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E. SATELLITE AND ELECTRIC POWER APPLICATIONS

ANOMALOUS SATELLITE DRAG AND THE GREEN-LINE CORONA

Richard C. Altrock
Air Force Geophysics Laboratory
Sacramento Peak Observatory*
Sunspot, New Mexico 88349

Satellite drag data for Skylab from Headquarters Aerospace Defense Command are compared with solar λ5303Å Fe XIV coronal scans from Sacramento Peak Observatory. During a short period in late 1977 and early 1978 there appears to be a distinct anti-correlation of anomalous drag with coronal intensity inferred at the center of the solar disk approximately two days earlier. The relation appeared at a time of a stable intensity pattern near the solar equator and evidently disappeared as the stable intensity pattern disappeared.

INTRODUCTION

It has been well established that coronal holes as observed in X-rays are the source of high-speed solar-wind streams. A number of studies have shown that streams emanating from holes near the sub-earth point impact on the geomagnetic field and cause disturbances in it (cf. Neupert and Pizzo, 1974). More recently, studies have shown that coronal holes may be identified in observations of λ5303Å of Fe XIV with sufficient precision to allow use of these data to predict recurrent geomagnetic disturbances during times of low solar activity (cf. Musman and Altrock, 1978). However, at best this technique results in a success ratio of approximately 80%. There are, therefore, times when an apparent low coronal emission at the sub-earth point does not result in a geomagnetic disturbance. This apparent lack of 100% correlation between regions of low emission in the green-line corona and high-speed streams has been confirmed by Kaufman (1978). This paper explores further the properties of these low-emission regions in their effect on another geophysical parameter.

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Recent Studies of satellite drag produced by density fluctuations in the atmosphere have resulted in inference of an anomalous drag that is uncorrelated with, among other parameters, geomagnetic disturbances (Lane and Hoots, 1978). Following a request from Headquarters Aerospace Defense Command, a preliminary comparison of these data with green-line data showed a favorable correlation with regions of low emissivity, and I have now found a subset of the observations that implies a direct connection between stable regions of low green-line emissivity and increases in satellite drag.

THE DATA

The observation and reduction of the green-line data are described in Musman and Altrock (1978). The data are basically coronal intensities at a given height above the limb obtained daily. I have utilized an equatorial average of the intensity in the latitude band $+15^{\circ}$ to -15°.

The satellite drag data are presented in the form of the total drag coefficient, B, having units of m^2/kg. The total drag is defined to be ρB, where ρ is density taken from the Jacchia 1964 model, which includes empirical corrections for geomagnetic index, a_p, and solar radio flux at 10.7 cm, $F_{10.7}$. Data are presented for Skylab (other data are being processed). The value of B is determined by comparison of the modelled motion with radar observations. Thus, variations in B represent unmodelled, or anomalous, variations in total drag.

The data are presented in Figure 1. The data set of B corresponding to unstabilized motion of Skylab ran from approximately DOY 340, 1977, to DOY 160, 1978. Data gaps of one day in $\bar{I}$ have been linearly interpolated over. $\bar{I}$ has been plotted increasing downwards.

RESULTS

Referring to Figure 1, we see that a stable coronal intensity pattern with a period of 27 days existed near the solar equator near the end of 1977. The intensity data became rather sketchy near the beginning of 1978, but at least four maxima can be inferred in this pattern (DOY 314, 341, 5, and 31). A fifth possible maximum near DOY 60 cannot be confirmed. After that, the intensity pattern can only be described as chaotic, with considerable difference between disk-center intensities inferred from east and west limbs and no clear recurrent features.

The satellite-drag data show many similarities to the shifted intensity values in the first half of the observation period. With an empirical value for the shift (or transit time from the center of the disk) of

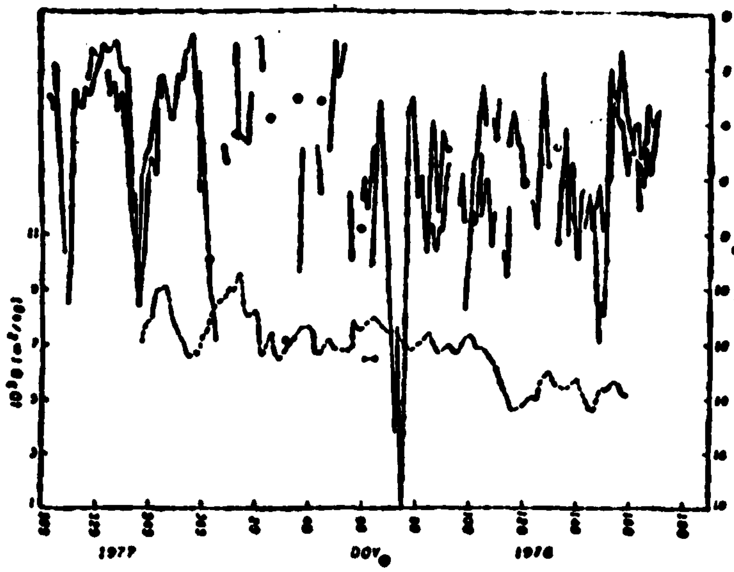

Figure 1: Total satellite drag coefficient for Skylab, B, (solid line) and average coronal λ5303Å intensity, Ī, (dashed lines) as a function of day of the year at the earth, DOY$_\oplus$. Uncertainty bar near B represents the integration time of each point. The 30° latitude average of equatorial green-line intensity is plotted at the day of limb passage (LP) + 8.75 days for east-limb data and at LP-4.75 for west-limb data, or at CMP + 2 for either limb. No distinction is made on the graph between east and west limb data. Circles represent isolated data points of Ī.

approximately two days, the *maxima in Ī correspond well* to the minima in B (DOY ∿ 342, 354-359, and 29). Other data, unavailable for publication at this time, show a similar pattern. The maxima in B at DOY ∿ 346 and 13 (and 37-40?) have associated minima in Ī. As time progresses, the stationary pattern in the corona becomes chaotic, and no clear periodic signal is seen in the B curve. Another interesting feature in B is the decline in the average level, beginning about DOY 60 and bottoming out near DOY 117. This does not appear to be correlated with any particular event in the equatorial corona, although it does correspond, more or less, to the onset of the chaotic coronal intensity pattern.

The choice of a transit time (shift) of two days from CMP is arbitrary and uncertain. Digital data was unavailable at the time of writing, so a cross correlation was not performed. A transit time of zero (or 27 days) actually appears to fit this extremely limited data set better. Alternatively, a transit time of eleven days would align the maxima of Ī with the maxima of B. This transit time seems unlikely due to the low propragation velocity required (∿ 160 km s^{-1}) and the low probability that such a slow stream could maintain its coherence over that length of time. One might expect that such a stream would be disrupted by overtaking high-speed streams. However, one cannot completely discount the possibility that the periodic variation in B is due to low-speed streams emanating from regions bright in the green-line. Because a mechanism for this has not been identified, I *prefer* to conclude that the source of the increases in B lies in faint green-line regions; i.e., a (weak?) high-speed stream.

CONCLUSIONS

1. A clear 27-day period has been identified in a portion of total drag data for Skylab, after correction for geomagnetic disturbances and solar radio flux.

2. A good correlation of the periodic maxima in this anomalous drag has been found with a stable periodic low-intensity region in the equatorial corona as observed in λ5303Å Fe XIV.

3. The onset of unstable, rapidly-evolving conditions in the equatorial corona appears to coincide with the disappearance of periodic variations in corrected drag.

4. From these limited data, it appears that stable regions of low coronal intensity observed near the equator on the east limb may be used to predict anomalous increases in satellite drag up to nine days in advance.

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