECTRA OF MoF_6 AND TcF_6

H. H. Claassen, Henry Selig and J. G. Malm
J. Chem. Phys., in press

Infrared spectra of gaseous MoF_6 and TcF_6 from $6-43\mu$, the Raman spectrum of MoF_6 gas, and an incomplete Raman spectrum of liquid TcF_6 are reported. These are interpreted in terms of the octahedral point group O_h . The fundamental frequencies for MoF_6 are $741(\nu_1)$, $643(\nu_2)$, $741(\nu_3)$, $264(\nu_4)$, $306(\nu_5)$, and $190(\nu_6)$. For TcF_6 they are $705(\nu_1)$, $551(\nu_2)$, $748(\nu_3)$, $265(\nu_4)$, $255(\nu_5)$ and ν_6 has not been determined.

Differences between the spectra of MoF_6 and TcF_6 are explained as a consequence of orbital degeneracy in the ground state of the latter, in analogy with similar differences in the 5d series.

HEAT CAPACITIES AND THERMODYNAMIC FUNCTIONS OF YH_2 AND YD_2 FROM 5° TO 350°K AND THE HYDROGEN VIBRATION FREQUENCIES

H. E. Flotow, D. W. Osborne and Klaus Otto
J. Chem. Phys. 36 866-872 (February 15, 1962)

Abstract in ANL-6493, p. 57

VAPOR PRESSURES OF SCANDIUM, YTTRIUM AND LANTHANUM

R. J. Ackermann and E. G. Rauh
J. Chem. Phys. 36 448-452 (January 15, 1962)

Abstract in ANL-6493, p. 56

THE SCANDIUM CHLORIDE-CESIUM CHLORIDE PHASE DIAGRAM

Rudolph Gut and D. M. Gruen
J. Inorg. Nuclear Chem. 2(3/4) 259-261 (December 1961)

Abstract in ANL-6394, p. 32

VIBRATIONAL SPECTRA OF ReF_6

H. H. Claassen, J. G. Malm and Henry Selig
J. Chem. Phys., in press

The infrared absorption spectrum from $6-43\mu$ and the Raman spectrum of ReF_6 gas are reported. They are interpreted in terms of octahedral point group O_h . The six fundamental frequencies are $755(\nu_1)$, $596(\nu_2)$, $715(\nu_3)$, $257(\nu_4)$, $246(\nu_5)$, and $193(\nu_6)$. Thermodynamic functions are calculated for the ideal gaseous state.

THE MAGNETIC SUSCEPTIBILITY OF ReF_6

Henry Selig, F. A. Cafasso, D. M. Gruen and J. G. Malm
J. Chem. Phys., in press

The magnetic susceptibility of ReF_6 has been measured in the range $4^\circ - 296^\circ\text{K}$ using the Faraday method. The susceptibility in the range $14^\circ - 300^\circ\text{K}$ can be expressed by means of the equation

$$M_{\chi}\text{ReF}_6 = \frac{(78 \pm 1) \times 10^{-4}}{T} + (0.87 \pm 0.03) \times 10^{-4}$$

from which one calculates a moment of 0.25 Bohr magnetons. Applying a theory developed for gaseous ReF_6 to the magnetic measurements reported here gives $\zeta = 3160 \text{ cm}^{-1}$ and $10 \text{ Dq} = 55,000 \text{ cm}^{-1}$. The diamagnetic susceptibility of WF_6 has been remeasured and preliminary measurements on TcF_6 are reported.

KINETICS OF THE VANADIUM(III)-NEPTUNIUM(V) REACTION IN PER-CHLORATE SOLUTIONS

E. H. Appelman and J. C. Sullivan
J. Phys. Chem. 66 442-445 (March 1962)

Abstract in ANL-6493, p. 59

SOME OBSERVATIONS OF Np(VI) IN CHLORIDE SOLUTIONS

Donald Cohen and Brian Taylor
J. Inorg. Nuclear Chem. 22 151-153 (1962) Note

Abstract in ANL-6445, p. 37

SPECTROPHOTOMETRIC ANALYSIS OF THE LANTHANIDES IN MOLTEN NITRATE MEDIA

W. T. Carnall
Anal. Chem., in press

The use of molten $\text{LiNO}_3 - \text{KNO}_3$ eutectic as a solvent medium in which the absorption spectra of the lanthanides can be observed, makes possible an extension of the normal spectral region of investigation into the near infrared to $\sim 2.6\mu$. It has thus been possible to demonstrate the existence of a number of lanthanide absorption bands in the $1.4 - 2.6\mu$ range, not previously reported in solution studies. These near infrared bands together with bands observed in the visible region of the spectrum should prove very advantageous in resolving mixtures of lanthanides.

THE VISIBLE AND NEAR-INFRARED ABSORPTION SPECTRA OF SOME TRIVALENT ACTINIDE AND LANTHANIDE ELEMENTS IN DClO_4 AND IN MOLTEN NITRATE SALTS

W. T. Carnall and P. R. Fields

Developments in Appl. Spectroscopy, in press

Absorption spectra of trivalent lanthanide and actinide elements have been studied in DClO_4 and the molten $\text{LiNO}_3\text{-KNO}_3$ eutectic. The results make possible a comparison of the spectra of the hydrated free metal ions with those obtained under anhydrous conditions with nitrate ions responsible for the ligand field experienced by the metal ion. The extension of measurements into the near-infrared region makes possible the comparison of intensities of the bands found with those found in the visible region. While these bands have previously been observed in crystal studies, a direct comparison in intensity has not been made.

EFFECTS OF SOLUTION COMPOSITION ON THE POTENTIALS OF THE COUPLES: Np(V-VI) , Fe(II-III) , Hg(0-I) , AND Hg(I-II)

A. J. Zielen and J. C. Sullivan

J. Phys. Chem., in press

A linear variation with hydrogen ion concentration was found for the formal potential of the Np(V-VI) couple at 25° in perchloric acid-sodium or lithium perchlorate solutions of ionic strength 2. The major portion and very probably all of this acid dependence is shown to be caused by activity coefficient changes, reaffirming NpO_2^+ and NpO_2^{2+} as the only Np(V) and Np(VI) species of consequence in acid solutions. Similar measurements in sodium perchlorate solutions were made of the Fe(II-III) , Hg(0-I) and Hg(I-II) couples. Equations for the formal potentials as a function of hydrogen ion concentration are given, and activity coefficient effects produced by the substitution of Na^+ or Li^+ for H^+ at constant ionic strength are discussed.

NUCLEAR MAGNETIC RESONANCE EFFECTS IN AQUEOUS SOLUTIONS OF 1-1 ELECTROLYTES

J. C. Hindman

J. Chem. Phys. 36 1000-1016 (February 15, 1962)

Abstract in ANL-6493, p. 52

EFFECTS OF ELECTROLYTES ON ROTATORY DISPERSION OF AQUEOUS TARTRATE SOLUTIONS

L. I. Katzin and Elsie Gulyas

J. Phys. Chem. 66 494-500 (March 1962)

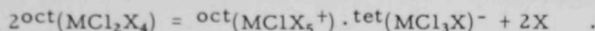
Abstract in ANL-6493, p. 63

IONIZATION DIFFERENCES BETWEEN COORDINATION STATES OF A CATION. OCTAHEDRAL-TETRAHEDRAL EQUILIBRIUM OF TRANSITION ELEMENT CHLORIDES IN DIMETHYLFORMAMIDE

L. I. Katzin

J. Chem. Phys., in press

In a high-dielectric-constant, low-base-strength medium, such as dimethyl formamide, formation of chloride complexes of the first transition elements in the tetrahedral configuration is promoted. The effect is linked with a greater dissociation (weaker anion complexing) of the octahedral configuration, as indicated by the over-all equilibrium expression



The corresponding change in the absorption spectrum has been followed for the chlorides of Mn(II), Fe(II), Fe(III), Co(II), Ni(II), and Cu(II). The spectra with and without added LiCl are described. Some relations to current ligand field theories concerning the configuration change are pointed out.

PARAMAGNETIC RESONANCE OF HYDRAZYL-TYPE RADICALS IN VISCOUS MEDIA

K. V. Sane and J. A. Weil

Proc. Intern. Conf. on Magnetic and Electric Resonance and Relaxation, Eindhoven, Netherlands, July 2-7, 1962, in press

The EPR spectra of solutions of the three free radicals: DPPH, its mononitro- and its dinitroparaphenyl derivatives show a strong dependence of their nitrogen hyperfine structure on the viscosity and the temperature of the solvent. Series of such spectra have been obtained and interpreted; the possibility of determining the anisotropic hyperfine parameters and an estimate of g anisotropy from these data has been investigated.

MOLECULAR WEIGHT STUDIES OF SEVERAL ORGANOPHOSPHORUS ACIDS

J. R. Ferraro, G. W. Mason and D. F. Peppard

J. Inorg. Nuclear Chem. 22(3/4) 285-292 (December 1961)

Abstract in ANL-6493, p. 63

RAMAN AND INFRARED SPECTRA AND NORMAL COORDINATE
TREATMENTS OF THE HYPOPHOSPHITE AND DIDEUTERIOHYPO-
PHOSPHITE IONS

J. S. Ziomek,* J. R. Ferraro and D. F. Peppard
J. Mol. Spectroscopy 8 212-221 (March 1962)

Abstract in ANL-6493, p. 62

THE ALKALI SALTS OF 2,2-DIPHENYL-1-PICRYLHYDRAZINE

J. A. Weil and G. A. Janusonis
J. Org. Chem. 27 1248-1250 (April 1962)

Abstract in ANL-6493, p. 63

Analytical Chemistry

THE SPECTROCHEMICAL DETERMINATION OF TRACE IMPURITIES IN
GRAPHITE

J. A. Goleb, J. P. Faris and B. H. Meng
Appl. Spectroscopy 16 (1) 9-12 (January 1962)

Abstract in ANL-6394, p. 39

*DePaul University, Chicago

EXTRACTION OF Ca(II), Sr(II) AND Ba(II) BY ACIDIC ESTERS OF PHOSPHORUS OXY ACIDS

D. F. Peppard, G. W. Mason, Sonia McCarty and F. D. Johnson
J. Inorg. Nuclear Chem., in press

The extraction of Ca(II), Sr(II) and Ba(II) from aqueous mineral acid, in the presence and absence of the corresponding sodium salt, into xylene solutions of $(GO)_2PO(OH)$, $G = 2$ -ethyl hexyl and para (1, 1, 3, 3 tetramethyl butyl) phenyl, and of $(GO)G'PO(OH)$, $G = n$ -octyl and $G' =$ phenyl and chloromethyl, has been investigated radiometrically. The distribution ratio, K , has been found to be inversely second-power dependent upon the hydrogen ion concentration in the equilibrated aqueous phase.

The dependency of K upon the concentration of extractant in the equilibrated xylene phase was found to be 2.5-power for Ca and Sr and 3.0-power for Ba in systems involving bis [para (1, 1, 3, 3 tetramethyl butyl) phenyl] phosphoric acid or n -octyl hydrogen chloromethyl phosphonate; 3.0-power for Ca, Sr, and Ba in systems involving n -octyl hydrogen phenyl phosphonate; and 3.0-power for Ca (Sr and Ba not proved) in systems involving bis(2-ethyl hexyl) phosphoric acid.

The effect of structural differences in the extractants is discussed, and the extraction of alkaline earths (II) is compared with that of Pm(III) and Cm(III).

APPLICATIONS OF LIQUID-LIQUID EXTRACTION IN INORGANIC SEPARATIONS

D. F. Peppard

Progress in Nuclear Energy, Ser. IX, Analytical Chemistry,
Vol. 2. London: Pergamon Press, 1961. pp. 201-223

Abstract in ANL-6394, p. 41

SOLVENT EXTRACTION OF ACTINIDES AND LANTHANIDES FROM MOLTEN SALTS

N. M. Isaac, P. R. Fields and D. M. Gruen

J. Inorg. Nuclear Chem. 21 (1/2) 152-168 (December 1961)

Abstract in ANL-6394, p. 41

RADIOCHEMISTRY OF URANIUM

J. E. Gindler

Natl. Acad. Sci., Natl. Research Council. Report NAS-NS-3050
(March 1962)

This monograph contains, in addition to an extensive bibliography, a review of the features of uranium chemistry of chief interest to the radiochemist and a collection of detailed procedures for the separation and determination of the uranium.

ELUTION CAPACITY OF ORGANIC SUBSTANCES IN SOLUTION-
ADSORPTION CHROMATOGRAPHYM. J. Sabacky, L. B. Jones, H. D. Frame, Jr., and H. H. Strain
Anal. Chem. 34 306-311 (March 1962)

Abstract in ANL-6493, p. 64

DETERMINATION OF OXYGEN IN ZINC, CADMIUM AND MAGNESIUM
BY CARBON REDUCTION IN AN INERT GAS STREAMB. D. Holt and H. T. Goodspeed
Anal. Chem. 34 374-378 (March 1962)

Abstract in ANL-6493, p. 65

MiscellaneousFIRST ISOLATION AND CHARACTERIZATION OF A FULLY DEUTERIATED
PROTEIND. S. Berns, H. L. Crespi and J. J. Katz
J. Am. Chem. Soc. 84 496-497 (February 5, 1962)

Abstract in ANL-6493, p. 68

THERMAL DENATURATION OF ORDINARY AND FULLY DEUTERIATED
DNA IN H₂O AND D₂OH. L. Crespi and J. J. Katz
J. Mol. Biol. 4 (2) 65-68 (February 1962)

Abstract in ANL-6493, p. 68

NONELECTRICAL LIQUID NITROGEN LEVEL CONTROLLER

B. D. Holt

Rev. Sci. Instr. 33 121-122 (January 1962)

Note

Abstract in ANL-6493, p. 69

NUTRITIONAL REQUIREMENTS FOR THE CULTIVATION OF FULLY DEUTERIATED YEASTS TORULOPSIS UTILIS AND SACCHAROMYCES CEREVISIAE

V. S. Mohan, H. L. Crespi and J. J. Katz

Nature 193 189-190 (January 13, 1962)

Letter

Abstract in ANL-6493, p. 69

CARBON DIOXIDE UPTAKE STUDIES IN ALGAE GROWN IN WATER AND DEUTERIUM OXIDE

M. I. Blake, A. S. Kaganove and J. J. Katz

J. Pharm. Sci. 51 375-379 (April 1962)

A procedure is described for studying carbon dioxide uptake in algae using C^{14} -labeled sodium bicarbonate as the source of carbon dioxide. Actively dividing, water grown and deuterium oxide adapted, Scenedesmus obliquus and Chlorella vulgaris were employed in these studies. Uptake comparisons were made over pH range 6 to 9 using appropriate buffer systems. Uptake was fairly constant in the range pH 6 to 8 for both the aqueous and deuteriated algae. Above pH 8 uptake dropped markedly. In general, the deuteriated algae showed between 10 and 30% lower uptake than ordinary algae. Greater chlorophyll content is associated with higher carbon dioxide uptake.

HIGH-TEMPERATURE KNUDSEN EFFUSION CELL ASSEMBLY

E. G. Rauh, R. C. Sadler and R. J. Thorn

ANL-6536 (April 1962)

To be described here is a Knudsen effusion cell assembly which was designed for use with a Bendix time-of-flight mass spectrometer for the study of vaporization processes at high temperatures. The cell is heated by electron bombardment, and temperatures up to 3100°K have been achieved. All of the original parts, except the effusion cell and the filament, are still in use after several thousand hours at temperature. Parts are easily replaced and aligned, and a variety of experimental arrangements is possible.

DOPING OF CRYSTALS BY ION BOMBARDMENT TO PRODUCE SOLID STATE DETECTORS

Torsten Alvager and N. J. Hansen

Rev. Sci. Instr., in press

Note

Rourke et al., have reported producing very shallow p-n junctions in silicon single crystals by ion bombardment. The authors have used this method to produce silicon charged-particle detectors. There appear to be at least two advantages over the diffusion methods usually used in the manufacture of shallow p-n junctions for use as particle detectors: the quantity of the desired impurity introduced can be precisely controlled by monitoring the ion beam current, and the undesirable impurities can be avoided. Further, if the ions are accelerated to only very low energies, the junction will be shallow, and owing to the discrete range of the ions, the depth will be well defined. The resulting detector will have a very thin window, or dead layer, and, for sufficiently high impurity concentration, the thickness of the window will be independent of the bias voltage applied to the detector. The high impurity concentration that can be obtained should make it possible to produce a device having a very broad sensitive volume.

Devices have been constructed 25 mm^2 in area giving an energy resolution for 6-Mev alpha particles of 75 kev, full width at half maximum. These preliminary results indicate that by using this method it is possible to construct detectors that have an energy resolution comparable to that obtained with diffuse devices.

ENCAPSULATED SURFACE-BARRIER PARTICLE DETECTORS. SOME METHODS AND TECHNIQUES

N. J. Hansen

ANL-6526 (March 1962)

This report describes in detail techniques that have been developed for the manufacture of encapsulated surface-barrier particle detectors. There is a belief among some workers in the field that it is not possible to control the conditions of manufacture well enough to assure consistent results. We have developed a method with which even inexperienced workers have been able to produce good devices with almost 100% yield. The devices manufactured to date have found use as counters and spectrometers for fission fragments, alpha particles, and low-energy electrons from radioactive nuclei. Devices, 50 mm^2 in area, have a resolution for 6.1-Mev alpha particles of 26 kev at room temperature and 18 kev at 78°K . Resolution for 1.1-Mev electrons has been measured as 7.5 kev at 78°K for devices 28 mm^2 in area. The silicon used has been n-type, grown with a 111 orientation, and purchased in the form of ingots about 2 cm in diameter; the resistivity has ranged from 100 to 3000 ohm-cm.

SOLID STATE SCIENCE DIVISION

PHOTOCONDUCTIVITY OF THE M CENTER IN KCl

Goro Kuwabara

Bull. Am. Phys. Soc. 7 345 (April 1962)

Abstract

The spectral response of photocurrent was measured for additively colored KCl. In crystals, in which M centers were oriented by 550-m μ light polarized along (0 $\bar{1}$ 1), the photocurrent for the light along (0 $\bar{1}$ 1) is larger than that along (011) at the F-band region as well as the M-band region. This suggests that the photoionization efficiency of the center responsible for dichroic absorption in the F region (possibly the M center) is far less than that of the isotropic center (F center). The photocurrent obtained for the light absorbed by the M band decreases rather slowly going from 0°C down to about -120°C, and rises sharply above room temperature. If we take the sharp rise as characteristic of the M center and assume the ionization efficiency of the F center to be constant in this region, we get about 0.4 eV as the thermal-energy gap between the first-excited state and the conduction band. This gap is probably large enough to accommodate other higher-excited states below the conduction band.

SIGN OF THE Li⁸ MAGNETIC MOMENT

Donald Connor and Tung Tsang

Phys. Rev., in press

The sign of the magnetic dipole moment of Li⁸ has been found experimentally to be positive, in agreement with theoretical expectation. Rates of transition among the Zeeman levels were compared for the two senses of circular polarization of a resonant rf field (1977 kc/sec in 3139 gauss). The short half-life (0.85 sec) of Li⁸ required use of the polarized neutron-activation, beta-emission anisotropy detection method previously applied to the measurement of the Li⁸ nuclear g factor.

GYROMAGNETIC RATIO OF F^{20}

Tung Tsang and Donald Connor

Bull. Am. Phys. Soc. 7 292 (April 1962)

Abstract

The gyromagnetic ratio (absolute value) of F^{20} (11-sec half-life) has been found experimentally to be 1.046 ± 0.002 by observing the destruction of β -emission anisotropy. A CaF_2 single crystal was placed in a static magnetic field (approximately 5000 gauss), and was irradiated with slow neutrons which had been polarized by reflection from a magnetic mirror. The polarization of F^{20} nuclei produced by capture of polarized neutrons was detected by β -emission anisotropy along and against the static-field direction. Resonance of F^{20} nuclei was observed through partial destruction of this anisotropy by impressing a radio-frequency oscillating magnetic field in a direction perpendicular to the static field.

ELECTRON CORRELATION IN ATOMS AND MOLECULES

Tung Tsang

Physica 28 265-268 (1962)

Using a modified Rayleigh-Schrödinger perturbation scheme, it is shown that the first order correction to the Hartree-Fock function due to electron correlation effects may be written as

$$\sum_{i>j} A(\chi_{ij}\phi_1 \dots \phi_{i-1}\phi_{i+1} \dots \phi_{j-1}\phi_{j+1} \dots \phi_N - \phi_1 \dots \phi_N)$$

where the ϕ 's are the Hartree-Fock SCF orbitals, A is the antisymmetrization operator, χ_{ij} is an antisymmetrized function of two coordinates. It is also shown that each pair function χ_{ij} may be evaluated by a variational procedure.

CALCULATION OF ELECTRON-COUPLED NUCLEAR SPIN-SPIN INTERACTIONS IN MOLECULES BY A VARIATIONAL PROCEDURE

D. E. O'Reilly

J. Chem. Phys. 36 274-280 (January 1, 1962)

Abstract in ANL-6394, p. 45

ANALYSIS OF NMR LINE SHAPES BY LATTICE HARMONICS

D. E. O'Reilly and Tung Tsang

Bull. Am. Phys. Soc. 7 293 (April 1962)

Abstract

Van Vleck's expressions for second (M_2) and fourth (M_4) moments of NMR absorption lines of nuclei in crystals resulting from dipolar and exchange interactions may be simplified by rewriting in terms of lattice harmonics (LH) of crystal point group. Only LH belonging to identity representation occur. The number of such functions, and hence the number of independent quantities needed to specify M_2 and M_4 , has been determined for all 32 point groups. The numbers vary from 15 to 81 for triclinic C_1 symmetry to 2 and 4 for cubic O_h symmetry. Coefficients for mononuclear simple cubic lattice (such as CaF_2) have been calculated and angular dependence of M_4 found. In NMR experiments where crystal is rotated about an axis perpendicular to magnetic field, projection of LH into such a plane yields angular dependence of M_2 and M_4 as finite series in $e^{\pm im\theta}$, $m \leq 4$ and $m \leq 8$, respectively, θ being the rotation angle. A similar angular dependence has been demonstrated for M_2 by McCall and Hamming.

OVERLAP REPULSION IN SODIUM-HALIDE CRYSTALS FROM ISOTHERMAL-COMPRESSION DATA

M. P. Tosi

Bull. Am. Phys. Soc. 7 237 (March 1962)

Abstract

The slope and the curvature of the overlap, repulsive energy, entering the Born model expression of the cohesive energy of the alkali halides, are evaluated as functions of the interionic distance in NaCl, NaBr, and NaI from the experimental pressure-volume relationship at room temperature, using the vibrational Mie-Grüneisen equation of state and its volume derivative at constant temperature. Over the compression range covered (up to linear compressions of almost 10%), deviations from a single-exponential, or an inverse-power, dependence of the overlap energy on the interionic distance become apparent. The overlap energy itself, as determined directly as a function of the interionic distance from the experimental data, can be fitted by an expression consisting of two exponential functions, pertaining to a first-neighbor and a second-neighbor contribution. The intervening parameters are very nearly the same as those determined by a careful Huggins-Mayer-type fit of the cohesive properties of the alkali halides at atmospheric pressure.

ELECTRON PARAMAGNETIC RESONANCE STUDIES OF ENERGY TRANSFER IN TRIPLET STATES

Bernard Smaller

Radiation Research 16 599 (April 1962)

Abstract

The recently discovered technique of detection of triplet states in aromatic phosphors has been used to study the intermediate steps involved in energy transfer in photosensitive processes. Using electron paramagnetic resonance, one can determine both triplet and free-radical concentration unambiguously and thus secure information as to the role of the excited metastable state in radiation damage. By use of suitable light filters and phosphorescence sensitizers (e.g. benzophenone) one can suppress direct absorption to the first excited singlet state and hence limit the considerations to the highly reactive excited triplet. Detailed studies have been conducted on the photoproduction of the free radicals $\dot{\text{C}}\text{H}_2\text{OH}$, $\dot{\text{C}}\text{H}_3$ and $\dot{\text{C}}\text{HO}$ in methanol. These can be considerably enhanced by the addition of various organic phosphors, most noticeably the heterocyclic of substituted aromatic type (e.g. indole, tryptophane, hydroquinone). The results can be most readily interpreted in terms of electron or proton transfer from excited state of sensitizer to substrate. The possible implication of free-radical sensitizers in contributing to the radiosensitivity of biological systems is indicated.

INVERSE OVERLAP MATRIX FOR PERIODIC ARRAYS OF ATOMS

T. L. Gilbert

J. Math. Phys. 3 (1) 107-117 (January-February 1962)

Abstract in ANL-6394, p. 47

HIGHER OXIDATION STATES OF SILVER

Juan McMillan

Chem. Revs. 62 65-80 (February 1962)

Abstract in ANL-6394, p. 54

PARAMAGNETIC RESONANCE AND CHEMICAL BONDING IN SOME COPPER (II) AND SILVER (II) COMPLEXES

J. A. McMillan and G. M. de la Roca

Bull. Am. Phys. Soc. 7 183 (March 1962)

Abstract

Kivelson and Neiman have pointed out the square symmetric character of the group $(-\text{O})_2\text{Cu}(\text{N}\equiv)_3$ and Maki and McGarvey's results on the salicylaldehydeimine support such a character. The square, symmetric, magnetic character of such groups seems to be rather general in view of measurements done at this laboratory on the copper (II) and silver (II) derivatives of the pyridine-monocarboxylic and -dicarboxylic acids. Strong differences in the spin-lattice relaxation time of different compounds have been observed.

EFFECTS OF SPIN-ORBIT COUPLING IN Si AND Ge

L. Liu

Phys. Rev., in press

A treatment of spin-orbit effects in some semi-conductors is given using the effective-mass method and orthogonalized-plane-wave type wave functions. In this formalism, the spin-orbit splitting of valence states in the crystal is expressed directly in terms of either experimental or calculated values of the spin-orbit splitting of the atomic core states. The calculation yields values in good agreement with experiments for the splitting at $\Gamma_{25'}$ for Si and at both $\Gamma_{25'}$ and L_3 for Ge. A demonstration is given of the enhancement of the spin-orbit splitting of valence states in the crystal over the corresponding atomic value.

The shift in the g tensor due to spin-orbit interactions is studied in Si and Ge. Because of crystal selection rules, the usual two-band approximation to the effective-mass sum rule is inadequate for Si and, in particular, the core state must be considered. When all important states are included, the calculations yield values in good agreement with experiment. In the case of Ge, it is found that core states do not contribute appreciably to the g tensor. However, the calculated value for the shift in the transverse component of the g tensor has an opposite sign to the measured one.

A certain matrix element of the deformation potential for Si is also evaluated based on the measured shift in the g value due to strain. The result is compared with other deformation potentials in Si.

DIRECT EVIDENCE FOR VACANCY-IMPURITY ASSOCIATION BY MEANS OF THE MÖSSBAUER EFFECT

J. G. Mullen

Bull. Am. Phys. Soc. 7 345 (April 1962)

Abstract

The Mössbauer spectrum was determined for Fe^{57} in NaCl. The source consisted of Co^{57} diffused into a single crystal of NaCl with extensive precautions taken to avoid any possible oxidation. With a 1-mil thick, annealed stainless-steel absorber, the resonance-absorption patterns consisted of four resolvable lines which were studied as a function of crystal orientation and temperature. At -182°C and with the (100) axis along the direction of motion, the absorptions were at about $v = 0.0, -1.0, -2.1$, and -2.5 mm/sec, with the line at $v = 0$ being more than twice as intense as the other absorptions and very broad. At -182°C and with the (110) axis parallel to the direction of motion, essentially the same absorptions were observed with different relative intensities. At room temperature with the (100) axis parallel to the direction of motion, absorptions at $v = 0.0, -0.8$, and -2.1 mm/sec were obtained, the latter probably being an unresolved doublet. The data are interpreted as direct evidence for associated impurity-vacancy pairs as theoretically predicted by Bassani and Fumi, and by Tosi and Airoldi.

SPECIFIC HEAT OF SAMARIUM METAL BETWEEN 0.4 AND 4°K

O. V. Lounasmaa

Phys. Rev., in press

In addition to the usual lattice and electronic terms, proportional to T^3 and T , respectively, the specific heat of most rare earth metals at low temperatures has two other contributions: a magnetic specific heat due to exchange interaction between the electronic spins and a nuclear specific heat due to splitting of the nuclear energy levels in the strong magnetic field produced by the 4f electrons. Samarium metal is antiferromagnetic below 13.6°K and the magnetic specific heat, according to the spin-wave theory, should be proportional to T^3 . The nuclear specific heat has a T^{-2} temperature dependence in the first approximation; the next term in a series expansion proportional to T^{-4} was also included in the analysis. We may thus write $C_p = AT^3 + BT + DT^{-2} - ET^{-4}$, where the first term represents both the lattice and magnetic specific heats. Values of the constants, as determined by the method of least squares from 71 experimental points between 0.4 and 2.5°K, are (for specific heat in millijoules/mole °K): $A = 0.88 - 1.11$; $B = 12.1$; $D = 8.56$; $E = 0.021$. The magnetic specific heat appears to depend on the time the sample spent in the vicinity of the antiferromagnetic Curie point when it was cooled down, hence the variations in the values of A . Constants B and D are probably accurate to 5% and 2%, respectively. The effective magnetic field at the nucleus, as calculated from the value of constant D , is 3.3×10^6 gauss.

THE SPECIFIC HEAT OF DYSPROSIUM METAL BETWEEN 0.4 AND 4°K

O. V. Lounasmaa and R. A. Guenther

Phys. Rev., in press

The heat capacity of dysprosium has been measured between 0.4 and 4°K in a He³ cryostat. In this temperature range the specific heat of the metal can be written $C_p = AT^3 + BT + CT^{3/2} + DT^{-2} - ET^{-3} - FT^{-4}$. The first term is the lattice specific heat, the second the electronic specific heat, the third the magnetic specific heat caused by exchange interaction between the electronic spins, and the remaining terms are the nuclear specific heat due to splitting of the nuclear energy levels by the strong magnetic field of the 4f electrons and by quadrupole coupling. An anomalous contribution to the heat capacity, probably due to the 0.08% oxygen impurity in the sample, was observed between 1.2 and 3.5°K. By excluding the measurements in this temperature region the following values were obtained for the constants in the above equation (for specific heat in millijoules/mole °K): $B = 9.5 \pm 10\%$, $C = 9.7 \pm 10\%$, $D = 26.4 \pm 2\%$. The result $A = 0.22$ by Dreyfus et al., was adopted and constants $E = 1.32$ and $F = 0.12$ were calculated from the available electron paramagnetic resonance data.

Considerable disagreement exists in the temperature range from 2 to 4°K between measurements of the specific heat of dysprosium by different investigators. It is shown, however, that the discrepancies appear to be in the magnetic specific heat only, C varying between 0 and 24. The various values of B are all in good agreement. Our result for D is in excellent accord with the value 26.6 obtained from electron paramagnetic resonance experiments on dilute salts. The magnetic field at the dysprosium nucleus as calculated from the value of D after the effect of quadrupole coupling had been subtracted is 7.1×10^6 gauss, in good agreement with $H_{\text{eff}} = 7.8 \times 10^6$ gauss determined for Dy¹⁶¹ by Mössbauer techniques.

RADIATION DAMAGE

William Primak and Marion Bohmann*

Progress in Ceramic Science, ed. J. E. Burke. New York: Pergamon Press, 1962. Vol. 2, pp. 103-180

Abstract in ANL-6245, p. 49

*Technical Information Division

HOLE PHOTOCONDUCTIVITY IN KBr CRYSTALS CONTAINING Br_2^-
MOLECULE IONS

C. J. Delbecq

Phys. and Chem. Solids 22 323-326 (December 1961)

Abstract in ANL-6445, p. 41

SPECIFIC HEAT DATA ANALYSIS PROGRAM FOR THE IBM 704 DIGITAL
COMPUTER

P. R. Roach

ANL-6497 (January 1962)

The purpose of the program described herein is to calculate the specific heat of a substance in the temperature range from 0.3 to 4.2°K, given temperature calibration data for a carbon resistance thermometer, and given experimental temperature drift and heating period data. The specific heats calculated from these data are then fitted by a curve by the method of least squares, and the specific heats are corrected for the effect of the curvature of the data.

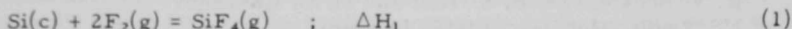
CHEMICAL ENGINEERING DIVISION

THE HEAT OF FORMATION OF SILICA AND SILICON TETRAFLUORIDE

S. S. Wise, J. L. Margrave,* H. M. Feder and W. N. Hubbard

J. Phys. Chem. 66 381 (February 1962) Letter

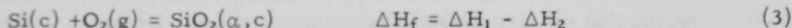
A recent paper by Chipman presented evidence that the standard heat of formation of silica is about 5 kcal more negative than the accepted value of -209.9 kcal/mole. Chipman's value is supported by earlier work of Golutvin, who found the heat of formation to be between -215 and -219 kcal/mole. To find out whether Chipman and Golutvin were correct about the currently-accepted value's being too high, the authors used fluorine-bomb calorimetry to determine ΔH_1 and ΔH_2 in the following reactions:



and



to give



ΔH_1 and ΔH_2 at 25° were found to be -386.02 ± 0.24 and -168.27 ± 0.34 kcal/mole. And, therefore, $\Delta H_{f298.15}^\circ = -217.75 \pm 0.34$ kcal/mole, substantiating the conclusions of Chipman and Golutvin.

PARTITION OF SOLUTES BETWEEN LIQUID METALS. I. THE ALUMINUM-CADMIUM SYSTEM

F. A. Cafasso, H. M. Feder and Irving Johnson

J. Phys. Chem., in press

The mutual solubilities of molten aluminum and cadmium have been measured and the partition of Pd, La, Ce, Pr, and U between these solvents has been examined. The partition coefficients (Al/Cd) of the lanthanons decrease in the order $\text{Ce} > \text{Pr} > \text{La}$. The partition coefficient of uranium and its activity coefficient in cadmium have been used to estimate the activity coefficient of uranium in aluminum solution. An approximate equation has been derived which connects the partition coefficient of a solute and its activity coefficient in each of two solvents which are partially miscible.

* University of Wisconsin

SOLUBILITY OF 3-d TRANSITION METALS IN LIQUID CADMIUM

M. G. Chasanov, P. D. Hunt, Irving Johnson and H. M. Feder
Trans. Met. Soc. AIME, in press

The solubilities of the transition metals from scandium to nickel in liquid cadmium were determined by sampling saturated solutions. At 400°C these solubilities (in ppm) are: Sc, 8200; Ti, 150; V, < 0.2; Cr, 2; Mn, 2500; Fe, 1; Co, 22; Ni, 12000. Relative partial molal enthalpies and excess partial molal entropies at infinite dilution for the solutes Cr, Mn, Fe, and Co are compared with similar data for the post-transition metals. Three new intermetallic phases, ScCd_3 , TiCd , and Ti_2Cd , encountered in the course of this work, are reported.

THE CRYSTAL STRUCTURES OF TiCd AND Ti_2Cd

R. V. Schablaske, B. S. Tani and M. G. Chasanov
Trans. Met. Soc. AIME, in press

In the titanium-cadmium system two intermediate phases, TiCd and Ti_2Cd , have been found and characterized by x-ray diffraction powder techniques. An earlier reference had reported the existence of the compound Ti_2Cd . No structural details, however, were given nor was there any indication of the possible existence of other binary compounds.

Studies of the solubility of titanium in liquid cadmium led to the discovery of both TiCd and Ti_2Cd . The solid phase in equilibrium with saturated solutions of titanium in liquid cadmium at temperatures below 620°C is TiCd , whereas Ti_2Cd is the equilibrium solid phase above 620°C. Both thermal analysis and x-ray studies show that a peritectic reaction between the gamma phase (Ti_2Cd) and cadmium to form the delta phase (TiCd) occurs at 620°C.

DECOMPOSITION PRESSURE OF UCd_{11}

Ewald Veleckis, H. M. Feder and Irving Johnson

J. Phys. Chem. 66 362-363 (February 1962)

The pressure due to decomposition of UCd_{11} to cadmium vapor and α -uranium was measured by means of a recording effusion balance. Cadmium was evaporated isothermally from powdered uranium-cadmium alloys contained in tantalum effusion cells until no further changes in sample weights were observed. The rates of vaporization in the heterogeneous region ($\text{U} + \text{UCd}_{11}$) were calculated from the weight loss vs. time records. Thirteen experiments were performed in the temperature range $305\text{--}378^\circ\text{C}$ with two effusion cells of different orifice areas. Decomposition pressures were calculated with the Knudsen equation and with the assumption that the cadmium effusate was monatomic.

The cell with the larger orifice yielded observed decomposition pressures 9% lower than the cell with the smaller orifice. This behavior suggests that the evaporation coefficient, α , of cadmium from UCd_{11} is less than unity; the correction to zero orifice area has been made on this assumption. The decomposition pressures are described by the equation $\log P_{\text{mm}} = 9.060 - 6105T^{-1}$. The free energies of formation can be calculated from the corrected experimental data with the equation ΔF_f° (cal/g-atom) = $-2861 + 3.753T$ (± 14 , std. dev.). The standard free energy of formation of UCd_{11} has also been determined in a parallel e.m.f. study at somewhat higher temperatures. In the most unfavorable instance, the pressure calculated from the e.m.f. measurements is only 7% higher than the extrapolated value based on effusion measurements. However, the slope of the line through the e.m.f. data differs appreciably from the slope of the line through the pressure data.

NEUTRON CAPTURE CROSS SECTIONS OF U^{236}

D. C. Stupegia, R. R. Heinrich and G. H. McCloud

Reactor Sci. & Technol. 15(4) 200-203 (December 1961)

Abstract in ANL-6394, p. 58

KINETICS OF PARTICLE GROWTH IN A FLUIDIZED CALCINER

B. S. Lee,* Ju Chin Chu,* A. A. Jonke and Stephen Lawroski
A.I.Ch.E. Journal 8(1) 53-58 (March 1962)

This study of the factors underlying the mechanism of particle growth in a fluidized calciner was conducted in a 3-in. diameter column. In such a calciner radioactive waste liquor from nuclear fuel reprocessing can be converted to a granular solid for disposal. To simulate the actual waste, aluminum oxide as bed material and aqueous aluminum nitrate solution as feed were used. Particle growth was traced through the addition of radioactive seeds. The effects on the growth rate of operating variables and physical properties of the feed were investigated. Statistical analysis of the data substantiated the proposed growth mechanism, and the resulting growth coefficient was correlated with the variables studied.

FLUORINE BOMB CALORIMETRY

W. N. Hubbard

Experimental Thermochemistry, ed. H. A. Skinner. New York:
Interscience Publishers, 1962. Vol. 2, Ch. 6, pp. 95-127

Abstract in ANL-6158, p. 39

RECENT ADVANCES IN COUNTING TECHNIQUES

Christopher Gatrousis, R. R. Heinrich and C. E. Crouthamel

Progress in Nuclear Energy, Series IX, Analytical Chemistry,
Vol. 2. New York: Pergamon Press, 1961. pp. 1-79

Abstract in ANL-6394, p. 55

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METALLURGY DIVISION

THE ATOMIC POSITION PARAMETER IN ALPHA URANIUM - ROOM TEMPERATURE AND ABOVE

M. H. Mueller, R. L. Hitterman and H. W. Knott

Acta Cryst. 15 421-422 (April 1962) Note

Alpha uranium, which is orthorhombic, can be described in terms of corrugated sheets parallel to the b face in which the y parameter is a measure of the degree of corrugation - the larger the value of y the greater the degree of corrugation. The change in y with temperature was determined since an increase in y makes the orthorhombic uranium lattice more nearly hexagonal. Most of the reported values of y and those determined here are in good agreement near room temperature, but the value of y at elevated temperatures has not been thoroughly investigated. The technique of Sturcken and Post was used. Except for a few preliminary x-ray measurements to recheck the room temperatures values of y and the temperature factor, B , using the Busing-Levy least squares program, data were obtained by neutron diffraction. Intensity data were obtained for the (040) (060) (080) and (0,10,0) for approximately 100°C intervals using a neutron wavelength of 0.98 Å. Plots of y and B versus temperature were made, and both y and B appear to rise gradually with some flattening near 625°C . Since the interdependence of these two variables was of interest, additional calculations were made on the 625°C data, holding B constant at 1.1 and 0.8. The corresponding y values were 0.1057 and 0.1058, indicating little dependence. The room temperature values of y determined by x-ray and by neutron diffraction are in excellent agreement. The results obtained with neutron diffraction at elevated temperatures, however, are considerably lower than the previously reported values.

DEFORMATION TWINS IN SILVER

T. H. Blewitt and J. K. Redman*

Bull. Am. Phys. Soc. 7 199 (March 1962)

Abstract

The velocity of twin formation and critical shear stresses of deformation twins was studied in high-purity silver, single crystals. The velocity of twin formation in silver was studied at room temperature by high-speed photography. It was found that twins a few tenths of a mm thick were formed in less than 1 msec. Assuming the peripheral velocity does not exceed the speed of sound, and that the twins are generated by a dislocation-pole mechanism, these results imply the simultaneous operation of about 10^4 dislocation sources. The critical shear stress was studied as a function of orientation and temperature. There was a strong orientation dependence with the critical shear stress increasing by a factor of about three as the tensile axis moved from the pole of (111) plane to the pole of the (113) plane on the dodecahedral plane. The temperature also greatly affected the critical shear stress, as it was found that the twinning shear stress increased by a factor of two from 4° to 300° K. These data place some stringent requirements on a dislocation-pole mechanism.

PRECIPITATION OF ZIRCONIUM HYDRIDE IN ALPHA ZIRCONIUM CRYSTALS

D. G. Westlake and E. S. Fisher

Trans. Met. Soc. AIME 224 254-258 (April 1962)

Abstract in ANL-6493, p. 89

A FAMILY OF INTERMEDIATE PHASES HAVING THE Si_2Mo -TYPE STRUCTURE

M. V. Nevitt and J. W. Downey

Trans. Met. Soc. AIME 224 195-196 (February 1962) Note

Abstract in ANL-6493, p. 87

* Oak Ridge National Laboratory

THE ANISOTROPY OF SELF-DIFFUSION IN ALPHA URANIUM

S. J. Rothman, J. J. Hines, James Gray, Jr.,* and A. L. Harkness**
 J. Appl. Phys., in press

The structure of alpha uranium leads one to expect that self-diffusion in it will be anisotropic. The structure is made up of corrugated layers of atoms, with the layers parallel to the (010) plane and the corrugations parallel to the [100] axis. Bond lengths in the corrugated planes (2.76 and 2.85 Å) are much shorter than bond lengths between the corrugated planes (3.26 and 3.32 Å). It seems reasonable to think that the frequency of jumps to nearest or next-nearest neighbor sites, i.e. inside the corrugated layers, is much greater than the frequency of jumps to more distant sites, i.e. between corrugated layers. In this case the diffusion coefficient in the [010] direction would be much smaller than in the other two principal directions. The measurements described show that this is indeed the case, i.e. that self-diffusion in alpha uranium is highly anisotropic with

$$D_{[010]} < D_{[100]} = D_{[001]}.$$

PHASE STUDIES ON ARC-MELTED PLUTONIUM-CARBON ALLOYS NEAR THE MONOCARBIDE COMPOSITION

O. L. Kruger

Bull. Am. Ceram. Soc. 41 299 (April 1962)

Abstract

Plutonium-carbon alloys near the monocarbide composition are of interest as reactor fuels. Non-consumable arc melting of the elements was selected as the best method of preparing high purity, high density alloys in the range of composition 42 to 60 a/o C. These alloys were investigated to determine the phase boundaries of arc-cast PuC.

Chemical, metallographic and X-ray examination of the arc melted alloys showed that pure PuC and Pu₂C₃ could be made by this method. The limiting composition for the presence of the Pu₂C₃ phase in these alloys was determined as 46 a/o C by metallographic and x-ray techniques. Precision lattice constants of the PuC phase were measured on alloys with 42 to 56 a/o C. The data show that cast PuC is non-stoichiometric with a solubility for carbon from 42.5 to 48.5 a/o C. The value for the lower limit of solubility is in agreement with metallographic results where α-plutonium was present in alloys of 42.1 a/o C. The average carbon-rich PuC lattice constant was 4.9730 Å. Near stoichiometric Pu₂C₃ had a lattice constant of 8.1256 ± 0.0001 Å.

* Chemistry Division

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THE URANIUM-RICH END OF THE URANIUM-ZIRCONIUM SYSTEM

S. T. Zegler

ANL-6055 (February 1962)

The uranium-rich end of the uranium-zirconium alloy system has been reinvestigated. The solubilities of zirconium in alpha and beta uranium were found to be 0.21 weight per cent at 662°C and 0.41 weight per cent at 693°C, respectively. The monotectoid decomposition of γ_1 at 693°C and the eutectoid decomposition of β at 662°C were confirmed. For alloys containing less than 150 ppm of oxygen by weight, the γ_1 plus γ_2 phase region boundaries have been located at 4.5 weight per cent and 22.0 weight per cent zirconium at the monotectoid temperature. Data are given which indicate that oxygen concentrations ranging from 160 to 355 ppm by weight have a marked effect on phase relations in the area of the γ_1 plus γ_2 phase region.

PRELIMINARY STUDIES IN THE SYSTEM UC-PuC

R. C. Lied and G. D. White

J. Am. Ceram. Soc. 45 149-151 (April 1962)

Abstract in ANL-6493, p. 92

VOLATILITY BEHAVIOR OF URANIA-LANTHANA SOLID SOLUTIONS

D. C. Hill

J. Am. Ceram. Soc. 45 143-144 (March 1962) Note

Abstract in ANL-6493, p. 94

INFLUENCE OF GAS FLOW ON DTA CURVES OF UO_2

Drago Kolar, E. D. Lynch and J. H. Handwerk

J. Am. Ceram. Soc. 45 141-142 (March 1962) Note

Abstract in ANL-6493, p. 95

STUDIES IN THE SYSTEM URANIUM-NEODYMIUM-OXYGEN

Drago Kolar, J. H. Handwerk and G. D. White

Bull. Am. Ceram. Soc. 41 299 (April 1962)

Abstract

The different U-Nd-O compositions were sintered in air and hydrogen at 1650°C. These compositions were then subjected to chemical, x-ray and DTA analyses. Solid solutions were readily formed in air within the approximate composition limits of 20-60 mole per cent Nd₂O₃. Mixtures of UO₂ and Nd₂O₃ when sintered in hydrogen were found to form solid solutions at a slower rate than corresponding compositions which were sintered in air. In some instances these solid solutions were incompletely formed by the heat treatment at 1650°C. The DTA curves were found to be in good correlation with the results of the chemical and x-ray analyses. These curves were found to detect the presence of the different phases.

ENERGY DEPENDENCE OF FISSION-FRAGMENT DAMAGE IN GOLD FILMS

K. L. Merkle

Bull. Am. Phys. Soc. 7 172 (March 1962)

Abstract

Damage produced by fission fragments in films of evaporated gold (500 Å thick) has been observed using transmission electron microscopy. Thin films of evaporated UO₂ were used as fission source. The fission fragments traveled through a layer of air and aluminum stopping foils. Simultaneous irradiation of several gold films in a homogeneous flux of thermal neutrons resulted in different amounts of damage, depending on the number of stopping foils. The number of spots, many of which could be resolved as dislocation loops, increased with the number of stopping foils up to a thickness equal to the range of the heavy fragments. It is believed that each spot is produced by an elastic collision between a fission fragment and a lattice atom. In the high-energy region a comparison between the density of spots and the theoretically expected number of knock-ons from Rutherford collisions has been made, and it can be shown that to produce these spots a minimum energy transfer of the order of 10⁴ ev is required.

NEUTRON-IRRADIATION-INDUCED DEFECTS IN MgO

P. F. Stablein

Bull. Am. Phys. Soc. 7 187 (March 1962)

Abstract

Measurements of the mechanical properties of MgO single crystals reveal that neutron irradiation with doses up to 10^{19} nvt does not affect the mode of deformation at room temperature. Microhardness measurements, followed by etching to reveal dislocation distributions, permit an analysis of plastic flow even on fully irradiated samples which are so embrittled by the irradiation that it has not been possible to bend them in 3-pt or 4-pt loading. It does require an increasingly higher stress to form a dislocation σ_c and to move it through the lattice σ_0 , so that the yield stress increases by a factor of five or more. Annealing at temperatures between 600° and 1000°C for various times restores part or all of the ductility. The annealing studies yield an activation energy of about 0.3 eV to remove the defects. The variation in the ratio σ_c/σ_0 is discussed with reference to the type of defect which can cause such a variation. Optical-absorption measurements have been made and compared with the above measurements, and it appears that the presence of color centers does not affect the mechanical properties.

GROOVE ETCHING IN URANIUM MONOSULPHIDE

J. P. Hugo and P. D. Shalek

J. Inst. Metals 90 215-216 (1962)

Abstract in ANL-6493, p. 93

MERCURY CORROSION OF TITANIUM AND TITANIUM ALLOYS AT ELEVATED TEMPERATURES

J. Y. N. Wang

NASA-AEC Liquid Metals Corrosion Meeting, Brookhaven National Laboratory, Dec. 14-15, 1961. TID-7626(Pt. 1) (April 1962). pp. 107-108

In connection with a proposed ANL design for a lunar power plant which consists of a fast reactor in a direct cycle with a mercury vapor turbine (ANL Report - 6261), a program has been initiated to evaluate the possibility of using and developing light weight materials for the intended system. The first phase of this project was to investigate the corrosion resistance of commercially available titanium and titanium alloys in mercury at 700°F. Surface treatments and possible inhibitors were also included. Since mercury corrosion at elevated temperatures is less understood than that by alkali metals, it is hoped that the knowledge gained from these observations will be a guide for subsequent studies.

A survey of the corrosion resistance of some sixteen commercially available titanium and titanium alloys has been made in mercury. From static autoclave tests conducted at 700°F, the alloys Ti-7Al-12Zr, Ti-2.5Al-16V, Ti-5Al-5Sn-5Zr and Ti-8Al-1Mo-1V have shown low weight changes (-1.73 to 1.63 mg/cm²) during 30 days of continuous exposure. Under identical test conditions, most of the alloys are more resistant to corrosion than unalloyed titanium (-79.7 mg/cm²). However, a beta-type alloy, Ti-13V-11Cr-3Al suffered a rapid failure by cracking in both vapor and liquid phases of mercury. No significant attack has been observed on the rest of the alloys in mercury vapor. In most of the cases, minor cracking can be easily corrected by heat treatment prior to the corrosion tests. Loop tests are now in progress.

The nature of these complex alloys has not yet been determined. It is possible that a variety of second phases has been formed or some measure of passivity has been achieved by the change in electronic structure of the solid solution. The presence of an optimum amount of zirconium, vanadium or chromium in good alloys provides the hope that a mercury-resistant titanium alloy could be developed for mercury service in the temperature range around 900°F.

An anodized film in the order of seven microinches and a carburized layer on titanium exhibit good mercury resistance in a static system at 700°F. At 850°F, both samples suffered a severe mercury attack. However, promising results have been shown by nitrided titanium in liquid mercury at both 700° and 850°F after a 30-day exposure.

The utilization of proper additives or inhibitors in mercury to reduce the corrosion attack on titanium is attractive because it permits using readily available light weight materials for the proposed reactor.

Tests conducted with saturated solutions of additives in mercury at 700°F in argon purged and evacuated pyrex glass capsule revealed that the addition of zirconium to mercury is beneficial in reducing the mercury attack of commercially pure titanium by factor of about 80. An extensive survey of other additives and long-term loop tests are planned.

ALUMINUM ALLOYS WITH IMPROVED HIGH TEMPERATURE AQUEOUS CORROSION RESISTANCE

J. E. Draley, W. E. Ruther and Sherman Greenberg
J. Nuclear Materials, in press

Several aluminum alloys with differing nickel/iron ratios underwent less corrosion at 350° than at 260°C. From the results of a study of their behavior within this temperature range, the composition Al-1 w/o Ni-0.5 w/o Fe-0.1 w/o Ti (A288) was chosen for further investigation.

The temperature at which improved corrosion behavior of this alloy was obtained depended on its silicon content, ranging from 315°C for 10 ppm Si to 360°C for 150 ppm Si.

Static corrosion tests of A288 at 260°, 290°C and 350°C indicated no "breakaway" phenomenon during about 200 days' exposure to water. Moderate extrapolation of the reported data could best be accomplished by assuming a linear behavior at 350° and nearly parabolic behavior for the two lower temperatures.

Under dynamic conditions (315°C, 18 ft/sec, low ratio of Al surface to system volume) the new alloy exhibited a constant corrosion rate of 4.2 mil per year, a considerable improvement over the older X8001 alloy. As in static tests, there was little or no improvement noted for A288 over X8001 in a one-month dynamic test at 260°C.

The application of stress during corrosion did not increase the intergranular penetration of A288.

No unusual or accelerated corrosion was found for A288 in a boiling test with a heat flux of 42 watts/cm² at 252°C, 600 psi.

Significant increases in high temperature tensile strength were obtained by adding small amounts of zirconium and chromium to the basic A288 composition. The creep resistance of the best alloy at 4000 psi-290°C was poor.

Experiments designed to probe the mechanism of corrosion indicated that the corrosion barrier for low silicon alloys at 350°C was concentrated at or near the metal-oxide interface and that the deleterious effect of silicon was shared by other members of its periodic group.

Chemical analyses showed that for low-silicon alloys at 350°C, the inner layer of corrosion product was enriched in iron and nickel, whereas the loose outer layer was depleted in these elements. At 290°C, the iron and nickel in the corrosion product were equal to the concentrations calculated from the composition of the alloy. For alloys containing more silicon, the corrosion product formed at 350°C was enriched in silicon.

STATUS REPORT ON LAMB WAVES

R. A. di Novi

ANL-6329 (March 1962)

This status report presents the theoretical and experimental aspects of Lamb waves that have been investigated as part of the research program of the Nondestructive Testing Group of the Metallurgy Division. The list of the several types of elastic waves that may be generated in an elastic plate usually includes just shear, longitudinal, and surface waves. In recent years, however, another type of elastic wave motion, known as Lamb waves, has been receiving recognition. Lamb waves designate that type of stress waves in elastic plates theoretically predicted by Horace Lamb and announced in 1916 at a meeting of the Royal Society of London. Nothing further was done with the subject, at least as far as literature references indicate, until 1945, when Floyd A. Firestone and Daniel S. Ling, who were then at the University of Michigan, undertook an extensive theoretical and experimental study. They were the first intentionally to produce such waves in plates, verifying, after 26 years, Lamb's theory, and the first to bring out those properties of Lamb waves which make them unique when contrasted with other elastic stress waves.

NUCLEAR QUALITY STANDARDS AND SPECIFICATIONS

W. J. McGonagle

Nondestructive Testing 20(3) 173-176, 181 (May-June 1962)

This paper contains a resumé of the problems of fabrication and use of nuclear materials and detection of flaws by nondestructive testing.

NEW DEVELOPMENTS IN NONDESTRUCTIVE TESTING AT ARGONNE NATIONAL LABORATORY

W. J. McGonagle

Proc. Bureau of Naval Weapons, Missiles and Rockets Symp.,
Concord, California, April 18-21, 1961. pp. 51-65

Projects under way or recently completed at Argonne are described. Among them are: 1) fundamental studies of the propagation of Lamb waves, 2) use of nondestructive testing techniques for determining the U^{235} content of fabricated fuels 3) evaluation of electron welding techniques and welds in materials roughly 0.030 in. thick, 4) development of ultrasonic imaging. Investigation of techniques of neutron radiography and eddy current testing are discussed in some detail.

PHOTOGRAPHIC FILM DETECTION METHODS FOR ULTRASONIC FIELD VISUALIZATION

Harold Berger and I. R. Kraska

J. Acoust. Soc. Am. 34 518-519 (April 1962)

Some confirming evidence is presented to support the idea that the direct action of ultrasonic waves on a photographic emulsion is influenced to a great extent by the softness of the emulsion. Significant increases in the photographic speed of an emulsion to ultrasonic exposure have been obtained by soaking the emulsion in water before the exposure in order to soften it and, thereby, make it more sensitive. Another method for obtaining photographic images of ultrasonic fields is also discussed. By exposing film, without darkroom techniques, to ultrasonic radiation in an iodine-water solution, it has been found that the emulsion tends to change color in the irradiated areas so that the ultrasonic image can be observed as it forms. In addition to this advantage, this method is capable of relatively good speed and yields fine-grain images which do not appear subject to fading.

A DISCUSSION OF NEUTRON RADIOGRAPHY

Harold Berger

Nondestructive Testing 20(3) 185-192, 194 (May-June 1962)

The advantages of neutron radiographic inspection are discussed, and the methods which can be used to perform neutron radiography are outlined. Several neutron image detection methods are recommended covering a variety of possible speed values, image resolution qualities and exposure situations. Some practical examples of neutron radiography are included along with suggestions for other application possibilities.

COMPARISON OF SEVERAL METHODS FOR THE PHOTOGRAPHIC DETECTION OF THERMAL NEUTRON IMAGES

Harold Berger

J. Appl. Phys. 33 48-55 (January 1962)

Abstract in ANL-6445, p. 58

VISUALIZATION OF INTERNAL STRUCTURE IN METALS USING NEUTRON RADIOGRAPHY

Harold Berger

Trans. ASM 55(1) 251-254 (March 1962)

Abstract in ANL-6493, p. 99

DESIGN AND OPERATION OF THE PLUTONIUM CERAMICS
LABORATORIES AT MOL

R. Billiau, Bernhard Blumenthal, J. Draulans and E. Vanden Bemden
Report Blg 64, BN-6107 03, Centre d'Etude de l'Energie Nucleaire
Societe Belge pour l'Industrie Nucleaire. (Brussels, 1962)

The Belgo Nucleaire-C.E.N. laboratory which is located at the Centre d'Etude de l'Energie Nucleaire at Mol, Belgium, is devoted to the study of plutonium-containing fuel elements. It was designed to provide for complete containment of alpha materials. Individual glove boxes are equipped for the preparation of uranium and plutonium oxide compacts and the study of some of their properties. This report describes the general layout of the laboratory, including its ventilation, the power supply, the leaktight glove boxes and their pressure control system for recirculated and once-through air, filters, glove ports, connecting ports and other pertinent details. Elementary safety rules and instructions for first aid to be followed in case of an accident are given.

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