$$\overline{\overline{H}}'=Q^{-1}\overline{H}'Q, \qquad H'=R^{-1}\overline{\overline{H}}'R,$$

where
$$Q=\cos\tfrac{1}{2}\omega t-i\sigma_Z\sin\tfrac{1}{2}\omega t,$$
$$R=1+\tfrac{1}{2}\omega'(x\alpha_y-y\alpha_x)+\tfrac{1}{8}\omega'^2(x^2+y^2).$$

Q is exact, R is accurate to second-order terms in ω'. It follows that $S=QR$, $H'=S^{-1}\overline{H}'S$.[3]

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Talladega College,
Talladega, Alabama,
October 25, 1935.

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[1] O. Halpern and G. Heller, Phys. Rev. **48**, 434 (1935). The present note follows the notation of this reference.

[2] H' denotes the covariant form of the Hamiltonian, $H'=\beta H$.

[3] The accents were erroneously missing in Eq. ($\bar{7}$a), reference 1.

The Ionosphere, Sunspots, and Magnetic Storms

During recent years there has been much published speculation concerning the relations between the condition of the ionosphere, radio transmission, and the phenomena of magnetic storms and sunspots. It has been observed that it is difficult to maintain high frequency communication over certain paths during magnetic disturbances and there is some evidence that the maximum useful frequency is lower during the minimum of a sunspot cycle than during the maximum. The following striking phenomena which corroborate and extend these data, have been observed by us at the National Bureau of Standards.

The normal-incidence noon value of $f_{F_2}{}^{x}$[1] which had been below 7500 kc/sec. during the summer, rose gradually during October, attaining the hitherto unobserved peak of 12,600 kc/sec. on October 21. This period of high $f_{F_2}{}^{x}$ approximately coincided with a period of high sunspot activity. On October 21 a series of magnetic disturbances set in. These were intermittent and at first mild, but reached considerable sustained intensity on October 23 and 24. The $f_{F_2}{}^{x}$ decreased slightly from October 21 to October 23, dropped very decidedly to 6400 kc/sec. on October 24, then rose slowly during the following days, as shown in Fig. 1. The noon $f_{F_2}{}^{x}$ was representative of the day values. The F critical frequencies during the night of October 24–25 were below those obtained on the preceding nights but not as much of a decrease as for the day values occurred.

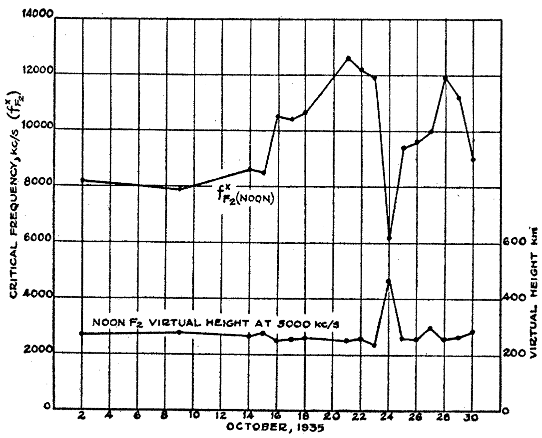

Fig. 1.

The F_1 critical frequencies were sharply defined on October 24. Both components were present. During the other days of this period $f_{F_1}{}^{0}$ was blunt and poorly defined as is normal for this season, and the extraordinary ray was not observed. The high values of $f_{F_2}{}^{x}$ were accompanied by low virtual heights of the F_2 region and *vice versa*, as shown in Fig. 1. The sharply defined F_1 critical frequencies seemed to be produced when the F_2 region rose and separated from the F_1. This is a normal summer day condition such as prevailed before the F_2 critical frequencies rose in October.

The high critical frequencies were accompanied by excellent transmission conditions for frequencies up to 30 megacycles per second, the limit of the receiver available, and probably conditions continued good up to 40 mc/sec. On October 24, the day of the low critical frequencies, transmission conditions were not as good as on previous days, many transmissions which had been received regularly on previous days failed, and others were much weaker. The critical-frequency data indicated that the maximum useful transmission frequency on October 21 was about twice that of October 24. The F_2 ionization density found on October 24 was about 23 percent of that found on October 21.

No deviations from normal were observed for the F_1 critical frequencies or virtual heights. No unseasonable change was observed during this period in the conditions of the E region, which is the region usually controlling transmission at the ordinary broadcast frequencies (550 to 1500 kc/sec.).

Dr. E. O. Hulburt[2] has given a reasonable theory for the low ionization densities and great virtual heights of the F_2 region during summer days. According to this theory these conditions are caused by atmospheric expansion produced by heating. Similar conditions seem to exist during the latter part of a magnetic storm. The results given above then indicate the probability that some agency acting during magnetic storms, heats the F_2 region to values abnormal for the season, causing the atmosphere there to expand, and in this manner reduces the ionization density and increases the virtual height of this region.

The effect of the sunspot activity seems to be to increase the ionization density of the F_2 region. On the other hand, though magnetic disturbances are more frequent and intense during the active part of the sunspot cycle, some agency acting for short times during these periods serves to decrease the ionization density of the F_2 region much below normal and increase the height of this region much above normal.

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National Bureau of Standards,
November 2, 1935.

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[1] $f_{F_2}{}^{x}=F_2$ critical frequency, extraordinary ray, i.e., the highest radiofrequency which is returned to earth by the F_2 region of the ionosphere.

[2] Hulburt, Phys. Rev. **46**, 822 (1934). Terr. Mag. 193, June (1935).