ω or Q is the mean value. In this way, considerations of range and energy do not need to be explicitly included. Figure 3 shows $P_1(M)$ for the arc-chord differences, for three different average values of M; M is in units of the electron mass. Figure 4 shows $P_2(M)$ for the sums of squares of chord angles. Figure 5 shows $P_3(M)$ calculated for the *uncorrelated* probability for 20 chord angles with 21 segments. The result will be slightly broader if the correlation were taken into account.

The arc-chord difference is certainly a less precise measure of the scattering. However, the overlap of the curves in each graph shows the difficulty in using multiple scattering as an indication of the mass of the particle, and indicates the extent to which especially large or small observed values of ω or Q can eliminate, respectively, a large or small mass value from consideration. The separate chord-angle method can serve to distinguish between protons and mesons in most, but not all cases, which the arc-chord difference cannot do as well. Neither method has any reliability for distinguishing meson masses closer even than the values used in preparation of the figures.

* Research carried out at Brookhaven National Laboratory under the auspices of the AEC, while the author was on summer leave from Smith College.

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[2] W. T. Scott, Phys. Rev. (to be published).
[3] A. H. Heatley, Trans. Roy. Soc. Canada **37**, 13 (1943).

Scattering of Slow Neutrons by Deuterium Gas

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PHYSICAL intuition is often considered of little use as a guide to the outcome of computations based on quantum-mechanical formulas. Here is an instance of an elaborate computation which finally led to results very similar to those obtained from a simple picture, a fact probably not to be surmised from inspection of the original formulas.

It is well known that slow neutron scattering experiments in deuterium gas can give information on the neutron-deuteron interaction.[1]

Only the total cross section has been considered so far as the calculation of the differential cross section requires involved transformations from the center of mass systems to the laboratory system, owing to the thermal velocities of the molecules.

A relatively simple method of calculation in which this effect is accurately taken into account has been devised by the writer, and is being used to compute the angular distribution in the laboratory system of monokinetic neutrons of energy 0.07 ev scattered by deuterium gas at a temperature of 90°K.

Two points of general interest have arisen as a result of these computations:

(1) Although $kT\sim\frac{1}{10}$th of the incident neutron energy for the figures quoted, the assumption of molecules initially at rest would lead to relatively small errors in the computed differential cross section ($\sim$1 to 7 percent, although percentage corrections to individual transitions may be large), according to the results obtained so far, which are for angles of scattering in the laboratory of 30° to 120°.

(2) The computed curves closely resemble those obtained from a semi-classical picture in which the incident neutron is scattered by two deuterons at a fixed distance (0.74A) apart on an axis with fixed but random orientation,[2] provided relative changes of phase on scattering by the two scatterers of (i) 0 and (ii) π-radians are assumed. Thus, it was found that for each initial molecular rotational quantum number J (the computations covered $J=0$, 1, 2, 3), the contribution to the differential cross section due to all transitions to final states of the same parity, had the form of curve (i), while for parity change the contribution had the form of curve (ii).

The respective quantum-mechanical curves follow closely the semi-classical curves for angles of observation (lab. system) around 30°, but fall off from the latter with increasing angle of observation to approximately $\frac{2}{3}$ of the semi-classical value at 180°.

Analytically, the quantum-mechanical formulas become identical with the semi-classical ones described above if the energy lost or gained by the neutron in the various molecular transition is treated as negligible, which, in fact, of course, is far from being the case. The same result is not obtained by neglecting the mass of the neutron compared with that of the molecule, since if we do this there is no recoil of the deuterium molecule, and the results then differ widely from the correct quantum-mechanical results.

The two methods of calculation (quantum and semi-classical) would however be expected to yield identical results for those diatomic molecules whose masses are, in fact, large compared to that of the neutron,[3] but the relatively good agreement for deuterium is perhaps surprising.

These calculations, together with graphs exhibiting the dependence of the various partial cross sections on angle of scattering, will be published in due course by the National Research Council of Canada.

[1] M. Hamermesh and J. Schwinger, Phys. Rev. **69**, 145 (1946).
[2] See Section 4 of the paper by E. Fermi and L. Marshall, Phys. Rev. **71**, 666 (1947).
[3] N. Z. Alcock and D. G. Hurst, Phys. Rev. **75**, 1609 (1949).

Observations on the Blood of Cyclotron Workers

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ATTENTION is called to the finding of two types of unusual cells in the blood of personnel of the 130-in. cyclotron at Rochester, New York. These, are, respectively, very early mononuclear cells and cells which appear to be lymphocytes with bilobed or double nuclei. These cells, particularly the latter, occur in very small numbers, and it has been necessary to inspect several thousand leukocytes from each person in order to be assured of the finding. The "early mononuclear cells" are large (approximately 18–20μ in diameter), peroxidase negative, have deeply basophilic cytoplasm, and no nucleoli. The "lymphocytes with bilobed nuclei" tend to be somewhat larger than typical large lymphocytes. The nuclei stain slightly lighter than the nuclei of the other lymphocytes but are similar in consistency and have no nucleoli. The cytoplasm is clear, basophilic, peroxidase negative, and commonly contains a few typical azurophilic granules.

Both kinds of cells have been found in individuals not associated with the cyclotron who have abnormal blood smears due to infections, specifically in several cases of infectious mononucleosis and in one case of acute pharyngitis due to Hemolytic H. Influenza. There is, however, no indication that the findings in cyclotron personnel are due to infections.

Early mononuclear cells are occasionally found in routine films of "normal blood," however, lymphocytes with bilobed nuclei have not, to our knowledge, been described previously, and it is felt that they represent a true departure from the usual or normal blood picture. Although it is not possible to draw any conclusions relative to the significance of these cells as indicators of radiation damage, the findings may conceivably have such significance, and are presented at this time so that they may come to the attention of responsible individuals associated with cyclotrons in other institutions.

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