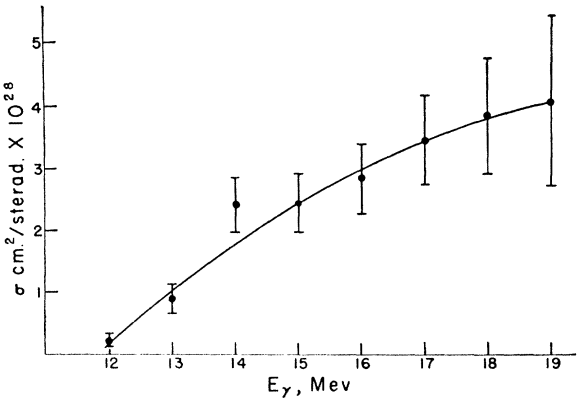

FIG. 3. Cross sections for proton emission at 90° as a function of γ-ray energy.

implied by the closeness of this value to the total photo-proton cross sections of neighboring elements determined by the radioactive-product method.[8]

With the threshold, the 90° cross section and the betatron intensity spectrum, the 90° excitation curve, calculated for a normal product nucleus, is shown in Fig. 3.

An upper limit to the neutron flux from the betatron was obtained in the heavy paraffin irradiation. Upper limits to Rh n-p cross sections at large and small angles were determined for 11–14-Mev neutrons, with coincidence proportional counters.[9] These values show that only a negligible fraction of our observed protons could come from an n-p reaction.

We take pleasure in acknowledging our indebtedness to Colonel C. R. Dutton of Picatinny Arsenal for permission to use the betatron and to Dr. B. A. Lloyd of the Arsenal for invaluable aid.

* Research carried out at the Brookhaven National Laboratory under the auspices of the AEC.

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A Delayed Coincidence Counting Measurement of $Hg^{203,205}$*

DANIEL BINDER
Sloane Physics Laboratory, Yale University, New Haven, Connecticut
December 5, 1949

AN attempt has been made to measure the half-life of the γ-ray in the beta-gamma-cascade emission from $Hg^{203,205}$ by a delayed coincidence measurement. The experimental arrangement makes use of a proportional counter as the beta-ray detector and a 931A photo-multiplier tube with an anthracene crystal as the gamma-detector. A resolution curve for the detectors and coincidence circuits was obtained by sending beta-rays from a P^{32} source through the proportional counter into the anthracene scintillation counter. The resulting plot of coincidence counting rate *versus* delay (placed in either channel) resulted in a symmetrical curve with a half-width of 7×10^{-8} sec.

The $Hg^{203,205}$ source was placed between the two counters with an absorber to stop the beta-rays from entering the scintillation counter and a similar curve taken. A compilation of two runs is shown in Fig. 1, and the curve is quite symmetrical. An upper limit for the half-life may be obtained by using theoretical expressions[1] for the coincidence *versus* delay curves. Increasingly larger

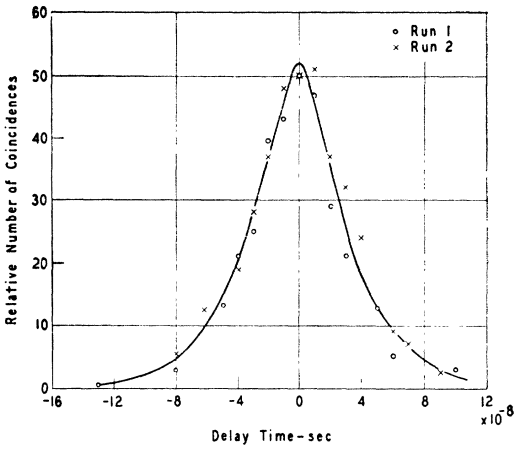

FIG. 1. Coincidence counting rate *versus* delay curve for the $Hg^{203,205}$ decay.

values for the half-lives were inserted in these expressions until a distinct asymmetry appeared in the curve. This occurred at 2×10^{-8} sec., which is then the upper limit.

From the work of Inghram, Hess, and Hayden,[2] the observed activity is probably due to Hg^{203}. Using this fact and the γ-ray energy given by Saxon[3] in Segré's formula,[4] an upper limit for the l-change may be determined. For $\Delta l=2$, the computed half-life is 9×10^{-10} sec., and for $\Delta l=3$, 2×10^{-5} sec. The l-change is thus not greater than 2, in agreement with Saxon's value[3] of 2 from the ratio of K and L conversion coefficients.

The author would like to thank Professors E. C. Pollard and H. L. Schultz for valuable discussions and Mr. F. G. Timperley for technical assistance.

* Assisted by the Joint Program of the ONR and the AEC.

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Coherent Neutron-Proton Scattering by Liquid Mirror Reflection*

D. J. HUGHES
Brookhaven National Laboratory, Upton, Long Island, New York
AND
M. T. BURGY AND G. R. RINGO
Argonne National Laboratory, Chicago, Illinois
December 7, 1949

THE importance of the coherent scattering of slow neutrons by protons in the determination of the range of nuclear forces has been emphasized recently by Blatt,[1] Blatt and Jackson,[2] and Bethe.[3] These authors show that the main uncertainty in the determination of the singlet as well as the triplet n-p range is the coherent n-p scattering. The coherent scattering has been measured with an accuracy of three percent in the parahydrogen experiment[4] and slightly less accurately by the scattering from hydrogen in crystals.[5] The former experiment contains a possible additional systematic error caused by the presence of orthohydrogen and the latter experiment possesses the uncertainty of the correction for temperature diffuse scattering (which lessens the observed coherent scattering). About a year ago, when plans for a repetition of the parahydrogen measurement were being considered, Hamermesh[6] and Wattenberg suggested that the coherent hydrogen scattering might be measured with the neutron mirror techniques then in use at Argonne Laboratory.[7,8] Hamermesh pointed out that the coherent scattering amplitude could be obtained from the critical angle of a hydrogen mirror with no theoretical uncertainty (no effect of inelastic scattering because only forward scattering is involved in glancing reflection), but

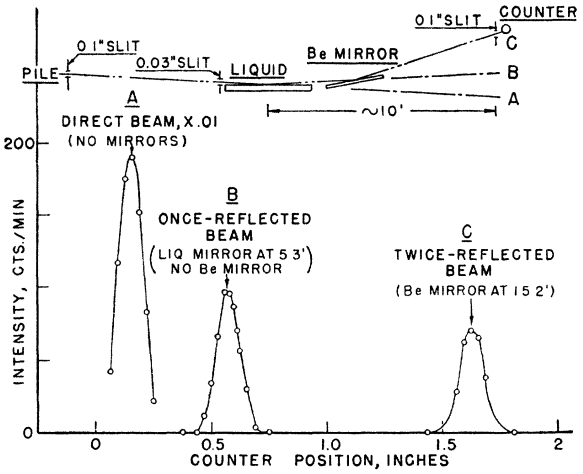

FIG. 1. Experimental arrangement of mirrors and the variation of the beam intensity with counter position.

that an accuracy of one percent in the amplitude would require measurement of a 10′ critical angle to 0.05′. Because of the difficulty of such an experiment, no plans for its performance were made.

Recently, however, we have devised a method which gives the coherent hydrogen amplitude very exactly with only a moderately accurate measurement of the critical angle. In this method, neutrons are specularly reflected from tri-ethyl benzene, a liquid containing a hydrogen to carbon ratio of 1.5 ($C_{12}H_{18}$). This compound is chosen because the (positive) amplitude of carbon is slightly greater than 1.5 times the (negative) amplitude of hydrogen. The critical angle, θ_c, for neutron reflection from the liquid is then proportional to $(a_C+1.5a_H)^{\frac{1}{2}}$, and a certain error in θ_c implies a much smaller error in a_H (approximately $\frac{1}{10}$th the error in θ_c for tri-ethyl benzene). If the two amplitudes are balanced more closely by changing the C−H ratio, the required accuracy in the critical angle becomes even less, but the angle would be so small that its measurement would not be feasible. With a carbon to hydrogen ratio of 1.5 and the previously accepted value for a_H, a critical angle of 6′ for a neutron wave-length of 8A was expected.

In spite of many misgivings, it proved to be extremely simple to reflect neutrons from the liquid surface. A thermal neutron beam (obtained from the Argonne pile) was collimated by 0.1-in. slits 10 ft. apart, and was incident on the liquid surface at an angle of 5.3′, as measured by the position of the reflected neutron beam relative to the direct beam (Fig. 1). The incident neutrons contained all the wave-lengths of the Maxwell distribution, hence all wave-lengths longer than the wave-length, λ_c, whose critical angle is 5.3′, were reflected. In order to measure λ_c, the beam of neutrons leaving the liquid was in turn reflected at a Be mirror. The intensity reflected by the Be mirror remains constant until the angle of incidence reaches the Be critical angle for the wave-length λ_c. The critical angle for the Be mirror as a function of wave-length had already been determined with monochromatic neutrons, hence λ_c could be obtained from the observed Be critical angle. As a second method of obtaining λ_c the transmission of the reflected neutrons in a standardized plate of gold was measured and λ_c calculated from the transmission and the known (Maxwellian) velocity distribution. The angle of incidence at the liquid mirror was then changed and the new λ_c measured again by both methods.

The critical wave-length, λ_c, for a particular angle, θ_c, at the liquid mirror then gives the amplitude $(a_C+1.5a_H)$:

$$\theta_c=\lambda_c[N(a_C+1.5a_H/\pi]^{\frac{1}{2}},$$

where N is the number of C atoms per cm³. The value of a_C is known to 0.5 percent from total cross-section measurements at energies slightly above thermal[9] and is taken to be 6.63×10^{-13} cm (corresponding to a free atom cross section of 4.7 barns). The value for a_H then becomes

$$a_H=-(3.75\pm0.03)\times10^{-13}\text{ cm}.$$

The standard error, 0.9 percent, is based on the statistics of the present measurement alone and does not include the (smaller) uncertainty in the carbon amplitude. Although there is no known source of systematic error, the measurement could be repeated with a different liquid to lessen the possibility of unknown errors and to push the accuracy even higher. Our result is five percent lower than the value of the hydrogen amplitude obtained in references 4 and 5 and is outside the error of those experiments as quoted by Blatt and Jackson[2] and Bethe.[3]

The changes in the nuclear force constants which will result from the present experiment can be estimated roughly from the curves given by Blatt, and Blatt and Jackson. From Fig. 2, reference 1, and Fig. 7, reference 2, it is seen that the new value of the hydrogen amplitude will raise the triplet n-p range to 1.71×10^{-13} cm and produce an increase in the singlet range of about 1×10^{-13} cm. This change in the singlet range is about half the amount needed to make the n-p range equal to the p-p range. Errors which are involved in the other constants necessary to infer the ranges may well make up the rest of the difference and thus attain consistency of the experimental constants with charge-independence of nuclear forces.

We wish to extend our thanks to Dr. R. Dodson, H. Prosser, and R. C. Anderson of the Brookhaven National Laboratory Chemistry Department for the purification of the tri-ethyl benzene, to Dr. M. Hamermesh for valuable help in the planning and analysis of the experiment, and to Dr. A. Wattenberg for his assistance while the measurements were being made at Argonne Laboratory.

* Work performed under the auspices of the AEC.
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Interatomic Distances in CF_3Br, CF_3I, and CF_3CN*

JOHN SHERIDAN** AND WALTER GORDY
Department of Physics, Duke University, Durham, North Carolina
December 2, 1949

INVESTIGATIONS of the microwave spectra of CF_3Br, CF_3I, and CF_3CN have been made which allow a partial determination of the structures of these molecules. Attempts are being made to obtain molecules with other stable isotopes concentrated so that an unambiguous assignment of the atomic distances can be made.

$C^{12}F_3Br^{79}$ and $C^{12}F_3Br^{81}$.—Measurements of the $J=8\rightarrow9$, $10\rightarrow11$, and $11\rightarrow12$ transitions have been made. The analysis of the hyperfine structure is incomplete. The moments of inertia I_B are 399.9×10^{-40} g/cm² for CF_3Br^{79} and 403.7×10^{-40} g/cm² for CF_3Br^{81}. If tetrahedral bond angles to the carbon are assumed, the distance $d_{CF}=1.32_6$A and $d_{CBr}=1.93_3$A are obtained. These are in close agreement with the corresponding values in fluoroform,[1] $d_{CF}=1.326$A, and in methyl bromide,[2] $d_{CBr}=1.936$A. The CF distance is considerably smaller than the added covalent radii[3] (1.51A), while the CBr distance is, within experimental error, equal to the added covalent radii (1.94A) of C and Br.

CF_3I.—The $J=14\rightarrow15$ and $11\rightarrow12$ transitions were observed for CF_3I. Analysis of the hyperfine structure has not been completed. The moment of inertia I_B is equal to 551.0×10^{-40} g/cm². If tetra-