LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twentieth of the preceding month; for the second issue, the fifth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

The Near Infrared Spectrum of MgO

Quite recently it has become possible to obtain single crystals of MgO as large as $3\times4\times0.5$ cm. These crystals are highly transparent to visible light, are quite hard and have much the appearance of glass. They are cubic crystals of the NaCl type, and may be cleaved quite easily, the cleavage surfaces being very plane and possessing a high degree of polish. Surfaces prepared in this manner require no further grinding or polishing before being used, and are very resistant to the effects of water, acids, heat, etc.

Since they are cubic in their structure, these crystals should, according to the classical theory of crystal structure possess only one absorption frequency in the infrared. Due to the high degree of symmetry of a cubic lattice, the overtones of this frequency should not appear, leaving the infrared spectrum extremely simple. Czerny and Barnes.[1] however upon examining other cubic crystals and in particular the alkali halide crystals, observed in every case several secondary absorption maxima upon the short wavelength side of the fundamental. The unexpected occurrence of these maxima was later explained by Born and Blackman[2] in a paper entitled *Über die Feinstruktur der Reststrahlen*, as being due to a slight, hitherto neglected anharmonicity of the forces existing between the atoms of the crystal. In view of the possible existence of such secondary maxima in MgO, the short wavelength side of the fundamental of these new crystals is of particular interest.

Using a rocksalt spectrometer the transmission curves for 5 thicknesses of MgO ranging from 3.05 mm to 0.075 mm were measured from 1μ to 16μ. In agreement with the result found by Tolksdorf[3] on a thin layer of MgO powder, the fundamental was located at 14.2μ. In addition weak transmission minima (absorption maxima) were found around 10.8μ, 8.3μ and 7.0μ. These do not form harmonic ratios with the fundamental and are therefore assumed to be analogous to the bands discussed above. It is hoped that in the near future a complete discussion of a comparison of these observed values with those calculated according to the equations given by Born and Blackman may be presented. Each of the plates measured was approximately 85 percent transparent from 1μ as far out as 6μ, the entire losses being reflection losses.

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February 15, 1935.

[1] M. Czerny, Zeits. f. Physik **65**, 600 (1930); R. Bowling Barnes and M. Czerny, Zeits. f. Physik **72**, 447 (1931); R. Bowling Barnes, Zeits. f. Physik **75**, 723 (1932).
[2] M. Born and M. Blackman, Zeits. f. Physik **82**, 551 (1933); M. Blackman, Zeits. f. Physik **86**, 421 (1933).
[3] S. Tolksdorf, Berlin Dissertation, 1928.

Interaction of Low Energy Neutrons with Atomic Nuclei

A number of elements have been shown by Fermi and his collaborators to have remarkably high stopping power for the slow neutrons which are so effective in producing many types of artificial radioactivity. This letter is to report measurements of a different type on the stopping power, for slow and fast neutrons of a large number of elements, the stopping power being expressed in terms of the neutron-nucleus collision cross section, and especially to direct attention to the result that the cross section for the hydrogen nucleus is about 3.5 times that of the deuterium nucleus, although the two nuclei have about the same cross section when measured with high energy Rn-Be neutrons.

The Rn-Be source, contained in a platinum capsule and surrounded by 1 cm of additional lead to reduce the gamma-radiation, was placed in the center of a paraffin sphere of 6 cm radius, it having been found that this thickness of paraffin gave a sufficiently large number of slow neutrons,[1] and yet permitted fairly good geometrical conditions, as shown in Fig. 1. The slow neutrons were

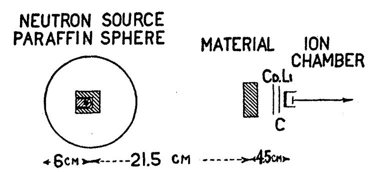

FIG. 1.

detected through the ionizing particles ejected by the neutrons from a layer of lithium placed in front of a shallow ionization chamber connected to an amplifier-recorder system.

The absorption and scattering of the neutrons was studied by interposing similar cylindrical samples of various materials in the path between the source and chamber. In order to separate out the effects of the slow neutrons from the fast neutrons, readings were taken with, and without a 1 mm thick Cd disk interposed. The Cd served as an effective slow neutron filter, absorbing practically all of the slow neutrons lying within its anomalous absorption region, but apparently had little effect on neutrons of higher (and possibly lower) energies. The number of recorded counts was reduced to about 35 percent when 1 mm of Cd was interposed, indicating that about 65 percent of the recorded neutrons were within the region strongly absorbed by Cd.

The results in Table I show the apparent neutron-nucleus cross sections, corrected approximately so as to

TABLE I. *Neutron-nucleus cross section for slow and fast neutrons.*

		Neutron-nucleus cross section $\times 10^{24}$ cm^{-2}	
Material	Atomic weight	Slow neutrons	Fast neutrons
H	1	13.3	1.68
D	2	3.4	1.71
Li	6.94	49	1.84
Be	9.02	3.8	1.65
B	10.82	600	1.60
C	12.0	2.8	1.65
O	16.0	3 est.	
F	19	<4	
Na	23	4.5	
Mg	24.3	2.5	
Al	26.97	1.9	2.4
Si	28.06	2.0	
P	31.03	7.2	
Cl	35.46	38	
K	36.1	34 est.	
Ca	40.07	<10	
Ti	48.1	<8	
Cr	52.01	7.4	
Mn	54.93	8.0	
Fe	55.84	7.8	3.0
Co	58.94	26	
Cu	63.57	5.9	3.2
Zn	65.38	3.6	3.3
Se	79.2	12	
Zr	91	17	
Sn	118.7	3.6	4.3
Sb	121.8	8	
I	126.93	10.1	4.6
Ba	137.37	100	
W	184.0	19	5.3
Hg	200.6	430	5.8
Pb	207.2	6.1	5.7
U	238.17	100	

express the cross-section value for those slow neutrons which disintegrate Li and are strongly absorbed by Cd. The results for high energy Rn-Be neutrons not slowed down by paraffin, from previous measurements,[2] are included in the last column. The corrections for the somewhat different geometrical conditions in the two sets of data have not yet been completely made, but measurements of the cross sections for high energy Rn-Be neutrons, using spheres of lead and copper instead of paraffin in the arrangement of Fig. 1, indicate that the high energy cross sections should be multipled by about 0.85 to make them correct relative to the slow neutron measurements. The nature of the measurements at this stage is such that the results, especially for the large absorptions, do not have much precision. We estimate that most of the smaller cross-section values are accurate to well within 10 percent, but the larger values within ± 25 percent.

While the variation of the cross section of nuclei in general with slow neutrons compared to fast neutrons will certainly be of theoretical significance, some elements having practically the same value (considering the geometric factors), others increased only slightly, and some increased enormously, probably one of the most interesting points in the table is the large increase in cross section of the proton compared to the deuteron.

The relative effects of H_2O and D_2O in enhancing the efficiency of neutrons in the production of artificial radioactivity in silver was tested by activating a strip of silver suspended above a Rn-Be source at the bottom of a test-tube, first in air, then immersed in 200 cc of H_2O, then in the same volume of D_2O (99.8 percent). The 2-min. period radioactivities obtained in air, H_2O and D_2O were respectively as 1, 2.0 and 6.5. Subtracting the direct effect in air, the enhancing effect of H_2O was 5.5 times that of D_2O.

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[1] Am. Phys. Soc. Bull., Feb. (1935).
[2] John R. Dunning, Phys. Rev. **45**, 586 (1934).

The East-West and Longitude Effects

In measuring the difference between the numbers of charged particles effecting a line of Geiger-Müller counters when it is tilted toward the west and then toward the east, the common practice is to rotate the line of counters about an axis normal to the equipotential gravitational surface at the location in which the experiment is being conducted. Now it has been shown in sea-level surveys by Clay[1] and by Millikan and Neher[2] that the variations in the surface magnetic field for the same geomagnetic latitude extend to sufficient heights to influence the charged particles coming in at the equator, giving rise to the "longitude effect." Our present surveys show this effect to be from 4 to 5 percent of the total intensity of the cosmic radiation at sea level. A glance at a map showing lines of equal horizontal intensity of the earth's magnetic field will show that these variations are quite large and extend over wide areas. As an example, on the coast of Peru where Johnson[3] and Korff[4] have studied the east-west effect, the horizontal intensity is 0.30 gauss while 8000 kilometers to the west it has increased to 0.35 gauss and has diminished to something like 0.28 gauss in the first 5000 kilometers to the east. These distances are of the same order as the radius of curvature of a charged particle which is just able to reach the earth's surface at this latitude and consequently will be influenced by these variations. A rough calculation shows that the surfaces of equal magnetic intensity in this region are tilted upward toward the west at an angle of several degrees. In order for the results of the east-west measurements to be interpretable, the axis of rotation of the counters must be more nearly normal to these surfaces of equal magnetic intensity. This means that the axis of rotation of the counters must be inclined *east* of the vertical.

Now it can easily be shown that the full east-west effect found by Johnson can be eliminated if the axis of rotation of the counters is tilted about two degrees west of the normal to the equipotential gravitational surfaces, and if the axis of the counters is set more nearly normal to the surfaces of equal magnetic intensity, this angle becomes two to four degrees in South America. The east-west effect then increases from six to eight percent to something like six to sixteen percent at sea level, the exact amount depending on the ratio of electrons to photons and the effect of the earth's atmosphere in absorbing each.