

individual projectiles. Section II, Fig. 1 represents two reactions in which deuterons are involved, section II gives a behavior characteristic of atoms of higher atomic number in which a neutron is added and the nucleus does not immediately disintegrate, but exhibits radioactivity.

WILLIAM D. HARKINS

University of Chicago,
April 12, 1935.

- ¹ W. D. Harkins and S. L. Madorsky, Phys. Rev. 19, 136 (1922).
² W. D. Harkins, Phil. Mag. 43, 315 (1921).
³ W. D. Harkins and D. M. Gans, Phys. Rev. 46, 397 (1934).

The Seasonal Variation of Ionization in Region F₂ of the Ionosphere

In his recent letter¹ in this journal Dr. E. O. Hulburt refers to the measurements of noon maximum ionization in Region F₂ and states that there appears to be a discrepancy between the results obtained in different latitudes. It is my object in this letter to show that by means of a different interpretation of the published data the discrepancy can be satisfactorily removed.

If we reject the contention of Kirby, Berkner and Stuart² that critical frequency measurements merely indicate absorption phenomena and accept an interpretation³ of their electron-limitation significance in terms of a pronounced seasonal variation of molecular temperature, we are obliged to conclude that noon Region F₂ maximum ionization in temperate latitudes does not follow the expected seasonal variation and is actually slightly higher on a winter noon than on a summer noon. Dr. Hulburt correctly points out that if my interpretation on these lines is accepted there is a discrepancy between this result and other evidence. He refers in particular to the ratio (1.5 to 1.8) for summer to winter noon ionization, quoted by me in a general ionospheric discussion in London, and which was, in fact, calculated from Dr. Hulburt's own values of short wave "skipped distances." The discrepancy can therefore be narrowed down to the difference between the interpretation of critical-frequency measurements made with medium wavelengths at short distances and with short wavelengths at large distances. It means, briefly, that my interpretation of the local ionospheric measurements indicates that the maximum Region F₂ noon ionization is slightly less in winter than in summer, whereas Dr. Hulburt's "skipped distance" data indicate, as he himself has shown,⁴ that Region F₂ ionization is 1.5 to 1.8 times as great on a summer noon as on a winter noon.

It would be improper for me to question the accuracy of Dr. Hulburt's measurements of "skipped distances" were it not for the fact that other measurements of similar character, made by C. R. Burrows⁵ in America, yield entirely different results which are in good agreement with the local ionospheric measurements, in that the measured critical frequency is less on a summer noon than on a winter noon. It is true that Burrows interprets his results in terms of absorption-limitation, but if we regard both local and long-distance measurements as referring to electron-

limitation phenomena (as Dr. Hulburt and I agree that they should be) there is accord between the conclusions drawn from both sets of measurements.

It may not be superfluous to add that this discussion is restricted to *noon* measurements and not to the maximum value of ionization density which may be experienced throughout the whole of a summer or winter day.

E. V. APPLETON

Halley-Stewart Laboratory,
King's College, London,
March 23, 1935.

- ¹ Hulburt, Phys. Rev. 47, 422 (1935).
² Kirby, Berkner and Stuart, Bur. Standards J. Research 12, 16 (1934).
³ Appleton, Phys. Rev. 47, 89 (1935).
⁴ Hulburt, Phys. Rev. 31, 1018 (1928); 35, 240 (1930); 39, 977 (1932).
⁵ Burrows, Proc. Inst. Rad. Eng. 19, 1634 (1931).

Nuclear Magnetic Moment of Na²³

Through the courtesy of Professor Hartree we were supplied in the summer of 1933 with s.c.f. functions for Na⁺ and with series electron functions for 3s, 3p, 4p calculated by J. McDougall in collaboration with him. We computed then by means of these functions the expected ratio between the hyperfine structure interval factor a in cm⁻¹ and the nuclear moment μ in nuclear magnetons as well as the absolute value of the doublet splitting $\Delta\nu$ for the 3p and 4p terms.

The theoretical values of the gross doublet splittings disagree with experiment by roughly the same large factor by which the Hartree function result for the h.f.s. disagrees with the Landé-Fermi-Goudsmit formulas. These discrepancies were brought out in the symposium on nuclear moments¹ in June, 1934, and it was emphasized that in view of them one cannot be sure of the theoretical conclusions about the values of nuclear moments for any but the simplest atoms.

For 3s, by taking into account only the energy of the series electron in the central field, the effective quantum number $n^* = 1.75$ as compared with 1.63 experimentally. Correcting for interaction with inner shells as has been done by McDougall,² we obtain a theoretical $n^* = 1.68$. The difference between this and 1.63 is small and the difference between the Landé-Fermi-Goudsmit result and the theoretical one is therefore significant. For 3p the theoretical $n^* = 2.26$ and the experimental = 2.12. It is vital to orthogonalize the series electron functions to the core functions in computing μ and $\Delta\nu$ because $1/r^3$ and $(1/r)(dV/dr)$ are sensitive to the amplitude of the functions at small r . The factor due to this correction is approximately 14 for 3p.

The effects discussed should similarly be sensitive to perturbations by configurations involving excitation of core electrons. A calculation of the first-order effect of a perturbation of (2s)²(3p) by (2s)(3s)(3p) changes the theoretical h.f.s. value by about 8 percent and is not sufficient to matter materially. Similarly the effect of (2p)⁵(3p)² on (2p)⁶(3p) is appreciable but not sufficient to bring about agreement. Effects on h.f.s. due to the first power of