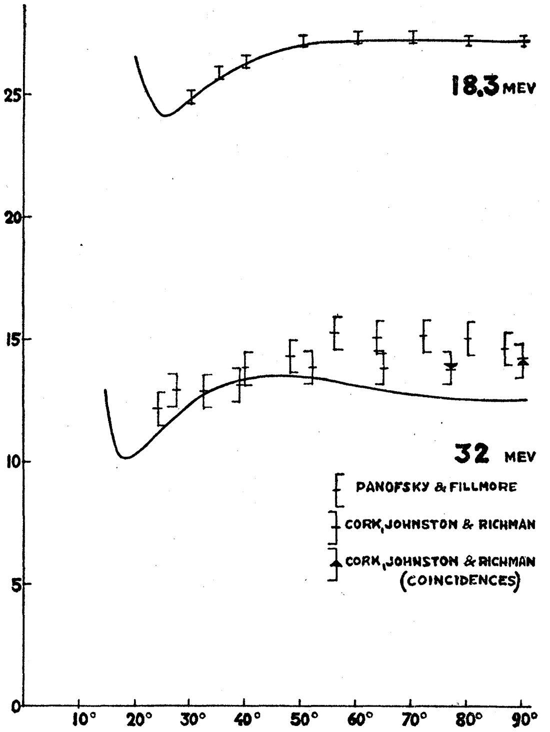

FIG. 1. The angular distribution of the differential cross section (in millibarns per steradian), at 18.3 and 32.0 Mev. In the latter case appropriate errors have been assumed so that the two series of experimental data (see reference 6) are consistent with each other.

for the determination of the D phase shift K_2 and the three P phase shifts $K_1^{(0)}$; $K_1^{(1)}$, $K_1^{(2)}$ corresponding to tensor scattering with $J=L-1$, $J=L$, $J=L+1$, respectively. (In computing K_1, the coupling with F state has been neglected.) For a potential including a repulsive core the Born approximation gives

$$\tan K_L^{(J)}=-\frac{M}{\mu}\int_{r_c}^{\infty}[F_L(kr)-\rho_L(kr_c)G_L(kr)]^2V_L^{(J)}(r)dr-(-1)^L\rho_L(kr_c), \quad (3)$$

where F_L and G_L are, respectively, the regular and irregular Coulomb wave functions, and $\rho_l(kr_c)=F_L(kr_c)/G_L(kr_c)$. The contribution of the core to the D phase shifts was found negligible for the range of energy investigated. To obtain the Coulomb wave function, the Schrödinger equation, corresponding to the Coulomb field alone, was solved numerically since the existing tables[2] do not cover the required range of (kr) values at high energy. The solution which vanishes for $r=r_c$ was normalized by comparison with the tables for sufficiently large values of (kr).

(1) 18.3 Mev.—For this energy, there exists excellent measurements.[3] Keeping a core radius of $0.38(\hbar/\mu c)$, we observed that the cross section at 90° is very sensitive to the variation of the coupling constant within the interval defined by Eq. (2). When $G^2/4\pi$ varies from 9.7 to 11, K_0 increases from 34.77° to 75.13°. The accuracy of the 18.3-Mev experiments provides, therefore, a severe restriction on the possible values of the coupling constant: we found[4] $G^2/4\pi=10.36\pm0.02$ for $r_c=0.38(\hbar/\mu c)$. With these constants we obtained the following values of the phase shifts: $K_0=52.8°$, $K_1^{(0)}=6.82°$, $K_1^{(1)}=-1.45°$, $K_1^{(2)}=1.85°$, $K_2=0.35°$.

The corresponding differential cross section[5] is plotted in Fig. 1. It is seen that the agreement with experiment is excellent.

(2) 32.0 Mev.—For this energy the experimental results[6] are not so good as for 18.3 Mev. The following phase shifts have been obtained: $K_0=44.85°$, $K_1^{(0)}=11.79°$, $K_1^{(1)}=-1.62°$, $K_1^{(2)}=3.79°$, $K_2=0.97°$.

The corresponding differential cross section is plotted in Fig. 1. One can notice a discrepancy of about 10 percent with the experimental data. This discrepancy can be compared with the similar one observed by Lévy for $n-p$ scattering at 40 Mev. It is consequently probably not fortuitous and might be due to several causes: the energy dependence of the potential presumably starts to be felt at these energies (see, for instance, reference 1, end of Sec. III); the detailed structure of the interaction at short distances might also become more significant. These problems will be investigated in more detail for the analysis of high energy nucleon-nucleon scattering.

The authors wish to acknowledge the kind hospitality they have received at the Laboratoire de Physique of the Ecole Normale Supérieure. They are also deeply indebted to Dr. Maurice Lévy for suggesting this problem and for continued guidance in the calculations.

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New Long-Lived Magnesium-28 Isotope*

R. K. SHELINE AND N. R. JOHNSON
Department of Chemistry, Florida State University, Tallahassee, Florida

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MAGNESIUM-28, a 21-hr β^- emitter, has been produced in both a betatron irradiation and a cyclotron bombardment. The nuclear reactions are

$$\mathrm{Si}^{30}(\gamma,2p)\mathrm{Mg}^{28}, \quad (1)$$

$$\mathrm{Mg}^{26}(\alpha,2p)\mathrm{Mg}^{28}. \quad (2)$$

The half-lives observed are 21.7±1.0 hr in the case of nuclear reaction (1) and 21.3±0.2 hr in the case of nuclear reaction (2).

In nuclear reaction (1) elemental silicon was irradiated for eight hours in the gamma-spectrum of the 100-Mev University of Chicago betatron. The silicon was dissolved in hot conc sodium hydroxide and carrier magnesium ion added. The solution was neutralized with hydrochloric acid precipitating silicon dioxide and filtered. Magnesium ammonium phosphate was precipitated from the filtrate which was buffered with ammonium chloride by the addition of primary ammonium phosphate. The magnesium ammonium phosphate precipitation was repeated twice more to insure purity.

In nuclear reaction (2) a disk of magnesium metal of ordinary isotopic composition was bombarded in an external beam of 39-Mev alpha-particles for ten hours in the University of California 60-inch cyclotron. The magnesium disk was coated with Krylon plastic spray except for the area in which the beam was concentrated. The magnesium could then be dissolved in dil hydrochloric acid in such a way as to produce the highest possible specific activity. The magnesium ammonium phosphate was then precipitated from the appropriately buffered solution, to which sodium chloride was added as a hold-back carrier. This precipitation was repeated four additional times.

The evidence for the assignment of this activity as Mg^{28} is very strong. Perhaps the strongest piece of evidence is the observation in milking experiments of Al^{28}, the daughter of Mg^{28}, with which it is in secular equilibrium. Al^{28}, which is a well-studied activity,[1] has a 2.3-min half-life and decays via a 3.01-Mev β^- and a 1.80-Mev gamma to Si^{28}. The half-life observed in the milking experiments agrees very closely with the reported 2.3-min half-life for Al^{28}. In addition, aluminum absorption curves on the activity, after it has been allowed to attain radioactive equilibrium, show the existence of the 3-Mev β^- of Al^{28}. When one adds to this the evidence from cross bombardment and nuclear systematics from this part of the isotope chart, the assignment as Mg^{28} seems unequivocal.

Mg^{28} has a half-life slightly more than 130 times that of the longest-lived magnesium activity previously known, Mg^{27} ($t_{\frac{1}{2}}=9.6$ min).[1] For this reason Mg^{28} should find considerable use as a tracer, particularly in the study of photosynthesis. Its use in plant physiology, soil science, and certain parts of biochemistry is immediately evident. Preliminary experiments using Mg^{28} as a tracer in plants have been encouraging.

It is probable that Mg^{28} could be produced by high energy cyclotron spallation reactions on elemental silicon or calcium chloride. Such methods of production of this activity might have the advantage of producing a large amount of high specific activity particularly advantageous in tracer experiments.

Because of the very considerable application which this isotope may find in other fields, this work is reported without a decay scheme for Mg^{28}. Work is continuing on the project and a complete report on this activity will be published in this journal in the near future. Thanks are due the staffs and crews of the University of Chicago betatron and the University of California 60-inch cyclotron.

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Thermal Rayleigh Disk Measurements in He^3-He^4 Mixtures

Bernard Weinstock, *Argonne National Laboratory, Lemont, Illinois*
and
John R. Pellam, *National Bureau of Standards, Washington, D. C.*

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PRELIMINARY investigations of the propagation of second sound in a 4 percent mixture of He^3 and He^4 have been carried out during a joint Argonne-NBS program conducted at the NBS Cryogenics Laboratory. For these experiments a thermal Rayleigh disk[1] apparatus was employed. The volume of the disk chamber was limited to $\frac{3}{4}$ cc by the amount of mixture available, and the diameter of the mirrored disk was accordingly reduced to 2.8 mm. A satisfactory fiber for suspending the disk and with small restoring constant was prepared from Duco cement. Second sound was generated by passing an alternating electrical current through a carbon strip resistance, and the frequency corresponding to maximum deflection of the disk from its equilibrium orientation gave a direct measurement of the wave velocity. The actual torque on the disk was computed from the observed deflection and the measured value of the restoring constant of the suspension, so that the kinetic energy density of the thermal wave was determined. Evaluation of the thermal resonance properties of the system permitted the kinetic energy density for unit heat current density to be computed and allowed a comparison with pure He^4. The apparatus was checked by measurements with pure He^4 directly, and reasonable agreement was obtained with the previously observed values. In the work with the mixture the power input to the system was severely limited by phenomena associated with the heat flush effect, and it was therefore necessary to amplify the resulting small disk deflection. This was achieved by turning the power on and off with a frequency corresponding to that of the freely swinging disk suspension. In this way a detection sensitivity of 10^{-8} dyne-centimeter was obtained in a system where the maximum torque was of the order of 1 microdyne centimeter.

We have found that the velocity of second sound in the 4 percent mixture increases continuously with decreasing temperature to a value of 38 meters per second at about 0.9°K. Table I gives representative values of the observed velocities for various temperatures. These results are in qualitative agreement with the earlier observations of Lynton and Fairbank,[2] who measured a 0.8 percent mixture down to 1.2°K. From this it appears likely that the quantitative aspects of Pomeranchuk's[3] theory for the second sound velocity of He^3-He^4 mixtures are incorrect. In his theory the second sound velocity of mixtures at first increases above that of pure He^4 but then decreases and extrapolates to a small value at absolute zero. For this to occur, he would have predicted the appearance of a maximum in the velocity of second sound for the 4 percent mixture at a temperature of about 1°K. Dingle,[4] on the other hand, suggests that, owing to strong interaction between the particles, the velocity of second sound in mixtures will behave at very low temperatures similarly to that of pure He^4 and in fact near absolute zero will approach the same value of first sound velocity divided by $\sqrt{3}$. So far our results are consistent with this latter prediction; choice, however, between Dingle and Pomeranchuk's views must await measurement at much lower temperatures.

Table I. Wave velocity of second sound in 4 percent He^3-He^4 mixture *versus* temperature.

Temperature (°K)	Wave velocity (m/sec)
0.9	38
1.0	36
1.25	31
1.5	28
1.75	24
1.95	16
2.0	0

Regarding the torque measurement, Koide and Usui[5] have suggested that thermal Rayleigh disk measurements with He^3-He^4 mixtures would be a sensitive test of a hypothesis that the He^3 component remains stationary in the center-of-mass system in the presence of second sound, rather than participate in the normal fluid excursion. They treated theoretically cases of He^3 concentration up to 0.8 percent for temperatures above 1.5°K, and predicted a marked decrease in torque resulting from the dilution. We have checked this effect in our investigations under even more extreme conditions and have found that at 0.9°K in the 4 percent mixture the torque has fallen to a few tenths percent of that for pure He^4. While our measurements agree with their prediction, it might be possible to explain our results without assuming that the He^3 does not participate in the normal fluid particle motion. In this connection, specific heat values for the mixture obtainable from our torque measurements agree well with calculated values deduced from the de Boer-Gorter[6] theory.

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The Structure of Deformation Bands

Edward W. Hart
General Electric Research Laboratory, Schenectady, New York

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IT is well known[1] that two parallel dislocations with opposite Burger's vectors, as shown in Fig. 1, and gliding on distinct planes can block each other's motion because of their mutual stress interaction. The angle, ϕ, between the line joining the two dis-

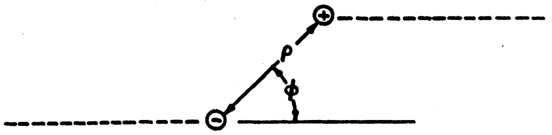

Fig. 1. Interacting edge dislocations. The horizontal lines define the glide planes containing Burger's vectors.