allowed to elapse before beginning the counting so that short-lived activities could decay out. The decay curve is a pure exponential. Observations taken twenty-four and forty-eight hours after irradiation showed no counts above the number expected on the assumption that the only activity present was 140-min Dy^{165}. A least-squares analysis of the decay curve yielded a half-life for Dy^{165} of 139.17±0.14 min, in agreement with recent values (140±1.5 min, 145±3 min) obtained by Bothe[1] and Slätis.[2] We wish to thank V. Walsh and M. Turso for their assistance in the experiment.

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[1] W. Bothe, Z. Naturforsch. **1**, 179 (1946).
[2] H. Slätis, Arkiv. Mat. Astron. Fysik **33A**, No. 17 (1947).

Gamma-Gamma Angular Correlation in Cd^{114}

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THE angular correlation of the gamma-rays emitted in cascade from the excited states of Cd^{114} has been measured with the apparatus described previously.[1] The source used was an aqueous solution of $InCl_3$ in a Lucite container, and the gamma-rays were detected with sodium iodide crystals 1½ inches in diameter and 1 inch long at a distance of 10 centimeters from the source. The data were taken at increments of 10° from 90° to 160°, and each detector was set on integral at the lower edge of the photo peak due to the 548-kev gamma-ray. Under these conditions the effect of the annihilation radiation is to raise the coincidence rate at 180° by 40 percent. A total of 100,000 coincidence counts was observed.

The data were fitted by least squares to an expansion in terms of Legendre polynomials. The correlation is given by $W(\theta)=1+0.111P_2(\cos\theta)+0.023P_4(\cos\theta)$ or $W(\theta)=1+0.084\cos^2\theta+0.106\times\cos^4\theta$, in which the angular resolution of the apparatus has been taken into account.

The above correlation is consistent with a spin assignment of 0–2–2 for the ground state and the two excited states of Cd^{114}, respectively. The first gamma-ray of the cascade is a mixture of 97 percent magnetic dipole and 3 percent electric quadrupole radiation with the electric and magnetic components in phase.

The intensity of the crossover gamma-ray relative to the main cascade has been measured with a sodium iodide scintillation spectrometer and found to be about 6 percent.

The correlation of the gamma-rays from Cd^{114} has been measured previously by Steffen.[2] He has repeated these measurements, and his new results are in agreement with those of the present work.[3]

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[2] Rolf M. Steffen, Phys. Rev. **83**, 166 (1951).
[3] Rolf M. Steffen, private communication.

Mechanical Properties of Thin Films of Silver*

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IN the study of the mechanical properties of thin films it is important to apply the stress uniformly in order to prevent "tearing" or other forms of stress concentration. This is especially true in the determination of the tensile strength of thin metallic films or in the measurement of the adhesion of these films to other metals. One simple method of applying the stresses to such metallic films is to subject them to high centrifugal fields. The method previously described in detail[1] of spinning magnetically suspended rotors in a vacuum or in gases at various pressures is ideal for this kind of investigation because accurately known stresses can be applied uniformly and at almost any desired rate. Also the usable rotor speeds are limited only by the bursting strength of the rotors.

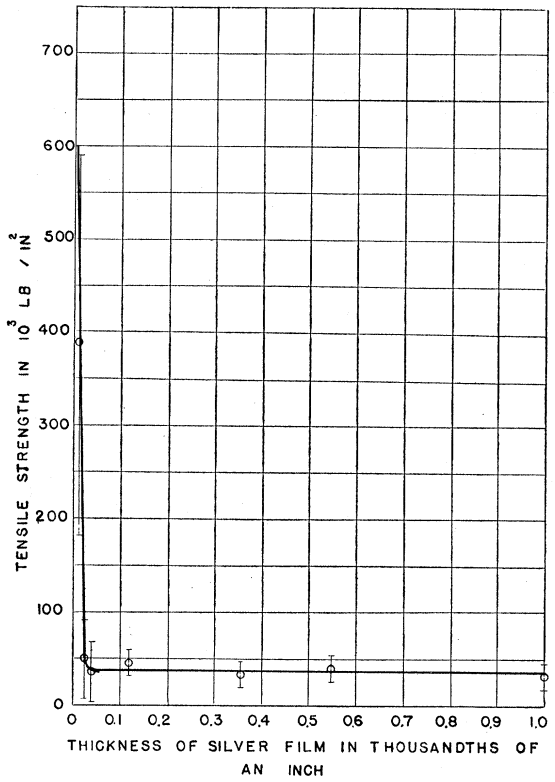

FIG. 1. Tensile strength as function of thickness.

In the experiments described here films of silver of uniform thickness were electro-deposited on small cylindrical steel rotors with rounded ends and the rotational speeds required to throw them off of the rotors were measured. The rotors were spun in a high vacuum. It can be shown that

$$4\pi^2N^2R^2d=T+(AR/h),$$

where N is the rotor speed in rps, R is the rotor radius, d the density of the deposited film, h the thickness of the film, T the tensile strength of the film, and A the adhesion. Consequently, by using rotors with different diameters and measuring the speeds at which the metallic films are thrown off of the rotor, it is possible to determine both the tensile strength T and the adhesion A.

It will be observed that if the ratio of the rotor radius to the thickness of the film is large even a small adhesion A makes the last term overshadow the first. Consequently, we have employed comparatively small rotors for these experiments. Also, by using well-known procedures in the electro-plating process uniform films of silver could be deposited on the steel rotors, which had relatively small adhesion. Figure 1 shows a plot of the tensile strength T *versus* the thickness h of silver films deposited on steel rotors 0.125 inch and 0.093 inch in diameter, respectively. It will be observed that the maximum tensile strength of the film is approximately constant down to thicknesses of about 2×10^{-5} inch, then markedly increases. For thicknesses greater than 2×10^{-5} inch the tensile strength is a little above the average of 18,200 lb/in.^{2} given in the tables[2] for annealed silver wire while for the films 2×10^{-5} inch thick, the minimum tensile strength measured was 104,000 lb/in.^{2}. For film thicknesses less than 2×10^{-5} inch, the tensile strength continues to increase.

It is well known[3] that very small fibers of glass and of some metals have higher tensile strengths than the bulk materials. Also, extremely thin films of mica are known to be very strong.[4]

The data of Fig. 1 show that an increased tensile strength also occurs in thin films of silver. An explanation of this increased tensile strength may possibly be found in the greater ease with which the "dislocations" can move to the surface if the film is very thin.

The values of the adhesion A obtained from the data were independently checked by electro-depositing the silver only on regions of the rotor surface small enough to eliminate the "hoop" strength and then by determining the rotor speeds at which they were thrown off. Although the data so far obtained are not conclusive, there is an indication that the adhesion of the silver film increases when the thickness is reduced below 10^{-5} inch.

* Supported by the Navy Bureau of Ordnance.
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[2] *Metals Handbook*, Am. Soc. Metals (1948).
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Difference in Viscosity of *Ortho-* and *Para*-Hydrogen at Low Temperatures

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THE cross section for the collision of two molecules depends, according to the quantum-mechanical theory of Massey and Mohr,[1] on whether or not the colliding particles are distinguishable. In the case of H_2, Halpern and Gwathmey[2] have defined two molecules to be distinguishable if, having the same electronic and vibrational eigenfunctions, they differ in their rotational or nuclear spin eigenfunctions. Under these assumptions Halpern and Gwathmey calculated the difference in viscosity at low temperatures for normal hydrogen (25 percent $p-H_2$ content) and hydrogen with another composition. For normal hydrogen and pure *para*-hydrogen, e.g., they predicted a relative difference of the order of several percent at 70°K. The gas with the lower $p-H_2$ content is expected to have the larger viscosity. The authors believe that it is possible to confirm their theoretical results from measurements of thermal conductivity made by Bonhoeffer, Harteck, and Farkas in a temperature region in which the rotational heat of the two modifications is still effective.

We have compared the viscosity of normal hydrogen (η_n) with that of hydrogen of variable $p-H_2$ content (η) using a bridge-arrangement. The results are given in Fig. 1. Our experimental viscosity-difference has the sign opposite to that predicted by Halpern and Gwathmey in the entire range of temperature and composition under consideration. The amount is smaller by about a factor of ten. Details will be given in the Zeitschrift für Physik.

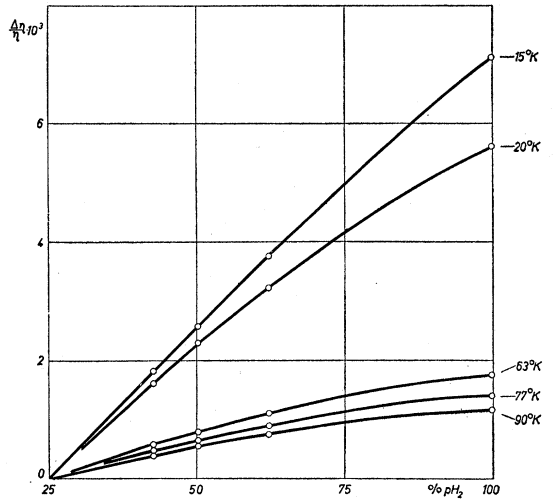

FIG. 1. Relative viscosity difference $\Delta\eta/\eta=\eta-\eta_n/\eta$ of hydrogen with variable $p-H_2$ content and normal hydrogen (25 percent $p-H_2$).

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[2] O. Halpern and E. Gwathmey, Phys. Rev. **52**, 944 (1937).

Some Data on the Elastic Scattering of 18.3-Mev Protons*

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AN attempt has been made to measure the absolute differential cross section for elastic scattering of 18.3±0.1 Mev protons by Al, Fe, Ni, Cu, Ag, Sn and Pt. Burkig and Wright[1] have previously obtained relative cross sections for 18.6-Mev protons on Al, Ni, Pd and W.

The present scattering experiment was carried out in a 12-in. chamber which was constructed with exit ports at 30°, 60°, 90°, 120°, 150° and 165° to the incident beam. A NaI(Tl)-scintillation counter can be placed in front of these.[2] The solid angle is defined by a ground hole of $\frac{1}{4}$ in. in the glass reflector over the scintillator and its distance of 23.1 cm to the center of the chamber. A rotating and retractable foil holder also carries a fluorescent screen which enables one to align the chamber and to focus the beam. The beam spot is slightly over 1 cm wide and 3 mm high.

TABLE I. Elastic scattering cross section in millibarns/sterad for 18.3-Mev protons.

Lab angle	30°	60°	90°	120°	150°	165°
Al	187±20	47±4	8.7±0.7	8.7±0.7	4.5±0.5	4.9±0.5
Fe	310±30	28±3	11 ±2	2.5±0.3	3.2±0.4	2.5±0.6
Ni	390±30	30±3	15 ±2	2.8±0.3	3.9±0.4	3.6±0.6
Cu	480±30	21±2	18 ±2	4.3±0.4	3.8±0.4	3.5±1
Ag	1480±100	73±5	6.5±0.6	4.2±0.5	3.0±0.4	3.0±0.5
Sn	1800±150	91±10	11 ±0.6	4.5±0.6	3.5±0.5	3.2±1
Pt	4300±300	170±10	35 ±1	11.5±0.6	4.2±0.4	4.0±0.5

The protons are collected in a graphite Faraday cup which is connected with a polystyrene condenser on which the voltage is measured with a quadrant electrometer.

To record the scattered protons a technique had to be employed which separated the elastic line from the inelastic scattering. This was done by measuring the high energy end of the pulse spectrum with a ten-channel discriminator. The channel width was 2 volts and the maximum pulse height 80 volts. At 30° inelastic scattering is negligible relative to the elastic scattering. Hence, the shape of the measured 30° elastic peak was used to correct the large angle curves of which the shape is distorted by inelastic scattering. It is, of course, possible to separate the elastic scattering only so long as the low lying levels and the ground state have a separation comparable to or larger than the resolving power of the detector. The 30° peak had a width at half-maximum between 3 and 5 percent for different detectors.

The results of these measurements are presented in Tables I and II. For Al and Pt, measurements were also carried out with the energy of the protons reduced to 15.5±0.2 Mev.

TABLE II. Elastic scattering cross section in millibarns/sterad for 15.5-Mev protons.

	30°	60°	90°	120°	150°	165°
Al	225±20	37.8±4	10.5±1	9.5±1	9.6±1	9.3±1
Pt	7200±500	325 ±20	65 ±5	17.2±1	9.5±0.6	7.4±1