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region have been given in a previous report.[1] The present paper will describe a series of performance tests of the photon counter in connection with attenuation measurements in the spectral range mentioned in the title. Data taken under a variety of counting conditions dealing with such parameters as source intensity, interdynode voltage, and amplifier gain will be presented and discussed. A summary of the data on the absorption coefficients of chromium and copper at $\lambda = 180$ A amply confirm the *a priori* expectation that a unique value of the absorption coefficient should result from measurements obtained under a variety of experimental conditions.

* Supported by the Office of Naval Research.
[1] D. E. Bedo and D. H. Tomboulian, Bull. Am. Phys. Soc. Ser. II, 4, 419 (1959).

W4. Stock Prices as Brownian Motion in a Periodic Lattice. M. F. M. Osborne, *U. S. Naval Research Laboratory.*—Since the normal distribution which characterizes Brownian motion[1] can arise in a great variety of stochastic processes, it is necessary to examine the "microscopic" details of such processes in order to distinguish them. Histograms of closing prices with respect to eights reveal a characteristic clustering at integers, halves, quarters, and odd one-eights in descending preference, like the markings on a ruler. Maxima cluster on the low side of integers and half-integers, minima on the corresponding high side. Thus the diffusion of stock prices is akin to diffusion in a one-dimensional, diatomic crystal lattice. The over-all distribution has a fluted structure, like sand on a tilted washboard. This phenomenon is a microscopic demonstration of "resistance" and "support" and helps to explain the very small values of serial correlations of price differences.[2]

[1] M. F. M. Osborne, Op. Research 7, 807 (1959).
[2] M. G. Kendall, J. Roy. Statist. Soc. A116, 11 (1953).

W5. Inelastic Energy Loss in High-Energy Atomic Collisions.* Arnold Russek and Chong Kook Lewe, *The University of Connecticut.*—Recently, some experimental data has been obtained on the inelastic energy associated with the scattering of many electron atoms.[1] This was accomplished by an analysis of the recoiling target atoms. In collisions of Ar^+ on Ar and Ne^+ on Ar at 75 kev, both "hard" and "soft" secondaries were observed at a fixed angle of recoil of the target atom. An interpretation of this data is here considered via the introduction of two "coefficients of restitution" describing the changes (before and after the collision) in the magnitudes of the components of relative velocity parallel and perpendicular to the direction of relative motion at minimum nuclear separation, $e_{\parallel}$ and $e_{\perp}$. It is found that the angular distribution of scattered primaries is somewhat affected by the value of $e_{\perp}$. On the other hand, the angular distribution of scattered secondaries is hardly affected by $e_{\perp}$ at all, but is critically dependent on $e_{\parallel}$. From the relative numbers of soft to hard secondaries at a given recoil angle, information can be obtained about the behavior of $e_{\parallel}$ and, therefore, of the inelastic energy as a function of impact parameter.

* Supported in part by a grant from Ramo-Wooldridge.
[1] V. V. Afrisomov and N. V. Federenko, Zhur. Tekh. Fiz. 27, 2557 and 2573 (1957).

W6. Thermodynamic Functions of Thermosetting Polymers. M. C. Petree, *U. S. Naval Ordnance Laboratory.*—The specific heat of seven amorphous thermosetting polymers has been measured as a function of temperature from 25 to 160°C.[1] The polymers were epoxides, a polyamide-epoxide copolymer, diallyl phthalate, and a polyester. The specific heat curves revealed four glass transitions. The corresponding entropy curves exhibit small changes in slope at the glass transition temperatures. Enthalpy plots were straight or slightly curved. Plotting the slope of the entropy curve (C_p/T) offers a sensitive way of locating the glass transition temperature, but is little better than the C_p curve itself. The data may be useful to those engaged in deciding whether the glass transition is kinetic in nature or is a thermodynamic second-order transition.

[1] R. W. Warfield, M. C. Petree, and P. Donovan, Naval Ordnance Lab. Rept. 6255.

W7. Magnetically Suspended Molecular Pump Rotors.* J. W. Beams and C. E. Williams, *University of Virginia.*—Magnetically supported rotors have been used in molecular pumps[1] to produce very high vacua. The rotors are made of alloy steel and the stators of nonmagnetic stainless steel, aluminum alloy, or copper. The vacuum chambers are made of glass or of stainless steel. The supporting electromagnet is situated outside and above the vacuum chamber. The entire pumping system may be baked out. The rotor is driven by a rotating magnetic field produced by field coils outside the vacuum chamber. With pressures below 10^{-6} mm Hg in the high-pressure inlet the rotor drive may be removed after reaching operating speed for the rotor will coast during the remainder of the usual pumping period. The use of small magnetically suspended rotors as absolute pressure gauges for very low pressures will be discussed.

* Supported in part by U. S. Navy Bureau of Ordnance.
[1] J. W. Beams, Science 130, 1406 (1959).

W8. New Method for Measuring Sputtering in the Region Near Threshold. Daniel McKeown, *Convair (Astronautics) Division, General Dynamics Corporation.*—In a recently constructed molecular beam apparatus a new low-level sputtering erosion gauge has been tested. The gauge consisted of a 10-Mc, gold-plated, quartz oscillator whose frequency was sensitive to the removal of substantially less than 10^{-6} g of gold. The gold plating was sputtered from the crystal by a singly charged argon beam at normal incidence. The beam energy was varied between 0 and 100 ev. Its intensity was 3×10^{-6} amp cm^{-2}. Since the sensitivity of the gauge is very high, sputtering rates were determined by measuring the increase in crystal frequency after only 30 sec in the beam. Rates for other metals or for nonmetals can be measured by using them to plate or overplate the crystal. The gauge has been used as a detector of neutral particles whose energy was above the threshold of sputtering. The process of deposition of the beam on the crystal can also be detected by a corresponding frequency decrease.

W9. Construction of Large Metal Ultra-High Vacuum Systems, Using Oil Diffusion Pumps and Neoprene Rubber Gaskets. I. Farkass and J. C. Simons, Jr., *National Research Corporation.*—Construction of large metal ultra-high vacuum system, with volumes ranging from ten liters to several hundred thousand liters, capable of pressures in the 10^{-10} mm Hg range is described. Use of high-speed oil diffusion pumps, only liquid nitrogen cooled cryogenic surfaces, and baking at 200°C to reach these low pressures is discussed. A description is given of an easily demountable, neoprene rubber O-ring seal which has been used successfully in the 10^{-10} mm Hg range. Experimental evidence is cited that, contrary to earlier reports, oil diffusion pumps maintain their pumping speeds well below 10^{-8} mm Hg.

W10. Ultra-High Vacuum Systems for Space Simulation and Surface Investigations in the 10^{-10} mm Hg Range. J. C. Simons, Jr., E. S. Candidus, and I. Farkass, *National Research Corporation.*—With the methods described in the previous abstract, large metal ultra-high vacuum systems were built. Electrical feed-throughs, windows, gauges, and rotary seals were connected to a 47-cu ft and to a 3-cu ft volume system. Application of these tools to space simulation problems and to investigation of surface behavior will be discussed. Data on creep-rupture experiments intended to measure surface influence will be presented.

W11. Escape Mechanisms for the Lunar Atmosphere.* S. F. Singer and E. J. Öpik, *University of Maryland.*—Because of the moon's low gravitational potential it is generally assumed that all light gases escape but that krypton and xenon are retained over times long compared to the age of the moon and accumulate an atmosphere of several mean-free-paths' thickness. We find, however, that Xe and Kr will escape when we consider that photoionization halves the effective molecular weight. This conclusion must be modified if the moon's magnetic field exceeds the interplanetary field. However, a more powerful ejection mechanism exists for an atmosphere which is very thin, essentially an exosphere, as a consequence of the assumption that the moon is positively charged due to solar uv photons. We note that a gas atom in describing a ballistic orbit starting at the moon's surface has a finite probability of being photoionized. If this occurs on the upward portion of the trajectory, the resulting ion is expelled electrostatically. The magnitude of the effect depends in detail on the relation between screening distance of the lunar surface charge to average altitude of the ballistic orbit. However, under most reasonable assumptions and even in the presence of a magnetic field the mechanism is fast enough to get rid of all gas atoms evolving from the moon's interior.[1]

* Supported by the U. S. Air Force Geophysical Research Directorate.
[1] W. F. Edwards and L. B. Borst, Science 127, 325 (1958).

W12. Formation of D, Li, Be, and B in an Expanding Universe.* Ralph A. Alpher, *General Electric Corporation,* James W. Follin, Jr., *Applied Physics Laboratory, The Johns Hopkins University,* and Robert C. Herman, *General Motors Research Laboratory.*—We have integrated the differential equations for light element abundances in the expanding cosmology previously described.[1] We included all exothermic reactions and estimated cross sections where no measurements on the direct or inverse reactions exist. At 200 sec ($kT = 29$ kev) synthesis is essentially complete. The corresponding nuclear density for best fit is approximately 2.5×10^{17}/cc and the abundances are all $1.5\pm20\%$ of present measurements relative to hydrogen. This indicates that $\frac{1}{3}$ of the solar system matter has been formed into stars, modified by proton reactions, and ejected into space.

* This work was partially supported by a Bureau of Naval Weapons, Department of the Navy contract.
[1] R. A. Alpher, J. W. Follin, Jr., and R. C. Herman, Phys. Rev. 92, 1347 (1953).

W13. Physical Conditions in an Expanding Universe at Galaxy Formation and at Present.* James W. Follin, Jr., *Applied Physics Laboratory, The Johns Hopkins University.*—As the universe expands adiabatically from the conditions for nuclear synthesis,[1] the matter cools with $\gamma = 5/3$ and the radiation with $\gamma = 4/3$. Compton scattering maintains equality of matter and radiation temperatures until hydrogen neutralization. At $T = 1000$°K ($t = 5\times10^5$ yr and $n = 30$) recombination starts and proceeds to 99% completion. The neutralization is limited by radiative capture rates and trapping of resonance radiation. The trapped Lyman α radiation is released as a broad line which should be observable between 10 and 100 μ when looking toward intergallactic space. Experimental detection of this line will lead to significant information about the universe and details of its structure will be presented.

* This work was partially supported by a Bureau of Naval Weapons, Department of the Navy, contract.
[1] R. A. Alpher, J. W. Follin, Jr., and R. C. Herman, Bull. Am. Phys. Soc. Ser. II, 5, 287 (1960).

Wednesday Afternoon at 2:00

Continental Room

(M. A. Tuve presiding)

Neutron Physics I

WA1. Neutron Moderation to Low Temperatures. Lyle B. Borst, *New York University.*—The moderation of neutrons to low temperatures requires mechanisms only imperfectly understood. Neutrons have been moderated to 4°K in ice immersed in liquid helium. The Maxwell distribution shows an effective cross section for a $1/v$ absorber (indium) 8.5 times that of room temperature, almost precisely the inverse ratio of effective velocities. The moderation mechanism is thought to involve rotational transitions of the water molecule associated with a nuclear spin flip analogous to the ortho-para transition in molecular hydrogen. The estimated transition energy for a free gas molecule is 0.001/ev, 30% higher than on inelastic process observed by Hughes.[1] While rotational transitions are not observed in condensed systems by conventional spectroscopic methods, they have been detected in a dilute solution of water in a nonpolar solvent such as carbon tetrachloride.[2]

[1] D. J. Hughes, H. Palevsky, W. Kley, and E. Tunkelo, Phys. Rev. Letters 3, 91 (1959).
[2] L. B. Borst, A. M. Buswell, and W. H. Rodebush, J. Chem. Phys. 6, 61 (1938).

WA2. High-Resolution Fast Chopper Measurements.* W. C. Olsen and P. P. Singh, *Atomic Energy of Canada Limited Chalk River Laboratories,* and R. E. Chrien, H. Palevsky, and D. J. Hughes, *Brookhaven National Laboratory.*—The 90-m flight path for the joint BNL-AECL fast chopper program at Chalk River has been completed recently and put into operation. This installation is intended for use in high-resolution neutron transmission measurements with a BNL-type fast chopper situated at the NRU reactor. Neutrons are detected with a BF_3 detector consisting of an array of 384 counters in a common gas atmosphere. Neutrons are timed by a modified version of the Brookhaven 1024-channel time analyser with punched tape output and automatic data plotting accessories. A net counting rate of 1 count per channel per min is obtained with 1-μsec channels at a chopper speed of 10 000 rps. This rate is comparable to that obtained at Brookhaven with a 20-m flight path. The over-all resolution, approximately 15 mμsec per m has been checked experimentally by examining resonances in Mn and U^{238}. The amount of overlap neutrons has been determined by using resonance and $1/v$ filters. The characteristics of the experimental system will be discussed and typical open beam spectra will be presented. It is expected that this facility will be especially useful for total neutron cross section measurements in the region from 100 ev to 10 kev.

* Work carried out under the auspices of the Atomic Energy of Canada Limited and the U. S. Atomic Energy Commission.

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