more than 0.6 percent of total sleep while in the adult chicken and pigeon it comprises 0.3 percent. Hishikawa *et al.* (*2*), however, have reported 7.3 ± 1.8 percent REM sleep in young isolated chickens. To our knowledge REM percentages for other avian species have not been reported.

We studied in widely separated enclosures two young adult species of diurnal (*3*) foveate avian predators—a hawk (*Buteo jamaicensis arborealis*) and a falcon (*Herpetotheres cachinnans chapmanni*)—for 1 year and for 6 months, respectively. Under Nembutal anesthesia (15 mg/kg), tetrapolar electrodes, 0.5 mm apart and insulated except for the terminal 0.5 mm, were implanted in the cerebral hemispheres 10 mm lateral to the sagittal line. One set was implanted in the hawk, and two sets 7 mm apart in the falcon. Sites of implantation corresponded to the dorsal cortical layer and underlying hyperstriatum (*4*). Periorbital screw electrodes were implanted to record eye movements [electrooculogram (EOG)]. Two insulated stainless steel wires 1 mm in diameter were placed in the neck muscles to record the electromyogram (EMG). All wires including the ground screw were soldered to a connector affixed to the skull with dental acrylic. The EEG, EOG, and EMG were recorded on an 8-channel polygraph (Grass, model 7). Seven 24-hour recordings were made of the hawk and three 24-hour recordings were made of the falcon. Additionally, 2- to 3-hour recordings were made three times a month during nocturnal hours. Two to four weeks of recovery time was needed after the operations to yield consistent EEG activity.

Waking and sleep behavior as well as electrical recordings were similar for both birds. The bird was lightly tethered and could fly a short distance within its cage. During wakefulness the head was elevated, and constant scanning eye movements and spontaneous motor activity were present. The EEG revealed wave frequencies of 10 to 24 hz and an amplitude of 8 to 20 μv. Occasional slow waves appeared. The EOG showed frequent conjugate as well as disconjugate eye movements. The experimenter's presence consistently evoked an alerting reaction with head and body movements directed toward the source of stimulation. Sleep onset was characterized behaviorally by immobility, eye closure, and abrupt lowering of the head, followed within minutes by burying the head under a wing. As sleep deepened, the head then sank toward the floor and the wingspread increased through greater relaxation. Perching was always maintained. The EEG revealed a moderate increase in scattered slow waves of 10 to 3 hz lasting 0.1 and 0.3 second and of 25 to 40 μv irregularly spread against the background activity described for wakefulness. No long trains of slow waves were observed. There was an occasional small eye movement deflection picked up by the eye-movement leads. The EMG flattened out as soon as behavioral sleep was initiated so that the distinction between N-REM and REM sleep in terms of muscle tone was unimpressive. The REM sleep episodes were usually first observed within 4 to 8 minutes once behavioral sleep occurred (Fig. 1). Very occasionally a short REM burst appeared within 30 seconds after the precipitous drop in EMG indicative of behavioral onset of sleep. The EEG activity revealed fast frequency and low amplitude. Eye movements occurred in clusters of 7 to 15 individual high-amplitude asynchronous deflections. Less often the eye movement deflections were "yoked" (*5*). Myoclonic jerks similar to those observed in mammals were also present. The eye movement bursts lasted from 3 to 15 seconds with intervening quiescence from 30 seconds to 5 minutes, the interval infrequently being as short as 15 seconds. Arousal threshold during sleep elicited by low-tone auditory stimulus was always highest during periods of rapid eye movement activity. Periods of sleep ranged from 3 to 40 minutes with interruptions of wakefulness for periods of 5 to 10 minutes in alternating and somewhat irregular arrangement throughout the night. Thus the nocturnal sleep pattern of 6 to 8 hours was punctuated by constant wakenings such that net sleep comprised 4 to 5 hours. The REM sleep averaged 7 to 10 percent of total sleep time (Fig. 2). Neither the lower nor the upper limits of percentage of REM sleep fit consistently into any particular period of the night.

The presence of low-voltage fast activity, bursts of rapid eye movements, muscle jerks, isoelectric EMG, and increased arousal threshold constituted evidence of REM sleep in these two birds (*6*).

In view of studies indicating the presence of high-amplitude slow wave activity during sleep in the chicken and pigeon (*7*), we are puzzled that amplitude rarely exceeded 45 μv. Furthermore, this slow wave activity was even observed at times during wakefulness. Tradardi (*8*) has pointed out that the EEG patterns in birds during sleep and wakefulness were not always clearly discriminable in that slow waves could be seen in both states. However, in his case the slow waves were of high amplitude. On the other hand, EMG activity of the neck muscles in his pigeons was diminished during N-REM sleep but was not isoelectric during REM sleep, whereas EMG activity in our birds became essentially isoelectric during both phases of sleep.

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9 October 1969; revised 28 January 1970

Search for an Effect of the Sun on the Frequency of 18-Centimeter Radiation

An apparent decrease in the frequency of the 21-cm absorption spectrum in Taurus A when the sun passed near the line of sight was reported by Sadeh *et al.* (*1*). This effect is not predicted by general relativity or by any known effects in the solar corona. Because of the extraordinary nature of this result, we have performed a similar experiment.

Each year in late December the sun occults a moderately strong 1720-Mhz emission source in W28, and passes within about 20 minutes of arc of a similarly strong 1612-Mhz OH emission source in W28S. These OH emissions are nearly unpolarized in contrast to the strongly polarized emissions at 1665 and 1667 Mhz in many other sources (*2*).

We used the 84-foot (26-m) radio telescope of Harvard's G. R. Agassiz Station and, simultaneously, the 120-foot Haystack antenna of M.I.T. Lincoln Laboratory to observe W28S at 1612 Mhz for several days bracketing the sun's close approach in December 1968. The Agassiz antenna was equipped with a room-temperature parametric amplifier which provided a system temperature of about 150°K when pointed away from the sun. On the day of the sun's closest approach, the sun's radiation caused the system temperature to increase by approximately 1000°K. The Agassiz receiver contained a 50-channel filter bank with nominal 500-hz bandwidth filters spaced by 500 hz. At Agassiz we employed Dicke switching against a sky horn and used linear polarization with the E vector oriented north-south on the sky.

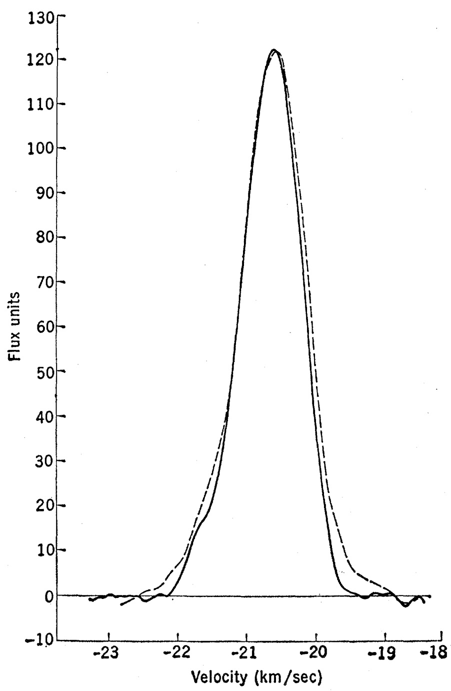
The Haystack antenna was also equipped with a room-temperature parametric amplifier which provided a system temperature of about 200°K away from the sun and 500°K at the time of the sun's closest approach. The Haystack receiver contained a 100-channel one-bit digital autocorrelator which was used at a 100-khz clock rate to provide a 40-khz usable window and 1-khz resolution. We used linear polarization at Haystack with the E vector vertical (*3*).

Using these two telescopes, we observed nearly simultaneously the 1612-Mhz OH emission from W28S in separate 5-minute intervals. Data were obtained from up to 24 such intervals each day at each site during the course of the experiment. Figure 1 shows a spectrum from each site obtained by averaging a typical day's data. In comparing these spectra, we took the changes in the velocity of the observer into account (*4*). The position of the 1612-Mhz OH emission from W28S needed both for pointing and for the velocity calculations was measured at Haystack to be $\alpha = 17^{H}57^{M}30^{S} \pm 4^{S}$; $\delta = -24° 04'.5 \pm 1'$ (1950).

After applying the known velocity corrections (*4*) we examined the data for the presence of an anomalous frequency shift. We averaged together all the data (for each site separately) to give a reference spectrum, and cross-correlated this reference spectrum with each of the daily averages, some of the hourly averages, and some of the individual 5-minute runs. We took the maximum of the cross correlation to define the apparent frequency shift with respect to the reference spectrum. This procedure is mathematically equivalent to least-squares fitting these spectra to the reference spectrum with a frequency shift as the free parameter. The scatter in the frequency shifts determined in this way is given approximately for a gaussian-shaped feature by

$$\sigma_{\Delta\nu} \approx (0.425)\frac{\sigma_N}{S}(\beta W)^{1/2}$$

where σ_N is the scatter due to noise on each spectrum, S is the peak of the spec-



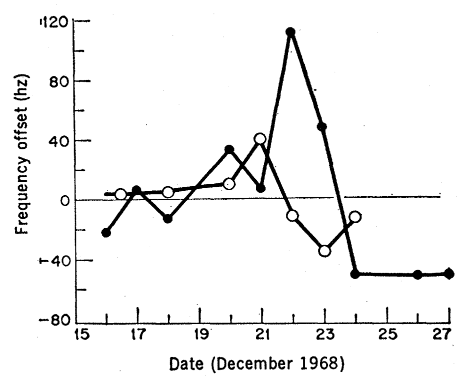


Fig. 1 (left). Spectrum of W28S at 1612 Mhz obtained from the average of all the data taken on 18 December 1968 at Haystack (solid curve) and on 26 December 1968 at Agassiz (dashed curve). The flux scale is based on the assumption that this emission is unpolarized. The velocity axis is with respect to the local standard of rest and is based on a line rest frequency of 1612.231 Mhz. The uncorrected width of this feature is about 5.4 khz and the signal to peak noise ratio for this spectrum is about 45. Fig. 2 (above). Apparent frequency shift of the 1612-Mhz OH emission feature from W28S. These points are based on daily averages except for the first Haystack point which represents a 2-day average. The closest approach of the sun occurred on 21 December 1968. Solid circles, Agassiz data; open circles, Haystack data.

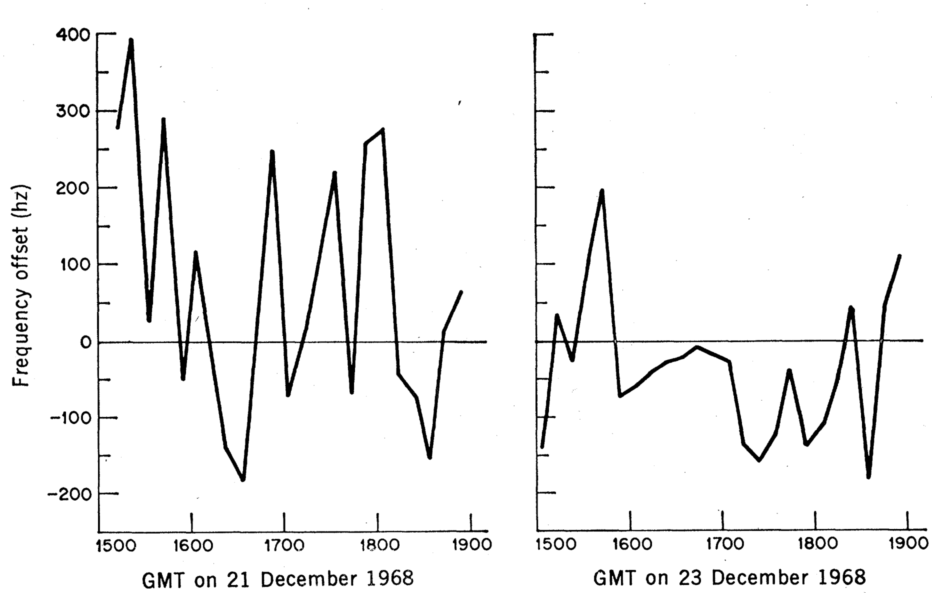


Fig. 3. Apparent frequency shift of the 1612-Mhz OH emission feature from W28S for individual 5-minute runs on the two dates indicated. These are Haystack data only.

trum, β is the instrumental resolution width, and W is the width of the signal (the full width to half amplitude in both cases). However, Fig. 1 shows that this feature is not gaussian; since the scatter in the frequency offset depends strongly on the shape of the feature, our error calculation is only approximate for this reason as well.

Using this formula, we calculate the error limits to be about 25 hz for the Haystack and about 50 hz for the Agassiz data for daily averages on days when the sun was not in the beam, and about 50 hz for Haystack and 150 hz for Agassiz on the 3 days surrounding the sun's closest approach. We believe that other sources of frequency errors, such as filter drifts, are substantially smaller than these limits.

Our results for the daily averages are shown in Fig. 2 and for some of the 5-minute averages in Fig. 3. These results show that any anomalous frequency shift of the kind reported by Sadeh *et al.* (*1*) is less than about 50 hz. Since Sadeh *et al.* observed Taurus A to within about 77 minutes of arc of the center of the sun and we observed W28S to within 36 minutes of arc, our frequency shift should be larger than the 100 hz measured by Sadeh *et al.*, whether due to the sun's mass or to the solar corona, provided that the solar corona has not changed significantly in the intervening months. Pulsar measurements made in June 1969 during the occultation of Taurus A, however, show that changes in the integrated electron density are unlikely to cause more than a few cycles change in the observed Doppler shifts at either the OH or hydrogen-line frequencies (*5*).

We have been informed (*6*) that the Taurus A observations reported by Sadeh *et al.* (*1*) were obtained by a direct measurement of the 21-cm absorption line with the main beam of the Naval Research Laboratory antenna directed toward Taurus A. We suggest the possibility of a systematic effect: the continuously changing extinction of the background hydrogen emission as the sun moves along the ecliptic could provide a variation in the Taurus A profile. An evaluation of this possible error requires a detailed knowledge of the antenna pattern and the precise hydrogen spectrum occulted by the sun.

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Sunglint Patterns in Satellite Pictures

Bowley *et al.* (*1*) recently presented a brief report on unusual dark patches appearing in sunglint patterns viewed by geosynchronous satellites. We had presented a very similar paper at an American Geophysical Union meeting in April 1969 (*2*), and it later became known to Bowley *et al.* that we had submitted an article on this work to the *Monthly Weather Review* (*3*). They fail to acknowledge this anywhere in their report.

Bowley *et al.* make extensive reference to a "model" that explains these sunglint patterns. Such a model was described in considerable detail in the oral and written versions of our paper cited above. They also fail to cite a number of earlier publications on this subject. Dark patches in satellite-viewed sun-glitter areas were noted as early as 1963 (*4*), and they have been mentioned in several other publications as well (*5*).

We would hope that in the future they take greater care in making proper attribution to previous work on their subject.

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4 December 1969; revised 12 December 1969

Our work was accomplished independently but at a later time than that of McClain and Strong. Our discovery of the anomalous sunglint areas was a side result of research performed for the Woods Hole Oceanographic Institution. We showed that satellite data (especially Applications Technology Satellite data) could be used directly and indirectly to infer upwelling in the ocean and hence aid in finding possible fishing areas. Our work was reported verbally to the Woods Hole Oceanographic Institution in May and in report form in June. The work was subsequently reported in the Quarterly Contract Report to the National Aeronautics and Space Administration, Electonic Research Center, in July 1969.

We did not become aware of the paper that Strong and McClain presented at the American Geophysical Union until very late in July, nor did the article in the *Monthly Weather Review* become known to us until well after we had completed our manuscript. It was felt that it represented independent research, and, as such, it did not alter our plans for submission to *Science*. Thus, we believe that any impropriety on our part, if it exists, was to continue our submission to *Science* without asking for an editor's note referencing the paper we belatedly