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J4. One-Species Analyses of Drift and Diffusion Contributions to Photocurrents and Their Interrelation. G. K. Lindeberg, *Minnesota Mining and Manufacturing Company.*—A method is proposed for studying photoconductivity in systems where very little is known at the outset about the natures of the current carrying species and the mechanisms governing their transport and recombination. Independent species contributions are introduced abstractly as being quantities which obey continuity equations and which determine variations of conductivity and emf. It is reasonable to use a minimal number of these species. In this paper a one-species analysis is developed. This suggests a sequence of two specific experiments, criteria for consistency of the one-species analysis within the experimental context, and possible directions of microscopic interpretation. The conductivity, emf, and recombination can be determined as functions of the species if analysis is consistent. The diffusion coefficient is obtainable, but the effective mobility is not completely specified in the experimental context. If the species are electronic carriers, and if the emf is identifiable with their Fermi level, the distribution of electronic states is available as the solution of an integral equation.

J5. Polarized Luminescence of Calcium Fluorophosphate. Peter D. Johnson, *General Electric Research Laboratory.*—The luminescence of synthetic single crystals of apatite, $3[Ca_3(PO_4)_2]\cdot CaF_2$, activated with Sb^{+3} and Mn^{+2}, is spontaneously polarized when excited with unpolarized 2537 A or 1850 A radiation. The luminescence due to manganese is completely polarized with its electric vector parallel to the crystal *c* axis. Antimony luminescence is partially polarized perpendicular to the *c* axis. These results lead to the conclusion that luminescent manganese substitutes for calcium in the "CaI" position. This site is on a trigonal symmetry axis which is parallel to the *c* axis of the apatite structure.[1] Most, if not all, of the luminescent antimony substitutes for calcium which is in reflection plane perpendicular to the *c* axis. This "CaII" site is one of low symmetry adjacent to a fluoride and 5 oxygen atoms. The effect on the emission spectra of substituting chloride for fluoride and the electron spin resonance of Mn^{+2} in apatite can be correlated with these results. Qualitative conclusions as to the nature of the states involved in antimony luminescence can be deduced from the polarization measurements and other optical data.

[1] St. Naray, Szabo Z. Krist **75**, 394 (1930).

J6. Temperature Dependence of Bombardment-Induced Conductivity. W. C. Schieve[*] and M. A. Pomerantz, *Bartol Research Foundation.*—Measurements[1] of the temperature dependence of the conductivity induced in MgO by 1.3-Mev electrons have been extended to 100°K. A maximum occurs near 250°K. The results were consistent with a $T^{3.3}$ law over the range 107°–190°K. Furthermore, the dependence of the crystal current I_c upon the primary beam current I_p is linear both at high and low temperature. The dependence of I_c is linear both at high and low temperature. The dependence of I_c upon applied potential V_c also was investigated. In one sample, the increase of I_c with V_c was slightly more rapid than linear. At low temperature, the effect is more pronounced, the conductivity departing from ohmic behavior at 3×10^4 v/cm. It is impossible to ascribe the temperature dependence of the bombardment-induced conductivity solely to the temperature variation of carrier mobility. The results can be explained in terms of the temperature variation of both lifetime and carrier mobility. A combination of optical mode (polaron), acoustical mode, and ionized impurity scattering is assumed, as well as temperature-dependent capture cross section for the carrier. A theoretical fit of the bombardment-induced conductivity vs temperature gives reasonable values for the parameters.

[*] Present address: U. S. Naval Radiological Defense Laboratory, San Francisco, California.

[1] J. F. Marshall, M. A. Pomerantz, and R. A. Shatas, Phys. Rev. **106**, 432 (1957).

J7. Enhanced Thermal Expansion Coefficient in X-Rayed NaCl.[*] M. F. Merriam,[†] D. A. Wiegand, and R. Smoluchowski,[‡] *Carnegie Institute of Technology.*—Additional results have been obtained on the enhancement, reported earlier,[1] of the thermal expansion coefficient of rocksalt irradiated with penetrating x rays. The fractional increase in expansion coefficient $\Delta\alpha/\alpha$ is roughly proportional to the defect concentration n/N as measured by the fractional volume expansion $\Delta V/V$. If $n/N=\Delta V/V$, then $\Delta\alpha/\alpha\approx14(n/N)$. Thermal annealing of $\Delta\alpha/\alpha$ proceeds roughly simultaneously with the annealing of $\Delta V/V$. The increase in expansion coefficient is apparently insensitive to the electronic state of a lattice defect. Although understanding of the effect is incomplete, the sign and order of magnitude of $\Delta\alpha/\alpha$ is given by thermodynamic arguments.

[*] Research supported by the U. S. Atomic Energy Commission and the Office of Naval Research.

[†] Now at General Atomic, La Jolla, California.

[‡] Now at Princeton University, Princeton, New Jersey.

[1] M. F. Merriam, D. A. Wiegand, and R. Smoluchowski, Bull. Am. Phys. Soc. Ser. II, **5**, 185 (1960).

J8. Thermoluminescence of Sodium Chloride Irradiated with 40-Mev Alpha Particles. C. Giamati, G. Allen, and M. Hacskaylo.—The effect of 40-Mev alpha particles on NaCl crystals has been investigated by means of post-irradiated thermoluminescence measurements. A possible mechanism is suggested to account for the results. The suggested interpretation of the results allows a partial separation to be made of the effects of atomic displacement from the effects of ionization. The explanation appears to be consistent with diverse other investigations of alkali halides.

J9. Mechanism for the Production of Interstitials in KCl by X Rays at Low Temperatures.[*] R. E. Howard,[†] S. H. Vosko,[‡] and R. Smoluchowski,[§] *Carnegie Institute of Technology.*—It is proposed that halogen vacancies and interstitials are formed in KCl by x rays at low temperatures through multiple ionization of the halogen ions. The positive halogen ion collides with one of the neighboring negative ions forming a Cl^+Cl^- molecule. The repulsive state of a normal Cl_2 molecule intersects this state near its energy minimum and leads to a de-excitation exchange. This permits the conversion of the high electronic excitation energy into several ev of kinetic repulsive energy which is sufficient to form, by means of a series of focused collisions, a halogen vacancy (*F* center) and an interstitial (*H* center) a considerable distance away as required by experiment. The efficiency of multiple ionization (Auger effect) is estimated and found to be in good agreement with the experiment.

[*] Supported by U. S. Atomic Energy Commission and Office of Naval Research contracts.

[†] Now at the National Bureau of Standards.

[‡] Now at McMaster University, Hamilton, Ontario.

[§] Now at Princeton University, Princeton, New Jersey.

J10. Determination of the Maximum Lattice-Chain Energy from Sputtering Yield Curves. Don E. Harrison, Jr., *University of Toledo.*—An analysis is presented which suggests that the "ankle energy," that is, the energy at which the experimental sputtering ratio curve begins to form a low energy tail, is the maximum energy which the metallic lattice can propagate in a close-packed direction. The effect appears to depend only upon the existence of a chaining threshold and not upon the mathematical model of the sputtering process. The equivalence is demonstrated for the author's statistical model and for the primary lattice ion model of Kinchin and Pease.

J11. Derivation of the Five Two-Dimensional Bravais Lattices. John R. Madigan, *Borg-Warner Corporation.*—The possible symmetry operations in a two-dimensional lattice are rotations about an axis perpendicular to and mirror reflection across a line in the plane of the lattice. The effect of either type of symmetry operation on a given set of basis vectors is to transform them into another set of possible basis vectors for the lattice. To be compatible with the requirement of translational symmetry in the lattice, the second set of basis vectors must be expressible as linear combinations of the first set with integral coefficients. This requirement restricts the allowed rotations and the types of lattices that can have mirror lines for elements of symmetry. It is possible to give a rigorous and yet simple treatment of the problem which not only deduces the allowed rotations but also the possible axial ratios and inter-axial angles. The method is applied to two-dimensional lattices and used to derive the five two-dimensional Bravais lattices. The extension to three-dimensional lattices is discussed.

J12. Anharmonic Attenuation of Localized Lattice Vibrations. P. G. Klemens, *Westinghouse Research Laboratories.*—Lattice modes localized about defects can interchange energy with the continuum of lattice waves by anharmonic interactions. The relaxation time of a localized mode is calculated, taking account of cubic anharmonicities and using perturbation theory analogous to the treatment of three-phonon interactions. At zero temperature the relaxation time is typically of the order of 100 periods but decreases with increasing temperature.

J13. Surface Vibrational Waves in Crystal Lattices with Complex Interatomic Interactions. D. C. Gazis and R. Herman, *General Motors Corporation,* and R. F. Wallis, *U. S. Naval Research Laboratory.*—The investigation of surface vibrational waves in crystal lattices is complicated by the necessity for satisfying the free boundary conditions at the surface. If the interatomic interactions include next-nearest neighbor interactions, next-next-nearest neighbor interactions, etc., the number of equations specifying the free boundary conditions may become rather large. A method has been developed which enables one in principle to satisfy the free boundary conditions when interatomic interactions of various ranges are included. Illustrative calculations of the frequencies and attenuation constants for surface waves in monatomic and diatomic linear chains with nearest and next-nearest neighbor interactions will be given. The application of the mathematical techniques to the evaluation of certain types of determinants will be discussed.

Thursday Morning at 9:45

New Yorker, Panel Room

(Howard Reiss presiding)

General Physics

JA1. Molecular Pumps for Producing High Vacua.[*] C. E. Williams and J. W. Beams, *University of Virginia.*—In order to produce the lowest pressure in a vacuum system it is important to bake out the system including the final stages of the pump. Completely bakeable molecular pumps have been developed.[1] The steel rotors are magnetically suspended inside of vacuum chambers made of nonferromagnetic materials such as glass or stainless steel. They are spun by rotating magnetic fields produced by field coils located outside the chamber. The stators are made of nonferromagnetic material which may be degassed by baking. Operational data will be given including ratios of the pressures on the high to the low sides of the pump and pumping speeds as a function of the clearance between rotor and stator, depth and shapes of grooves, and the peripheral speed of the rotor. Pressure ratios of over 10^4 and pumping speeds of a few liters/sec are not difficult to obtain. The fore pumping system consists of the usual rotary oil pump, diffusion pump liquid nitrogen trap series arrangement.

[*] Supported by Navy Bureau of Weapons and U. S. Army Office of Ordnance Research.

[1] J. W. Beams, Science **130**, 1406 (1959).

JA2. Pressure-Modulated Infrared Emission Spectra of Nitrous Oxide.[*] Richard R. Patty[†] and Dudley Williams, *The Ohio State University.*—A device for producing periodic variations in the volume of a gas sample has been developed. At a frequency of 8 cps the processes occurring within the sample are approximately adiabatic; consequently, sample temperature can be computed as a function of compression ratio *c* and the ratio γ of the specific heats of the gas. The range of temperature variation is sufficiently large to make it possible to observe the infrared emission spectra of various gases. Emission spectra of nitrous oxide in the vicinity of the 1167 cm^{-1}, the 1285 cm^{-1}, and the 2222 cm^{-1} vibration-rotation bands have been observed for various compression ratios. By addition of certain nonabsorbing gases, it is possible to obtain various effective values of γ. The observed integrated emission of each band as a function of the partial pressure of nitrous oxide is discussed and compared qualitatively with predictions based on integrated band absorption.

[*] Supported in part by the U. S. Air Force Cambridge Research Center.

[†] National Science Foundation Graduate Fellow.

JA3. Electronic States of F_2. A. Amith,[*] *Harvard University.*—ASMO and "Atoms in Molecules"[1] schemes were employed to calculate the electronic levels of F_2—represented as a 14-electron system with nuclei of charges +7 eu: After allowing electronic promotions among the $n=2$ molecular orbitals and neglecting spin-orbit degeneracy, there resulted 44 terms of 14 distinct symmetry groups. In the primitive configurational calculation, ASMO predicted a nonbinding ground state $('\Sigma_g^+)$,whereas AIM predicted a binding one. With full C. I., both predicted stable ground states, but the binding energies were overestimated (exptl.: 1.65, ASMO: 4.16, AIM: 8.30 ev) at an equilibrium internuclear distance ρ_E which was underestimated (exptl.: 141, ASMO and AIM: 1.16 A). Some excitation energies at the experimental ρ_E are

	ASMO: primitive/ with C.I.		AIM: primitive/ with C.I.		Exptl.
$^3\pi_u$	3.00	2.64	3.51	3.18	3.16 ev
$^1\pi_u$	4.70	3.88	5.01	4.72	4.28
$^1\Sigma_u^+$	19.70	13.51	14.72	11.85	11.96

The effects of the ionic character of the atomic species upon the resulting molecular terms, and the validity and applicability of the calculations, will be discussed.

* Now at the RCA Laboratories, Princeton, New Jersey.
[1] W. E. Moffitt, Proc. Roy. Soc. (London) **A210**, 245 (1951).

JA4. Absorption Coefficient of Beryllium in the Vicinity of the *K* Edge.* D. J. BAKER AND D. H. TOMBOULIAN, *Cornell University*.—The available experimental data[1,2] on the absorption coefficient of Be for photon energies above and below the K absorption edge (112 ev) are compared with predictions from theory.[3] Plots of the logarithm of the mass absorption coefficient as a function of the logarithm of the wavelength of the incident photon result in straight lines whose slope is 2.40. The "K-absorption jump" (the ratio of the absorption coefficient just above and just below the K edge) is found to be 6.8. These results are in fair agreement with the corresponding quantities expected from the theory of photoelectric absorption involving K shell electrons.

* Supported by the Office by the Office of Naval Research.
[1] L. C. Andrews, Phys. Rev. **54**, 994 (1938).
[2] R. W. Johnston and D. H. Tomboulian, Phys. Rev. **94**, 1585 (1954).
[3] H. A. Bethe and E. E. Salpeter, *Quantum Mechanics of One-and-Two-Electron Systems* (Academic Press, Inc., New York, 1957), p. 303.

JA5. Low Energy X-Ray Mass-Attenuation Coefficients. ALAN J. BEARDEN, *Cornell University*, AND P. R. WISE, *The Johns Hopkins University*.—The attenuation of x rays with energies from 853 to 2991 ev by Al and Mylar films, and C_2H_4, N_2, O_2, Ne, and A gases, has been measured using a high-resolution beryl monochromator. Experimental determinations of the mass-attenuation coefficients with less than 2% probable error have been obtained by low kilovoltage operation of the x-ray tube and by flow-proportional counter detection with pulse-height discrimination. Some features of flow proportional counting using He-A-CH_4 gas will be discussed. A comparision of this work with previous determinations of a few experimental values in this x-ray energy region[1] and a discussion of theoretical predictions for photoelectric cross section will be presented.

[1] C. L. Andrews, Phys. Rev. **54**, 994 (1938).

JA6. Theory of Conformal Solutions Applied to Liquid Alkali Nitrate Mixtures. J. L. KATZ, *University of Chicago*, HOWARD REISS, *Atomics International*, AND O. J. KLEPPA, *University of Chicago*.—Kleppa and Hersh[1] have found that the molar enthalpy of mixing for equimolar liquid alkali nitrate mixtures may be represented by the approximate expression, $\Delta H_m=(U/4)[(d_1-d_2)/(d_1+d_2)]^2$, where U is the lattice energy of the mixture and d_1 and d_2 are the interionic distances characteristic of the two pure salts. We have derived an expression similar to this by applying a suitable modification of Longuet-Higgins' theory of conformal solutions.[2] Our results and those of H. Reiss and S. W. Mayer[3] seem to indicate that the lack of success of first-order conformal solution theory may have been due to its application to mixtures of substances whose intermolecular potentials were not really conformal.

[1] O. J. Kleppa and L. S. Hersh, J. Chem. Phys. (to be published).
[2] H. C. Longuet-Higgins, Proc. Roy. Soc. (London) **A205**, 247 (1951).
[3] H. Reiss and S. W. Mayer (to be published).

JA7. Mean Square Length of Isotactic Poly-α-Olefins.* PAUL M. PARKER, VICTOR E. MEYER, AND JACK B. KINSINGER, *Michigan State University*.—The mean square end-to-end length of long isotactic vinylic hydrocarbon-type chains (poly-α-olefins) has been calculated by treating the problem as a Markov process in the manner of Tobolsky.[1] The problem of excluded volume is ignored. An outline of the calculation and the result will be presented and discussed.

* Work supported in part by a grant from the Research Corporation and in part by a National Science Foundation Summer Fellowship.
[1] A. V. Tobolsky, J. Chem. Phys. **31**, 387 (1959).

JA8. Flame Propagation in Free Radical Containing Solids at Low Temperatures. A. L. BERLAD, *Convair Scientific Research Laboratory*.—A theory of flame propagation in free radical containing inert matrices is formulated. Although the general theoretical formulation is nonadiabatic, the near-adiabatic approximation may be employed, in conjunction with experimentally determined flame propagation velocities, to deduce the activation energy E for the jump of an interstitial free radical in an inert solid matrix. The spatial temperature and composition profiles associated with the given near-adiabatic flame are deduced simultaneously. The *complete* nonadiabatic formulation is *necessary*, however, to a deduction of existence limits for flame propagation. This is demonstrated. Application of the formulation is illustrated for the case of flame propagation in N atom containing solid N_2. For this case, an experimentally determined burning velocity of 2 cm/sec is used to deduce a value of $EW1$ kcal/mole, as well as the associated temperature and composition profiles.

JA9. "Sectio Aurea" in the Composition of Crystalline Matter. NICHOLAS EFREMOV.—If we assume the concept of harmonical mass relations of chemical elements in the structure of crystals, we can precalculate the chemical formulas of some rockforming minerals and that of silicates in particular. This precalculation is based on the rule of "sectio aurea" (series of relations 2:3, 3:5, 5:8, or 3:5:8, etc.) which characterizes the relations between two or three components (Me-metal, Si, O) constituting the chemical composition of rockforming silicates. The empirical data are in good agreement with this theoretical precalculation:

Silicates	Mass relations
Forsterite—Mg_2SiO_4	$Si:Mg_2:O_4=3:5:7$
Anorthite—$CaAl_2Si_2O_8$	$Si_2:CaAl_2:O_8=3:5:7$
Albite —$NaAlSi_3O_8$	$NaAl:Si_3:O_8=3:5:8$

The same rule explains for the first time the so-called "anomalies" in the chemical composition of iron monosulfides, as pyrrhotite, etc. The formula of the most abundant pyrrhotite is not FeS (as usually given in manuals), but Fe_6S_7, Fe_5S_6, etc., where mass relations S:Fe = 2:3. Not only the composition of rockforming silicates, but also that of some igneous and metamorphic rocks constituting the earth's crust, follow the same rule.

JA10. Adsorption of Air and Oxygen by Evaporated Films of Titanium and Zirconium. E. J. ZDANUK AND S. P. WOLSKY, *Raytheon Company* (introduced by W. C. Dunlap).—The Wagener calibrated capillary flow technique was used to study the adsorption of air and oxygen by evaporated films of titanium and zirconium at room temperature. By the use of a premelting and outgassing filament shield the films on the walls of the reaction flask were formed at dynamic ambient pressures of 10^{-8} mm Hg or less. The Bayard-Alpert type ionization gauges used in this apparatus had LaB_6 coated filaments. This modification permitted low filament temperature operations thus minimizing the effect of thermal gaseous reactions. A glass plate with evaporated gold electrodes in the reaction flask was used to measure the electrical resistance of the metal film as a function of its thickness. The resistances also were sensitive to adsorption and desorption processes occurring in the reaction flask. The adsorption rates were measured in the pressure range of 10^{-4} to 10^{-8} mm Hg.

JA11. Theory of the Surface Tension of Fused Salts.* HOWARD REISS AND S. W. MAYER, *Atomics International*.—A theory of the surface tension of fused salts is presented based on the Reiss, Frisch, Helfand, and Lebowitz[1] theory of liquids, modified by the theory of conformal solutions due to Longuet-Higgins.[2] The theory allows one to compute the surface tension of a fused salt knowing only the temperature, the density, and the diameters of the ionic hard cores. It has been applied to uni-univalent, uni-divalent, and uni-trivalent salts. Agreement with experiment is very good. The mercuric salts, known to be un-ionized, yield anomalous results. This is expected on the basis of the theory and indicates that it may be useful in structural investigations.

* Work performed under contract to the U. S. Atomic Energy Commission.
[1] H. R. Reiss, H. L. Frisch, E. Helfand, and J. L. Lebowitz, J. Chem. Phys. **32**, 119 (1960).
[2] H. C. Longuet-Higgins, Proc. Roy. Soc. (London) **A205**, 247 (1951).

JA12. Correlation in the Diffusion of Hydrogen in Hydrides.* G. G. LIBOWITZ AND HOWARD REISS, *Atomics International*.—The metal hydrides are excellent systems for the study[1] of the vacancy mechanism of diffusion because the vacancy concentration can be controlled at one temperature by fixing the composition of the hydride. They are even more suitable for the study of correlation effects[2] in diffusion. To this end we have calculated the correlation factors for the diffusion of hydrogen and deuterium in the tetrahedral or octahedral sites of typical hydrides. Hydrogen diffusing in deuteride is also considered. Diffusion studies involving correlation also should yield information on the clustering or ordering of vacancies in these substances.

* Work performed under contract to the U. S. Atomic Energy Commission.
[1] B. Stalinski, C. K. Coogan, and H. S. Gutowsky, J. Chem. Phys. **33**, 933(L) (1960).
[2] J. Bardeen and C. Herring, *Imperfections in Nearly Perfect Crystals* (John Wiley & Sons, Inc., New York, 1952), p. 261.

THURSDAY MORNING AT 9:45

New Yorker, Terrace Room

(E. P. WIGNER presiding)

Symposium on General Relativity

K1. Curved Empty Space-Time as the Building Material of the Physical World: an Assessment. J. A. WHEELER, *Princeton University*. (30 min.)

K2. Observables in General Relativity. P. G. BERGMANN, *Syracuse University*. (30 min.)

K3. Convergence Problems in Quantizing Gravitation as a Spin-Two Meson Field. R. P. FEYNMAN, *Carnegie Institute of Technology*. (30 min.)

K4. Cosmological Inferences from Astronomical Observations. THOMAS GOLD, *Cornell University*. (30 min.)

THURSDAY MORNING AT 9:45

Martinique, Empress Josephine Room

(J. D. JACKSON presiding)

Theoretical Physics III: Hyperfragments; Weak Interactions; Many-Body Systems

KA1. Double Hyperfragments and Relative Parity of Λ and Σ Hyperon. SYUREI IWAO,* *Syracuse University* (introduced by R. L. Arnowitt).—In a previous paper[1] a theory of hyperfragments was developed. The parameters of the two-body N-Λ interaction were determined from the observed binding energies of the Λ hyperon. They explained well the present experimental status of hyperfragments. We here apply this method to the so-called "double hyperfragments." The double hyperfragments are bound states of two Λ particles and ordinary nuclei. One might expect such systems could be produced by the absorption of high-energy K^- mesons by complex nuclei or by Ξ^- absorption. One has only one additional parameter in the ${}^1S_0$ state not previously determined by the single hyperfragment analysis. With the use of global symmetry one expects that double hyperfragments should exist for $A\gtrsim 4$. The binding energies of the double hyperfragments are of interest because the sign of the ${}^1S_0$ potential for the Λ-Λ interaction is closely related to the relative parity of the Λ and Σ particles. Thus the two-pion exchange potential gives an attractive force here for the same parity while zero for opposite parity. For opposite parity bound states will form for $A\gtrsim 5$.

* Supported in part by the National Science Foundation and the U. S. Air Force Office of Scientific Research.
[1] S. Iwao and E. C. G. Sudarshan, Phys. Rev. Letters **4**, 140 (1960).

KA2. Analysis of the Light Λ-Hypernuclear Systems. K. DIETRICH,* R. FOLK,† AND H. J. MANG, *Institut fuer Theoretische Physik, Heidelberg*.—The ground-state energy of the systems consisting of a lambda particle bound to two, three, and four nucleons is computed from elementary two-particle potentials. Both the nucleon-nucleon and the Λ-nucleon interactions are assumed to be spin dependent, central potentials with square well shapes outside of a hard core. The ground-state energy is computed as a function of the parameters of the Λ-nucleon interaction. A method first introduced by J. Brenig[1] for many fermion problems is adapted to these hyperfragment systems and consists essentially of solving the two-particle problem for each pair in an "average field" of the remaining particles. This "average field" is chosen in a self-consistent calculation so as to minimize the "first corrections" to the energy. The accuracy is checked by computing higher order corrections and by computing the energy using three independent approximate expressions.

* Now at Institut fuer Theoretische Physik, Frankfurt.
† Now at Princeton University, Princeton, New Jersey.
[1] J. Brenig, Nuclear Phys. **4**, 363 (1957).

KA3. Muon Capture in He³. LINCOLN WOLFENSTEIN, *Carnegie Institute of Technology*.—The rate Λ of the muon capture reaction $\mu^-+He^3\rightarrow H^3+\nu$ is of great interest because

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