The Total Neutron Cross Section of Dysprosium and Neodymium

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STUDIES by Fermi and Marshall[1] of the order intensities of Bragg-reflected neutron beams for many substances show that the (111) plane of lithium fluoride is particularly well suited for neutron monochromator work since the reflectivity for high orders is relatively very small. Their measurements show that the second order contributes only about 0.1 percent of the first order intensity, and the third order about 4 percent for a neutron energy of $\sim$0.04 ev. In addition, the first order reflectivity is greater than that of the LiF(100) planes previously used[2,3] for energy dependent cross section measurements.

Such LiF(111) crystals have recently been used with the crystal spectrometer at the Argonne National Laboratory. Figure 1 shows the spectrum obtained from the heavy water pile with the (111) crystals as compared with that of the LiF(100) crystals formerly used. Neither of the spectra has been corrected for the effect of varying resolution, which is to shift the maximum of the distribution to higher energy. The resolution of the (100) crystals is slightly better, but the superiority of the reflectivity of the (111) crystals is obvious. The decreased high order reflectivity in the case of the LiF(111) crystals is evidenced by the sharper intensity decrease in spectrum measurements at large glancing angles for this crystal.

The cross sections of dysprosium and neodymium have been examined briefly in the region of low neutron energies with the new crystals. For dysprosium (Fig. 2) $\sigma\sqrt{E}$ is plotted against E; this would show a $1/v$ cross section as a horizontal line. In addition to the two resonance levels at 1.74 and 5.5 ev, there is evidence of a level at negative energy and of one at an energy higher than 20 ev. The sample was a pressed pellet of Dy_2O_3 of surface density 0.89 g/cm². No correction has been made for the small oxygen scattering cross section or for resolution of the instrument.

Neodymium was measured in the form of pressed pellets of Nd_2O_3 powder with surface densities between 5 and 18 g/cm². It was necessary to subtract 6.2×10^{-24} cm²/atom, $\frac{3}{2}$ the atomic oxygen scattering cross section, in the calculation of the total cross section of the neodymium atom. The

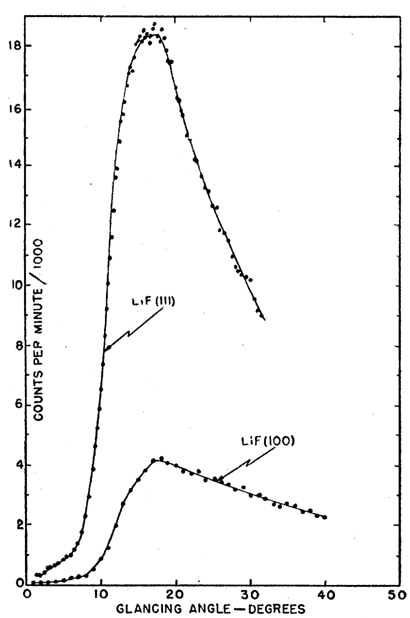

FIG. 1. Neutron spectrum.

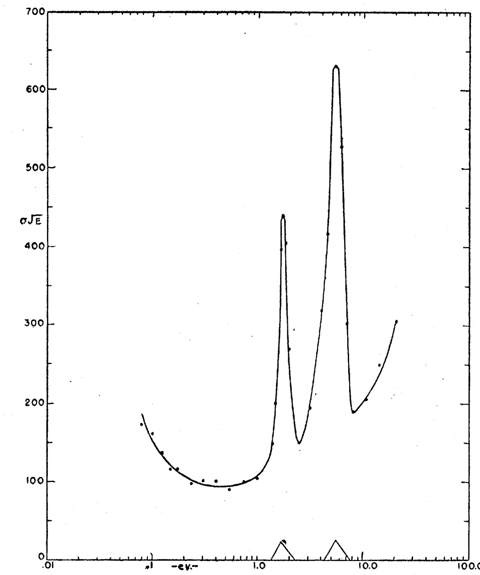

FIG. 2. Total cross section of dysprosium.

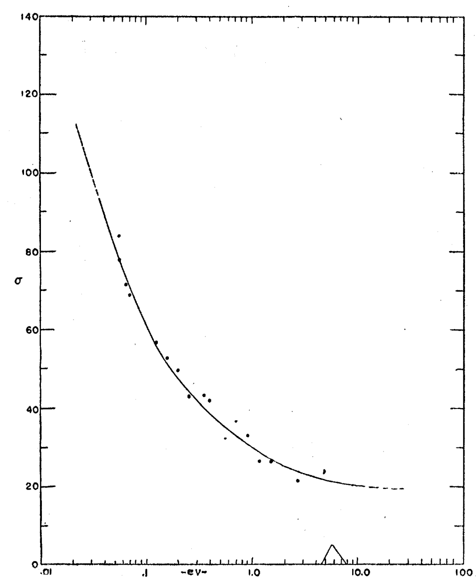

FIG. 3. Total cross section of neodymium.

results are shown in Fig. 3. A plot of σv (cross section $\times$neutron velocity) against E shows a marked rise with energy, indicating a large scattering cross section or a strong resonance level at higher energy. The curve becomes nearly horizontal if a constant value of 15×10^{-24} cm^2/atom is attributed to scattering, thus making the absorption cross section at 0.025 ev about 92×10^{-24} cm^2/atom. In the present measurement, however, much significance cannot be attributed to the value of the scattering cross section evaluated in this manner. Earlier measurements[4,5] at a single energy gave the absorption cross section for kT neutrons at about 75×10^{-24} cm^2/atom.

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[1] E. Fermi and L. Marshall, Phys. Rev. **70**, 103A (1946).
[2] W. H. Zinn, Phys. Rev. **70**, 102A (1946).
[3] W. J. Sturm and S. H. Turkel, Phys. Rev. **70**, 103A (1946).
[4] H. Bomke and H. Reddemann, Zeits. f. Physik **120**, 56 (1942).
[5] W. Riezler, Ann. d. Physik **41**, 476 (1942).

Temperature of the Upper Atmosphere

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According to Appleton[1] the penetration frequency, f, of a radio wave through an ionospheric layer at normal incidence is related to the maximum electron density of the layer thus, for the ordinary ray

$$N = kf^2. \tag{1}$$

Experimental values of f are determined through systematic observation at many places. From such experimental determinations N is readily found, and hence throughout the day dN/dt is available. From the well-known relationship

$$dN/dt = q - \alpha N^2 \tag{2}$$

between time rate of change of ionization, rate of electron production, q, and recombination coefficient, α, Appleton has argued that at night α may be found at once, since $q=0$. He has also suggested that across sunrise or sunset times, for equal values of N, both q and α may be determined on assumption of equal values of α. Such evaluations have been carried out by Mohler[2] and by Appleton[1] over limited time intervals. Furthermore, Appleton[3] has proposed that for times equally spaced either side of noon, q and α at these times may be considered approximately equal, and hence q and α may be found in the daytime.

In extending the earlier calculations I have evaluated q and α throughout the 24 hours for three typical latitudes during an equinoctial interval at sunspot minimum. The variations in α were quite interesting, and it appeared possible to get at the absolute temperature in the upper atmosphere by means of these values and use of J. J. Thompson's[4] relationship involving the recombination coefficient and absolute temperature at low pressures, i.e.,

$$\alpha = \alpha_0 (T_0/T)^3. \tag{3}$$

Reference values of α_0 and T_0 were decided upon after

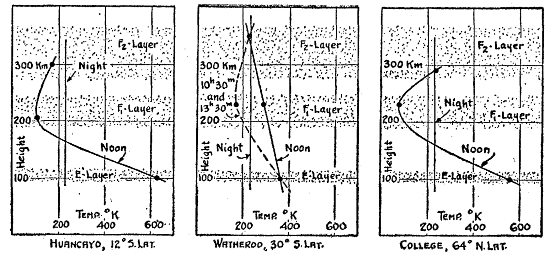

Fig. 1. Calculated relation between temperature and ionospheric height. The vertical line at 230°K represents the assumed night temperature, according to Vegard and Tönsberg.

examination of the work of Vegard and Tönsberg[5] who evaluated T_0 at about 230°K on the basis of studies of auroral spectra at Tromsø, Norway. This value for T_0 was used with the night value of α set equal to α_0 for each location. The assumption was made that $T_0 = 230$°K everywhere above 100 km in the early morning hours.

Noon values of T were found for Huancayo, Peru (12° S.Lat.), Watheroo, Western Australia (30° S.Lat.), and College, Alaska (64° N.Lat.), from CRPL published data[6] of f for these locations and the foregoing argument.

From Fig. 1 it appears that at E-layer heights of 100 km, high temperatures are to be expected, and that F_1- and F_2-layers (around 200 km and 350 km, respectively) may be at considerably lower temperatures. Apparently there is a remarkable variation in temperature in these regions of the atmosphere from night to day.

The Watheroo, Western Australia, temperatures in the F_1-layer go through a reversal in trend around $10^{\mathrm{h}}30^{\mathrm{m}}$ and again around $13^{\mathrm{h}}30^{\mathrm{m}}$ local mean time and so an additional calculation at these times has been made and indicated in the central group of the figure by a dotted line. Other detailed fluctuations in temperature around sunrise and sunset were found.

[1] E. V. Appleton, Proc. Phys. Soc., London **45**, 673 (1933).
[2] F. L. Mohler, Bur. Stand. J. Research **25**, 507 (1940).
[3] E. V. Appleton, Proc. Roy. Soc. **[A] 162**, 451 (1937).
[4] J. J. Thomson, *Conduction of Electricity Through Gases* (The Cambridge University Press, 1928), Vol. 1, p. 38.
[5] L. Vegard and E. Tönsberg, Geofys. Pub. Oslo (Norway) **11**, No. 2; **12**, No. 3, 1935.
[6] CRPL-*F* Series, Ionospheric Data, Nat. Bur. Stand., Washington, D. C.

Erratum: On the Disintegration of Negative Mesons

[Phys. Rev. **71**, 209 (1947)]

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In the letter to the Editor with the above title, Fig. 1, the block diagram of the registering set, shows the "delay" in a wrong place, that is between counters "C" and "coincidences III." Actually the "delay" must be understood to be between counters "A" and "coincidences III" and between counters "B" and "coincidences III." No delay is inserted between counters "C" and "coincidences III." For more details, see M. Conversi and O. Piccioni, Phys. Rev. **70**, 859 (1946).