THE INFLUENCE OF THE SUN ON JUPITER'S RADIO EMISSION

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Abstract

A number of papers, dating from 1960 up to the Voyager encounters in 1979, have examined the possibility of some relationship between solar activity and ground–based observations of Jupiter's Decametric Radio Emission (DAM). This work is reviewed and the problems inherent to such studies are discussed. The results are compared with more recent work using observations of the DAM, the Hectometric Radio Emission (HOM) and various solar wind parameters, all observed by the two Voyager spacecraft. The Non–Io DAM, recorded by both Voyagers and combined using the superposed epoch technique, is found to correlate with the solar wind density, pressure and velocity, as well as with the interplanetary magnetic field (IMF) magnitude. In agreement with the earlier work using ground–based observations, there are indications that the Non–Io DAM is somehow associated with magnetic sector structure although the precise details of the relationship are still not known and it is still not clear if this is a fundamental effect or some secondary effect of intercorrelation. The HOM intensity is found to be modulated by the solar wind density, but not by the solar wind velocity. None of these Jovian correlations are as strong as those found recently for the Saturn Radio Emission by Desch and Rucker (1983).

1 Introduction

This review paper surveys the following topics. In the next section, the historical background is presented briefly and the first indications of solar influence on the DAM are outlined. The limitations of the early investigations and the problems inherent to a systematic statistical search for possible solar influence on Earth–based observations are discussed in Section 3. Artificial periodicities in the observational data are considered separately in Section 4. Ground–based observations, up to the time of the Voyager encounters, are discussed in Section 5, leading to the general conclusion that the DAM is in some manner related to IMF sector structure. Section 6 outlines the results obtained so far, from in–situ observations by both Voyagers, of the solar wind and the Jovian radio emission. In Section 7, the present situation is discussed as far as possible and a few questions are raised for future investigation.

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2 Historical background

The DAM was discovered accidentally in 1954 by Burke and Franklin, (1955). In the years following this discovery, statistical techniques established the existence of preferred regions defined in central meridian longitude (CML) by a relatively high occurrence probability and, somewhat ambiguously, the term "source" was adopted to refer to these regions. To the present day, however, very little is known about the extent in latitude of these so–called sources and the suggestions by Genova (1984) represent the first serious attempt to clarify this situation.

A number of important observations and some far–sighted suggestions were presented by Gallet (1957). In particular, Gallet foresaw the possibility of solar influence on the DAM in his suggestion of a long–term anticorrelation ("inverse sunspot effect") between the sunspot cycle and the probability of occurrence of the DAM. This effect was first established by Carr et al. (1961) several years later. The original data of Carr et al., extended by Roberts (1963) to include data published by Gallett (1961), is shown in Figure 1(a). Carr et al. (1958) also noted that the most intense DAM noise storms seemed to occur at roughly 7– to 8–day intervals [Figure 1(b)], an important result to which we shall refer again in Section 4.

In 1964, Bigg (1964) discovered that many of the DAM noise storms were closely correlated with the position of the Galilean satellite Io relative to the Earth–Jupiter line. This effect, originally demonstrated by occurrence probability histograms, was later combined with the source location in CML to be presented in a single three–dimensional plot of the type shown in Figure 2. The terms Io– and Non–Io emission were adopted to refer, respectively, to DAM that was correlated or not correlatedwith the position of Io expressed by geocentric longitude. The inverse sunspot effect is now regarded (Carr and Desch, 1976) as being due to a sharp latitudinal beaming of the Non-Io A-source emission rather than an effect of changing sunspot number.

The Io effect was not known when Carr et al. (1960) first suggested that the DAM might be due to the effect of solar particles incident upon the upper atmosphere of Jupiter. On the assumption that these particles would disturb the Earth's magnetic field as they passed by on their way to Jupiter, Carr et al. suggested the existence of a systematic lag of some 8 days between periods of enhanced geomagnetic activity and DAM events (Figure 3). Around the same time, Warwick (1960) found that DAM events, in which the emission extended to frequencies of 30 MHz and above, tended to follow some one or two days after periods of decametric solar continuum.

Roberts (1963), however, using the data presented by Carr et al. (1960), calculated the cross correlation between the geomagnetic Ap–index and a "daily Jupiter burst index" (Figure 4) and found that, although a 1% significant peak indicated that DAM followed periods of enhanced geomagnetic activity by 8 days, another equally significant peak suggested that DAM preceeded enhanced geomagnetic activity, also by 8 days. Similar (unpublished) results were obtained by Higgins, using 19.7 MHz observations of Jupiter made at CSIRO in Australia, and Roberts, therefore, concluded that all of these correlation peaks were due to statistical fluctuation.

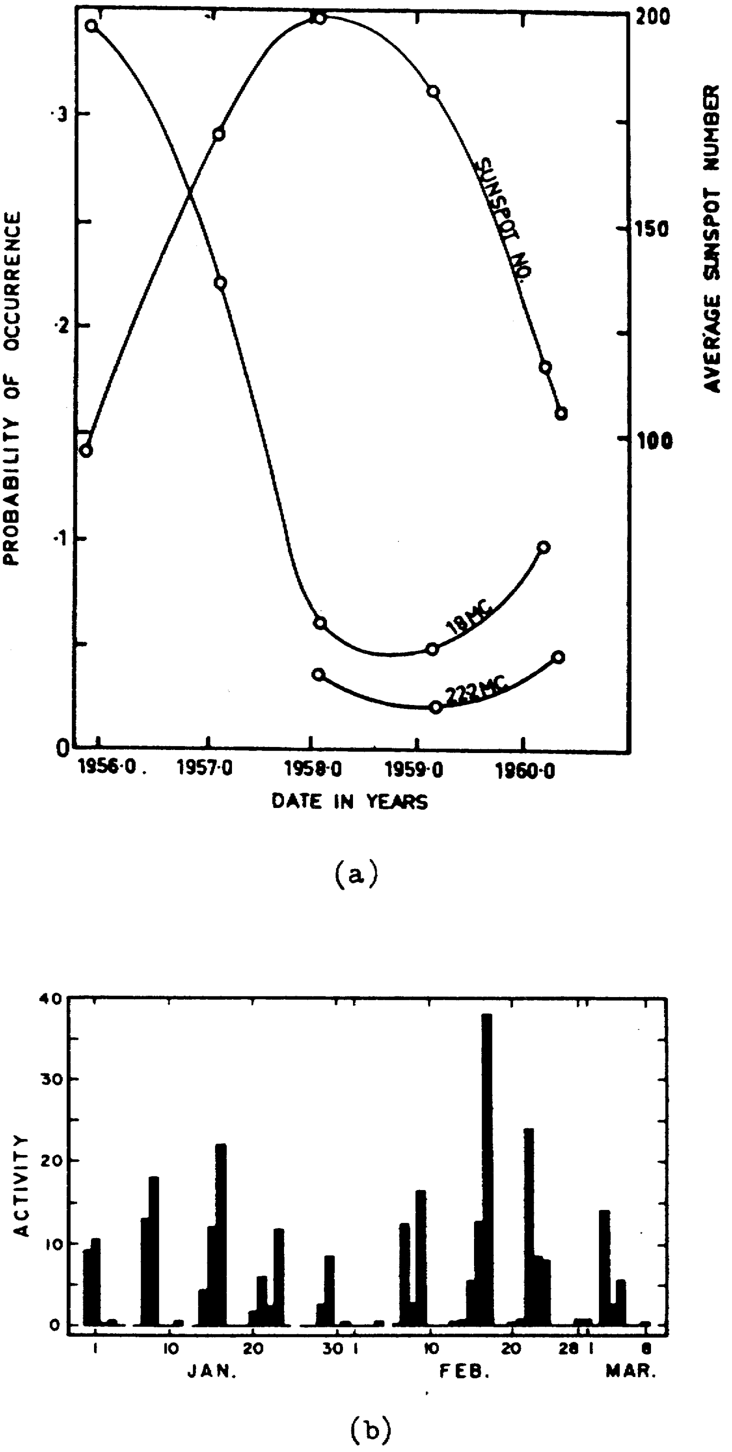

Figure 1: (a) Annual variation of Jupiter burst activity compared with the sunspot cycle, from 1956 through 1960 (Roberts, 1963). (b) Daily Jovian activity showing the B-day periodicity (Carr et al., 1958).

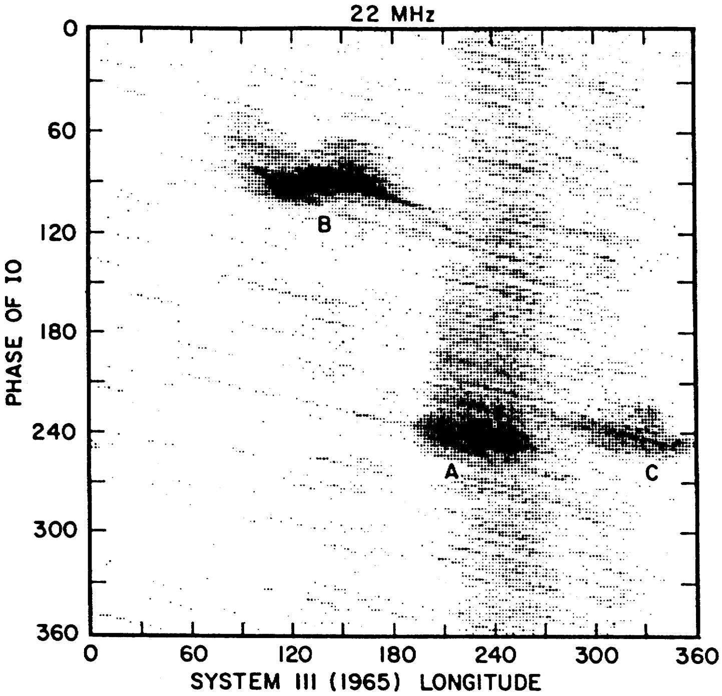

Figure 2: DAM events plotted by CML and Io–phase, for fixed–frequency observations at 22 MHz, from 1958 through 1975 (Thieman, 1979).

3 Analysis Problems

Implicit in all of the earlier suggestions concerning the possibility of a short–term correlation between solar activity and the DAM, is the assumption that solar particles disturb the Earth's magnetic field as they pass by on their way to Jupiter where they somehow trigger the DAM. Even if this simple model were completely true it would only be precisely realized close to opposition for particles travelling with uniform and constant radial velocity. A number of complicating factors exist, however. These have been considered in studies by Sastry (1968), Douglas and Bozyan (1970), Kovalenko (1971), and Barrow (1972). The pro- blems may be summarized as follows:

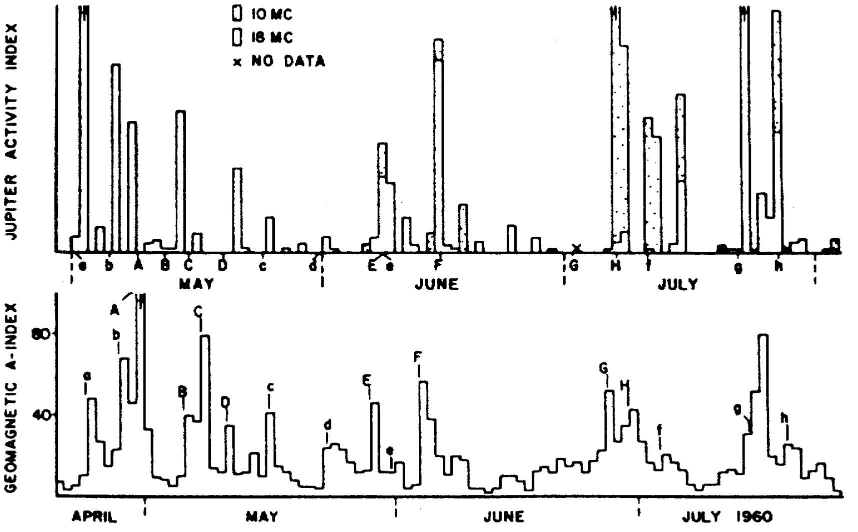

Figure 3: Comparison of the geomagnetic Ap–index with the daily Jupiter activity index, for two frequencies in 1960. The time scale for the Ap–index has been advanced 9 days relative to the Jupiter activitiy time scale (Carr et al., 1960).

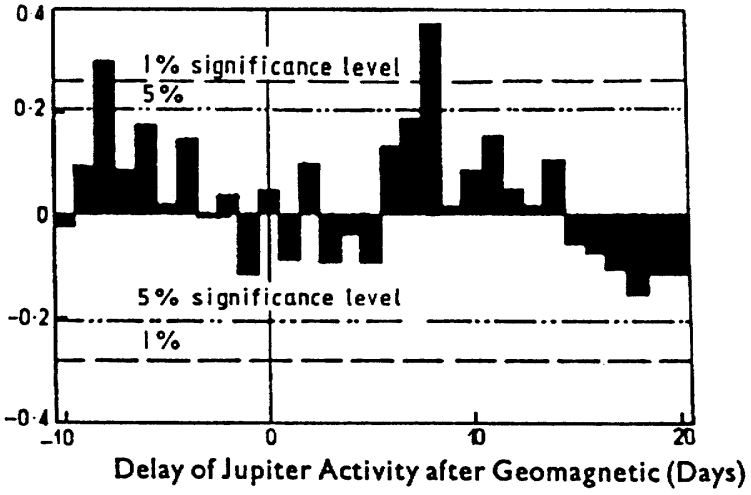

Figure 4: Linear cross correlation between the daily Jupiter burst index, given by Carr et al. (1960), and the geomagnetic Ap–index (Roberts, 1963).

a) Changing Earth–Sun–Jupiter geometry, as shown in Figure 5, where the delay a in days between the arrival of particles at the Earth and at Jupiter is given by:

$$\Delta = \frac{d_j - d_e}{v_r} - \frac{\Phi}{\Omega} \tag{1}$$

d_e, d_j are, respectively, the mean distances from the Sun of the Earth and of Jupiter, v_r is the particle velocity, Ω is the angular velocity of solar rotation and Φ is the Earth–Sun–Jupiter angle, increasing positively from zero after opposition. We note that the value of Δ indicated will depend upon both the geometrical configuration (angle Φ) and the particle velocity predominant during the period to be studied.

b) Possible beaming of solar–activated DAM in directions away from the Earth, after the activating particles have caused a geomagnetic enhancement.

c) Intermittent periods of DAM data, mostly for a few months at a time, close to each opposition.

d) Possibility of both solar–correlated and uncorrelated types of DAM.

e) Range of particle velocities possible during an apparition, even if the velocities were radial and roughly constant over shorter periods (We now know that the solar wind velocity is radial and very nearly uniform out to and beyond the orbit of Jupiter, but it is certainly not constant for long periods).

f) Artificial periodicities in the data may indicate spurious correlations. These will be considered separately in Section 4.

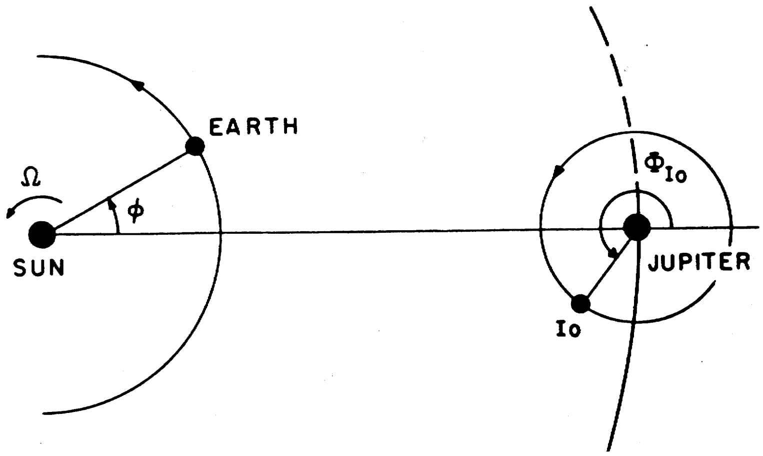

Figure 5: Earth–Sun–Jupiter geometry.

If we invoke the method of superposed epochs or Chree analysis (Chree, 1912), using DAM events as epochs against continuous values of some parameter (such as a geomagnetic index) representing solar activity, we should be able to eliminate possible effects of b) and c) above. If we are looking for correlation in the form of some systematic delay between a solar event and a corresponding DAM event, then a) and e) will tend to cause a range of delay values rather than a single value (i.e. peak broadening in the superposed epoch analysis), while d) will tend to create a "background noise" to the peaks. The effect of a) may be reduced to some extent by restricting the study to observations made relatively close to opposition. While these effects tend to confuse the situation, a correlation should still be recognizeable if it exists.

4 Periodicities

DAM observations made from a single Earth–based station will contain periodicities due to the rotation periods of Jupiter and the Earth as well as the revolution period of Io. Without detailed analysis we can see, at once, that the 7 to 8–day periodicity observed by Carr et al. (1958) and by Roberts (1963) is almost certainly due to the fact that, approximately,

$$17T_j = 7T_e = 4T_{io} \tag{2}$$

where T_j is the rotation period of Jupiter, T_e is the rotation period of the Earth and T_{io} is the revolution period of Io. More generally, as given in a different context by Douglas and Bozyan (1970), there will be numerous harmonics and beat periods given by

$$\frac{1}{T} = \frac{k}{T_j} + \frac{l}{T_e} + \frac{m}{T_{io}} + \frac{n}{T_{jy}} \tag{3}$$

T_{jy} is the length of Jupiter's year and hardly relevant to our present interest which concerns periodicities of some 2 to 30 days. The quantities k, l, m, n, can have values 0, ±1, ±2, etc. Sastry (1968) conducted a power spectrum analysis, based upon DAM observations taken in 1951 – 1963, and found a number of periodicities, as shown in Figure 6. It can be seen that the two most prominent of these correspond to frequencies of 0.13 and 0.15 cy/day, that is to periods of 7.7 and 6.7 days, respectively. It is the combined effect of these two periodicities that accounts for the 8–day periodicity found by Carr et al. (1958) and by Roberts (1963). If we attempt to calculate these from Equation 3, writing $n = 0$, we find that neither periodicity can be generated unless $k, l, m \neq 0$. In other words, both peripdicities must involve the revolution period of Io. Earth–Jupiter interactions ($k, l \neq 0$; $m = n = 0$) will certainly occurr although, according to Sastry, these will be of lower spectral power. For example, the 0.18 cy/day, 5.6 days, periodicity is probably the case $k = 2$, $l = 5$, $m = n = 0$.

Clearly, if we confine analyses to Non–Io DAM we eliminate the 7 to 8–day periodicity. If we combine DAM data from several observing stations at different terrestrial longitudes, as, for example, in the catalogue of fixed–frequency observations by Thieman (1979), we would hope considerably to reduce the effect of Earth rotation.

Ward (1960) pointed out that a number of periodicities, less than 27 days, existed in most geomagnetic indices. According to Ward, these are given by $27/N$ where $N = 1, 2, 3, 4, 5, 6$. The case of $N = 2$ could often occur; 3 and 4 could occur quite frequently, but 5 and 6 only occasionally. Nowadays, we would identify such subperiodicities with IMF sector structure.

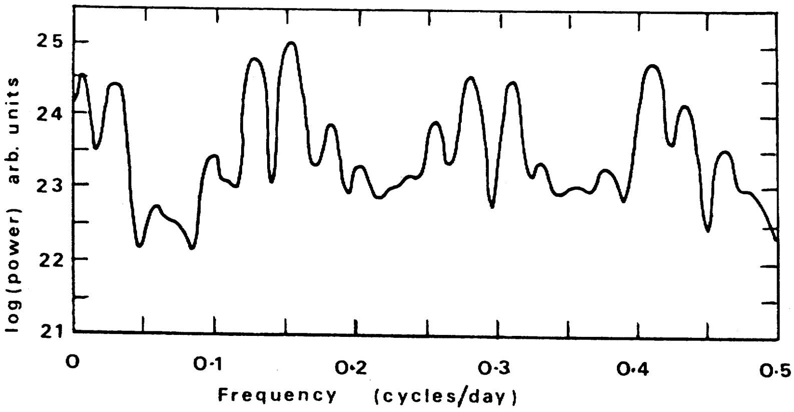

Figure 6: Periodicities occurring in the power spectrum of theoretical occurrence probabilities, calculated by Sastry, (1968).

5 Ground–Based Observations up to Voyager

Following the work of Sastry (1968), a number of authors used different criteria to select DAM events and then attempted to correlate these events with various indicators of solar activity. For example, Kovalenko (1970), and Kovalenko and Malyshkin (1971), found indications of a short–term association of Non–Io DAM with both shock–waves and high–velocity solar–wind streams at Jupiter. Gruber (1975), however, combining observations from 1960 to 1967, found an anticorrelation, with lag–times of 5 and 27 days, between changes in sunspot number and Non–Io DAM.

In a somewhat different approach, Conseil et al. (1971) found indications of a relationship between the rate of change of solar wind velocity observed at the Earth and the phase of Io during periods of Io–correlated A–source activity. These, and other earlier correlation studies, were reviewed in a more general paper by Carr and Desch (1976), who commented that, little or no general agreement then existed concerning possible solar–Jovian relations.

Relative to the foregoing, Kennedy et al. (1974) extrapolated solar wind particle fluxes, measured near the Earth, and showed that most low– and high–speed stream collisions should occur before the streams arrived at Jupiter. This, they suggested, would give rise to recurrent peaks in the particle flux at Jupiter. A model particle flux density at Jupiter appeared to be strongly correlated with Non–Io A–source DAM during the period October 1967 to May 1968 when a stable two–sector solar wind structure existed.

Barrow (1972) applied the considerations of Sections 3 and 4 to a superposed epoch analysis of swept–frequency DAM data taken from 1961 to 1968 [subsequently listed in the

University of Colorado Radio Observatory (UCRAO) catalogue by Warwick et al. (1975)], against the daily geomagnetic character index C_p, from 1961 through 1968. Periods of two months, before and after each opposition, were chosen as a compromise for the condition a) in Section 3. As Equation 1 indicates that the delays indicated by any possible correlation peaks should depend upon the angle Φ, observations before and after opposition were considered separately as a further test for correlation. Significant correlation peaks were found to occur, corresponding to delays of about 12 days in the after opposition data and –9 days in the before opposition data. Barrow (1978) subsequently extended the study, using the geomagnetic A_p–index, to include the 14 apparitions from 1960 to 1975, confining the analysis to Non–Io DAM and identifying spurious periodicities from the considerations listed in Section 4. The correlation peaks were enhanced somewhat by the selection of Non–Io DAM but a negative lag again appeared in the before opposition data. Refining the study still further, Barrow (1979) then analysed fixed–frequency data taken from the Thieman (1979) catalogue over a period of some 17 years (Figure 7). As this catalogue consists of a combination of fixed–frequency data from every observing station in the world, periodicities due to single–station observations were greatly reduced. Again, however, a peak close to epoch, corresponding to the negatively delayed peaks in the previous analysis, persisted in the before opposition data. We have seen in Section 3 a) that the exact position of the superposed epoch peak is not critical, as the delay indicated will vary somewhat according to the values of the solar wind velocity predominant during the period of the analysis. Barrow (1979), therefore, interpreted these results as indicating an association of the Non–Io DAM with IMF sector structure, noting that (Figure 8) for solar wind velocities of the order of 350 km/sec, the sector boundary could encounter the Earth a few days before it encountered Jupiter. He also found (Figure 9) that the correlation appeared to be considerably more pronounced for periods such as 1962 – 1964, when a relatively stable long–lived sector structure existed. These results were consistent with the findings of Oya and Morioka (1977), Terasawa et al. (1978), Levitskii and Vladimirskii (1979), and Pokorny (1982), all of whom reached similar conclusions from somewhat different arguments.

Thus, at the time of the first Voyager encounter, some measure of agreement had developed concerning possible solar control of the Non–Io DAM although the exact nature of the relationship remained obscure. As all of the foregoing analyses were statistical, it was not possible to decide which of the various solar activity indicators was fundamental to the control of Non–Io DAM, as some measure of intercorrelation exists between a number of solar and solar wind parameters and IMF sector structure.

6 Voyager Observations

Observations with the Voyager Planetary Radio Astronomy (PRA) experiment showed that the low–frequency radio spectrum (Figure 10) of Jupiter contains three distinct components in addition to the well–known DAM; a hectometre–wavelength emission (HOM), and two components at kilometre wavelengths (bKOM and nKOM). The PRA experiment and the characteristics of each of these components have been reviewed by Alexander et al. (1981) and by Carr et al. (1983). Up to the time of writing this review, the KOM

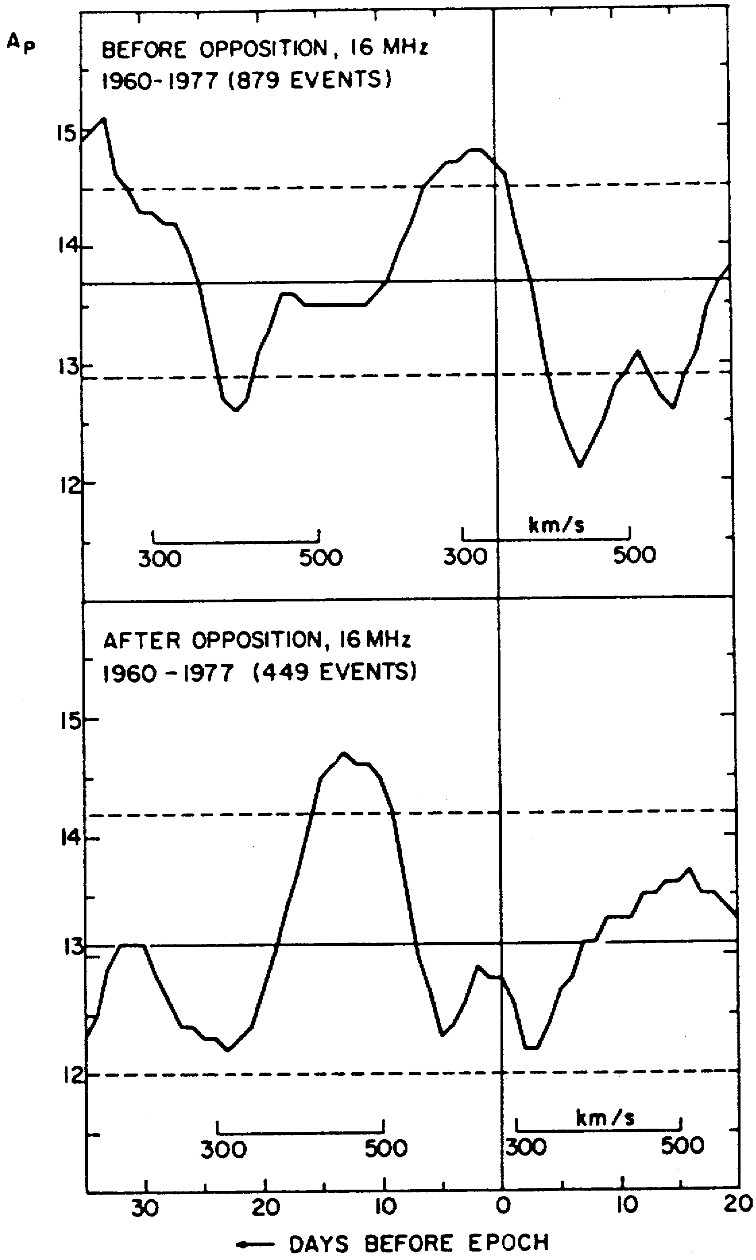

Figure 7: Superposed epoch analyses of Non–Io DAM against the geomagnetic A_p–index for 16 MHz data from 1960 through 1977. The broken lines indicate 99% confidence levels.

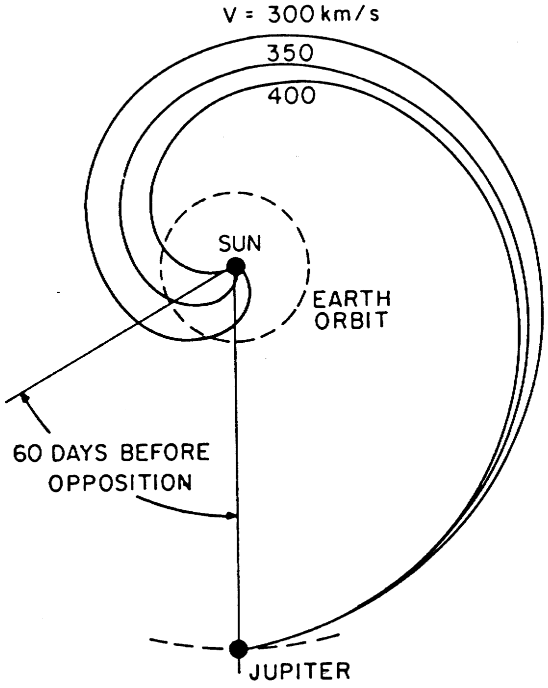

Figure 8: Idealized solar wind velocity spirals that could produce coincidences or negative delays during the 60–day period immediately before opposition.

had not been investigated for possible solar wind control and the present discussion is, therefore, only concerned with the HOM and the DAM.

6.1 HOM observations by Voyager

The HOM extends from about 3 MHz down to 100 kHz and is not, therefore, accessible from Earth–based observations. The occurrence probability of HOM as a function of CML differs from that of the DAM and there is no indication of control by Io. Also, the HOM has a distinct spectral peak close to 1 MHz (Brown, 1974). Thus, the HOM is certainly distinct from the Io–correlated DAM and probably distinct from the Non–Io DAM. On the other hand, Lecacheux et al. (1980) have suggested that the HOM may be simply a low–frequency extension of the DAM.

Earth–based observations have demonstrated that the DAM is somehow related to solar activity through the solar wind. Relative to this, Desch (1982) and Desch and Rucker (1983) found that Saturn's kilometric radiation (SKR) is strongly correlated with a number of solar wind parameters, notably the density and the ram pressure, while Gallagher and D'Angelo (1981) have shown that the terrestrial (auroral) kilometric emission (AKR) is also controlled by the solar wind. Thus, some measure of solar wind control of the HOM might also be expected.

Zarka and Genova (1983) examined the power spectrum of HOM (Figure 11) and found several peaks common to both Voyager–1 and Voyager–2 observations. The peak, close

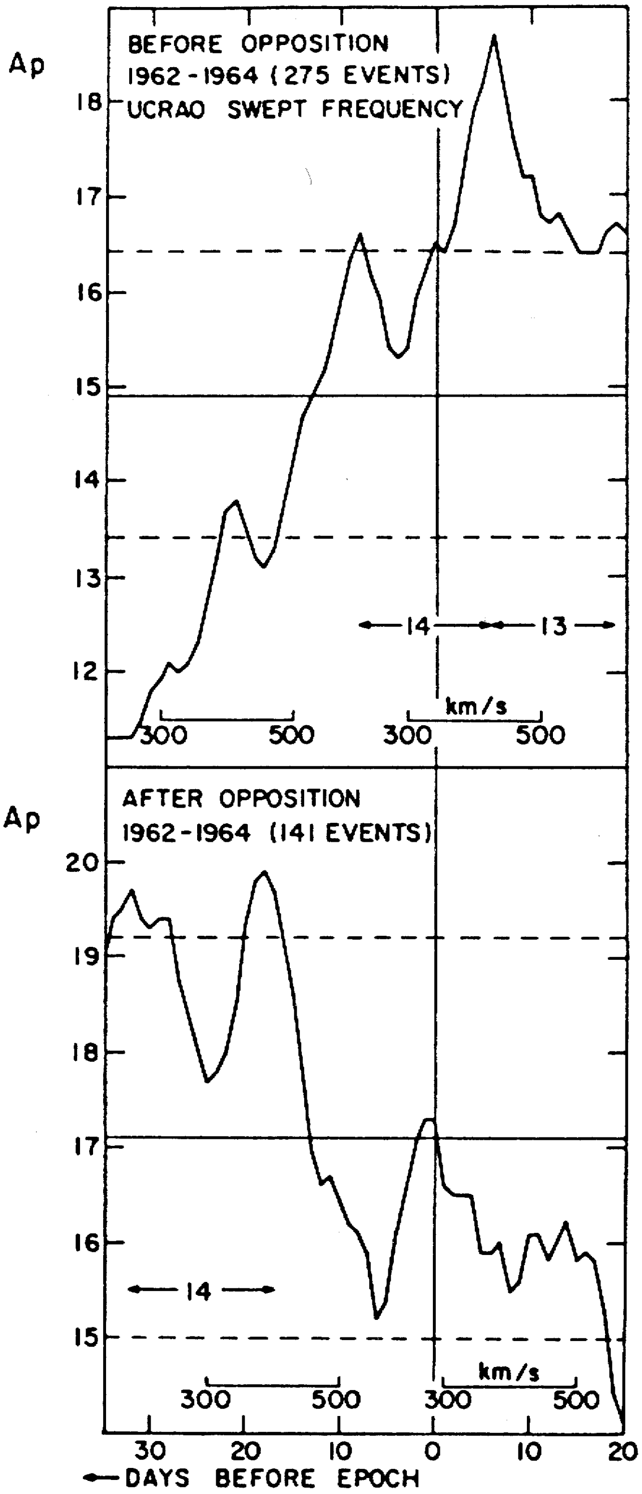

Figure 9: Superposed epoch analyses of Non–Io DAM against the geomagnetic A_p–index for swept–frequency data from 1962 through 1964. The broken lines indicate 99% confidence levels. Significant periodicities, approximating to one half of the solar rotation period, are apparent in both the before– and the after–opposition data.

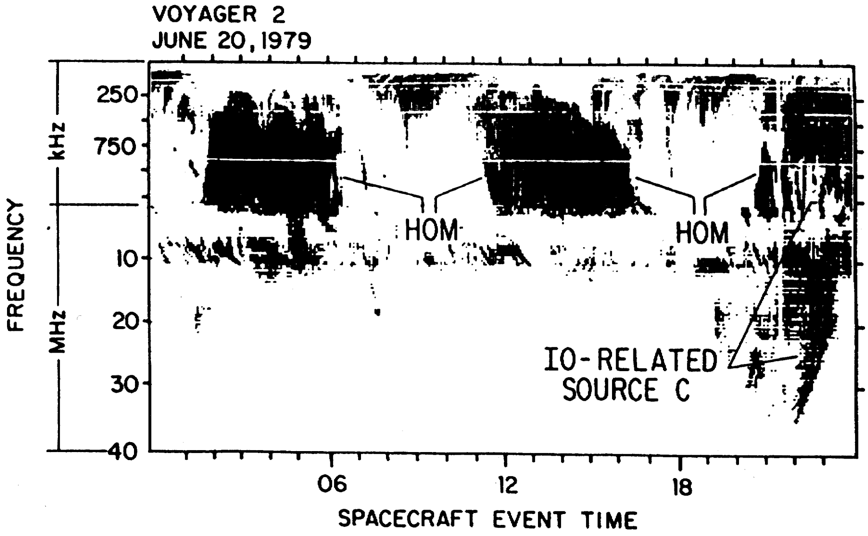

Figure 10: 24–hr frequency–time dynamic spectrum from the Voyager–2 PRA experiment, comparing HOM emission with DAM and KOM activity on June 20, 1979. Note that the Io–controlled event does not contribute significantly to the HOM emission.

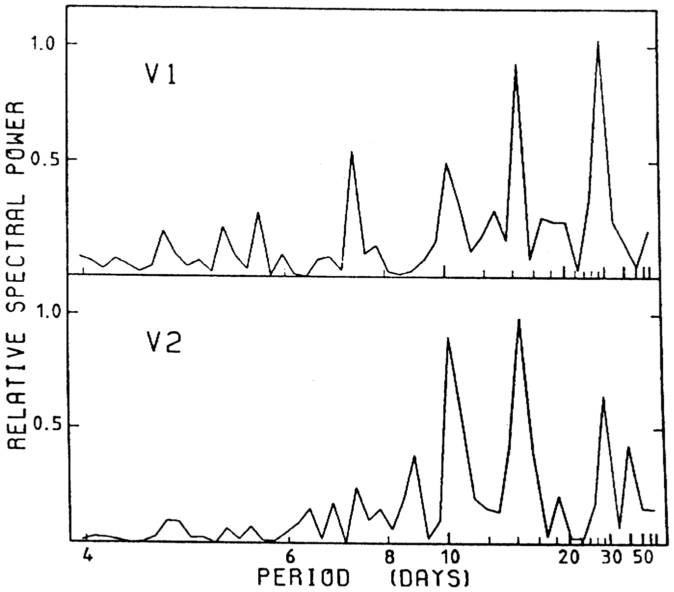

Figure 11: Power spectrum of the intensity variations observed by Voyager–1 and by Voyager–2 for the period 15 December, 1978 to 5 July, 1979. Corrections have been included for the changing distance between the spacecraft and Jupiter. Fluctuations shorter than two days have been smoothed (Zarka and Genova, 1983).

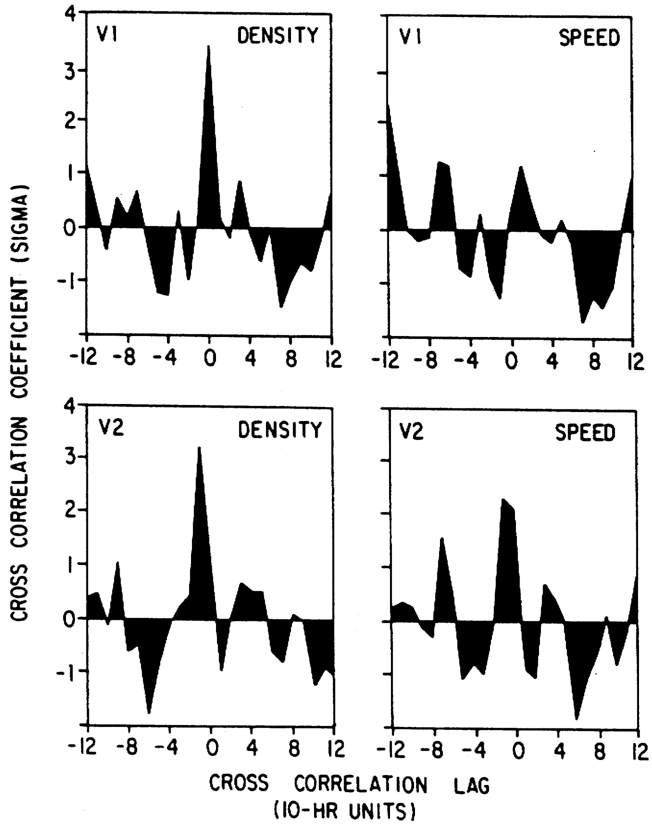

Figure 12: Cross correlation coefficient, expressed in terms of standard deviation, against time–lag in Jovian rotations (10–hr) for HOM energy, correlated with solar wind density and with solar wind velocity, for both Voyager–1 and Voyager–2 data sets.

to 14.5 days, they attributed to IMF sector structure at Jupiter and hence inferred solar wind control of the HOM.

Desch and Barrow (1984), following Desch and Rucker (1983), investigated the linear cross correlation between HOM energy and the solar wind density and velocity fluctuations at Jupiter (Figure 12). For periods of 74 and 173 days before the encounters of Voyager–1 and Voyager–2, respectively, a significant positive correlation was found between variations in the HOM energy and the solar wind density but not the solar wind velocity. The radio data are averages, per Jovian rotation (10–hr), of the total HOM energy observed within a bandwidth of about 500 to 1000 kHz by the PRA receiver low–band. The solar wind variations are also 10–hr averages, as they would appear at Jupiter after ballistic projection from the spacecraft, in the manner described by Desch and Rucker (1983). Each time series was randomized before cross correlation (Jenkins and Watts, 1968) to eliminate the tendency, present in all data sets, for adjacent points in the same set to be highly correlated.

As a further test of the validity of the cross correlation, the unrandomized Voyager–2 HOM, solar wind density and solar wind velocity profiles were autocorrelated to search for common periodicities, as shown in Figure 13 (the corresponding Voyager–1 data were not available for a sufficiently long period). It can be seen that the HOM and the density

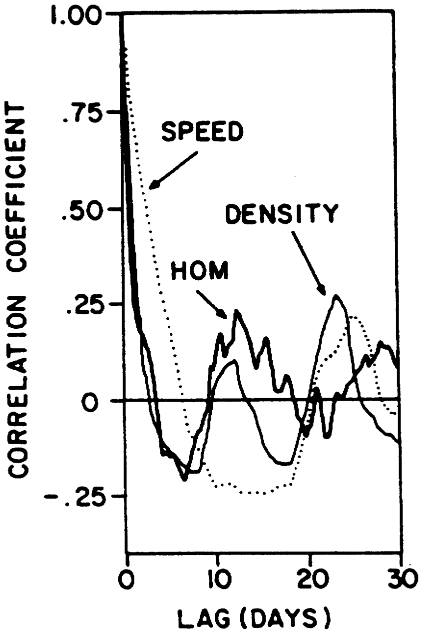

Figure 13: Autocorrelation coefficient versus time–lag in days for HOM energy, solar wind density and solar wind velocity, observed by Voyager–2.

curves have similar shapes up to about 18 days lag. Both show a peak at about 13 days and both show similar "persistence" times, that is the width of the main peak from zero days lag to the first zero crossing. This latter is an indication of the typical time scale between changes in the time series being autocorrelated. Thus the HOM and the solar wind density at Jupiter fluctuate on similar time scales. The solar wind speed autocorrelation, however, does not match the HOM auto–correlation curve in either periodicity or persistence and we conclude, therefore, that solar wind speed is not an important factor in the control of HOM.

As the solar wind density tends to increase along the leading edge of high speed streams, which are in turn related to IMF sector structure, these results seem to complement the association of Non–Io DAM with sector structure previously suggested by Barrow (1979). It will be recalled that Zarka and Genova (1983) attributed a 14.5 day periodicity in the HOM to IMF sector structure effects at Jupiter.

6.2 DAM observations by Voyager

The Voyager DAM observations have been discussed by Alexander et al. (1981); events, recorded by each spacecraft between 15 and 40 MHz, have been catalogued by Barrow (1981). There are less DAM data available than HOM data due to the lower sensitivity of the PRA receiver high–band. There are also gaps in some of the solar wind observations due to periods when one or other of the spacecraft was in the Jovian magnetotail. This imposes restrictions upon the periods available to study for possible solar wind effects. For these reasons, the method of superposed epochs was invoked, to combine the data from Voyager–1 and Voyager–2, in preference to the cross correlation technique used for the HOM. Suitable data are available for some 25 days prior to each encounter; also, for a similar period after Voyager–1 encounter, if radio data from Voyager–1 is set against solar wind data from Voyager–2. To date, the effects on the DAM of variations in solar wind density, pressure and velocity, as well as IMF magnitude, have been examined. The results of the superposed epoch analyses are summarized in Figures 14 and 15.

Superposed epoch analyses of the combined Voyager–1 and Voyager–2 data, for the two periods preceeding each encounter, are shown in Figure 14. Each analysis is normalized by expressing the correlation in terms of a modified standard error (Bell and Glazer, 1958; Barrow, 1972) which defines the confidence level. It can be seen that, for the Non–Io DAM, significant correlation is found with the solar wind density and the solar wind velocity as well as with the IMF magnitude. The solar wind pressure results closely follow those for density, as might be expected. If the Voyager–1 and Voyager–2 data are examined separately, however, we find (Figure 15) that the correlation shown in Figure 14 is almost entirely due to the Voyager–2 data. There is no suggestion of a correlation effect for the Io DAM in any of these cases.

Cross correlation, as described for the HOM in Section 6.1, can only be calculated for continuous data sets and this restricts the technique to separate examination of the Voyager–1 and Voyager–2 pre–encounter periods. Again taking the radio parameter as average energy per rotation (10–hr), but this time for the frequency band 16.4 to 19.7 MHz, correlation is found to be good for the DAM and the solar wind velocity observed by Voyager–2, but only marginal for the corresponding Voyager–1 observations. The time series were again randomized in the manner described for the HOM in Section 6.1. In this case, however, all of the DAM is included, as Non–Io event selection is not readily available for the energy averages. Clearly, cross correlation is a somewhat crude approach in the case of the DAM.

7 Discussion

The results of the superposed epoch analyses, presented in the previous section, raise the interesting question, "What might be different for the two pre–encounter periods that could give rise to the well–defined correlation seen in the Voyager–2 data and the almost complete absence of correlation for the Voyager–1 data?" The two most obvious considerations that may be relative are (i) the positions of the two spacecraft and (ii) the condition of the interplanetary medium at the line of the observations.

According to Alexander et al. (1981), the two spacecraft approached Jupiter from Sun–Jupiter–spacecraft angles [expressed in hours as "Jovian local time" (JLT)] of about 11 hr for Voyager–1 and about 9.5 hr for Voyager–2. The corresponding spacecraft Jovicentric declinations (D_e for an observer at the Earth) were about +3 deg for Voyager–1 and about +7 deg for Voyager–2. After encounter, both spacecraft followed trajectories in latitudes close to +5 deg at about 4 hr JLT for Voyager–1 and about 3 hr JLT for Voyager–2. Carr and Desch (1976) have reviewed the possible effects of beaming in the DAM and have drawn attention to the critical dependence of this upon D_e. It may be that the difference in the correlations for Voyager–1 and Voyager–2 are a result of the difference in D_e during

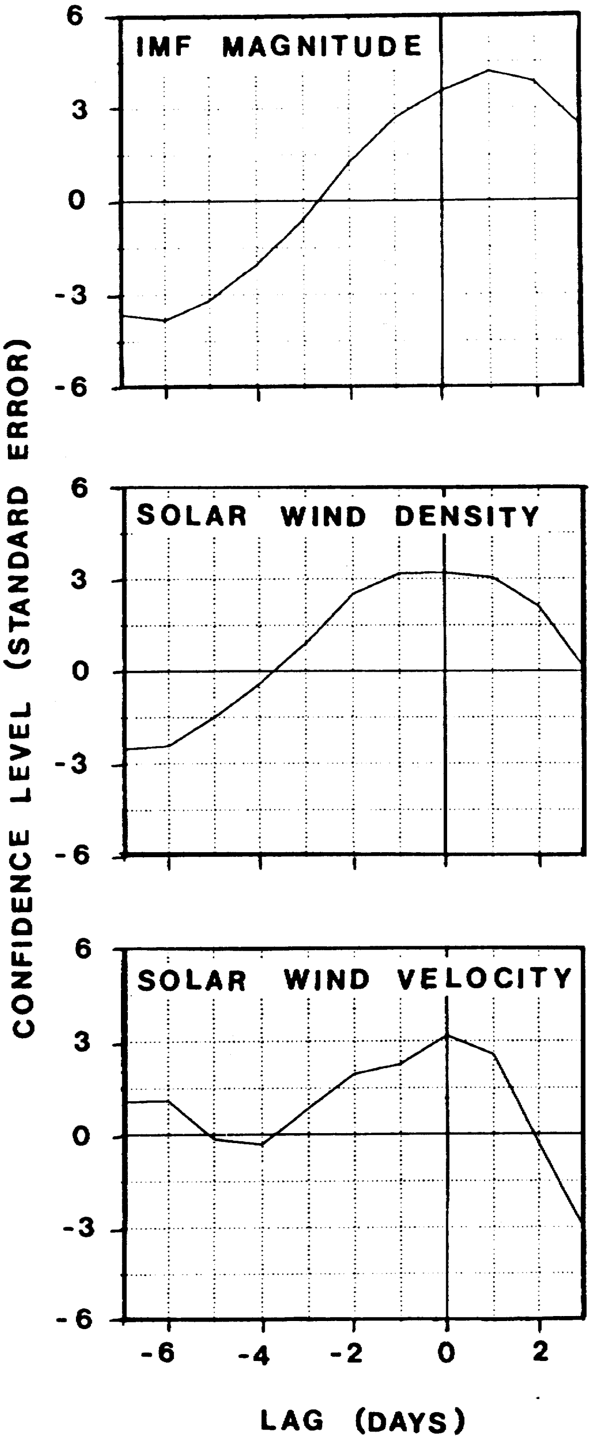

Figure 14: Superposed epoch analyses of the combined Non–Io DAM observed by both Voyager–1 and Voyager–2 during the periods preceeding each encounter.

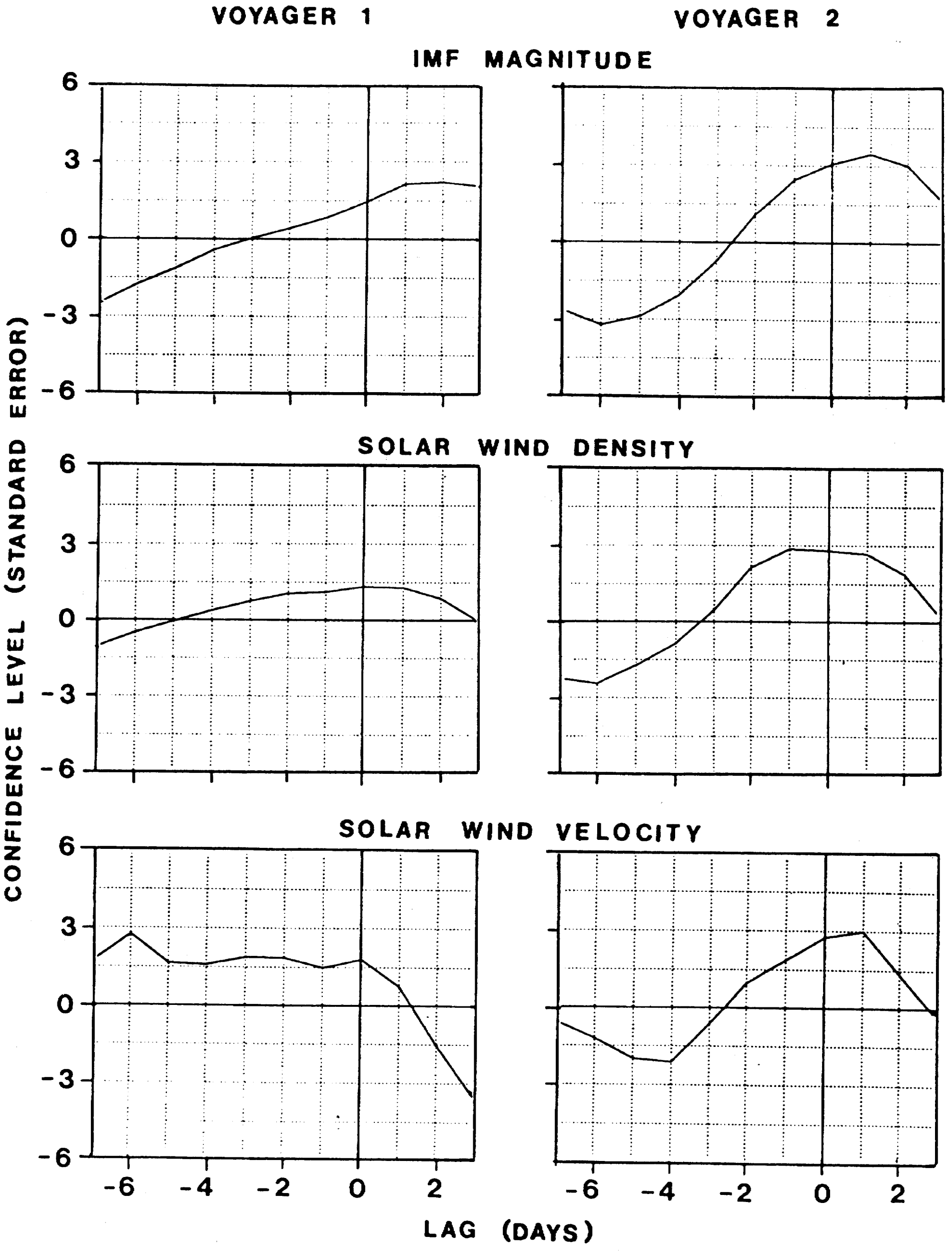

Figure 15: *Superposed epoch analyses uf the Non–Io DAM observed before each encounter by Voyager–1 and by Voyager–2.*

approach. Unfortunately, it is not possible (because of data gaps) to make an effective comparison of pre– and post–encounter correlation.

An alternative possibility is shown in Figure 16, where time profiles of the solar wind density, IMF magnitude and B_z component are compared for the six month period preceeding Voyager–2 encounter. It can be seen that, for some 50 days prior to Voyager–2 encounter, the IMF magnitude and the solar wind density both show a well–defined periodicity of some 13 days with corresponding sharp reversals of the B_z component, indicating a well–defined IMF sector structure, which is not present during the period preceeding Voyager–1 encounter. This structure is also confirmed by the autocorrelation curves shown for the HOM in Figure 13. It has already been seen, in Section 5, that correlation effects may relate back to IMF sector structure and it seems likely that the present results for the Voyager DAM data are a further manifestation of this.

No further space–borne observations are likely to be forthcoming in the foreseeable future and Earth–based observations are already, comprehensive and well documented (Warwick et al., 1975; Thieman, 1979). Further statistical investigation is possible, perhaps involving different criteria for event selection, for example, by frequency or by individual source. Kennedy et al. (1974) and Oya and Morioka (1977) considered possible effects for the Non–Io A–source emission while Terasawa et al. (1978) also included the Non–Io C–source in their study. There is little, however, to suggest that the results of a systematic source–by–source statistical analysis would differ greatly frorn those already obtained, even if sufficient data exist for such a study of the Non–Io B–source. Most investigations so far have separated Non–Io emission using the well–known CML and Io–phase criteria given by Carr and Desch (1976). It may well be more profitable to re–define Io and Non–Io emission, perhaps on the basis of spectral characteristics, as suggested by Genova (1984). Even if correlation studies can be further refined, however, the question of the fundamental relation may remain unresolved due to intercorrelation between the various solar parameters.

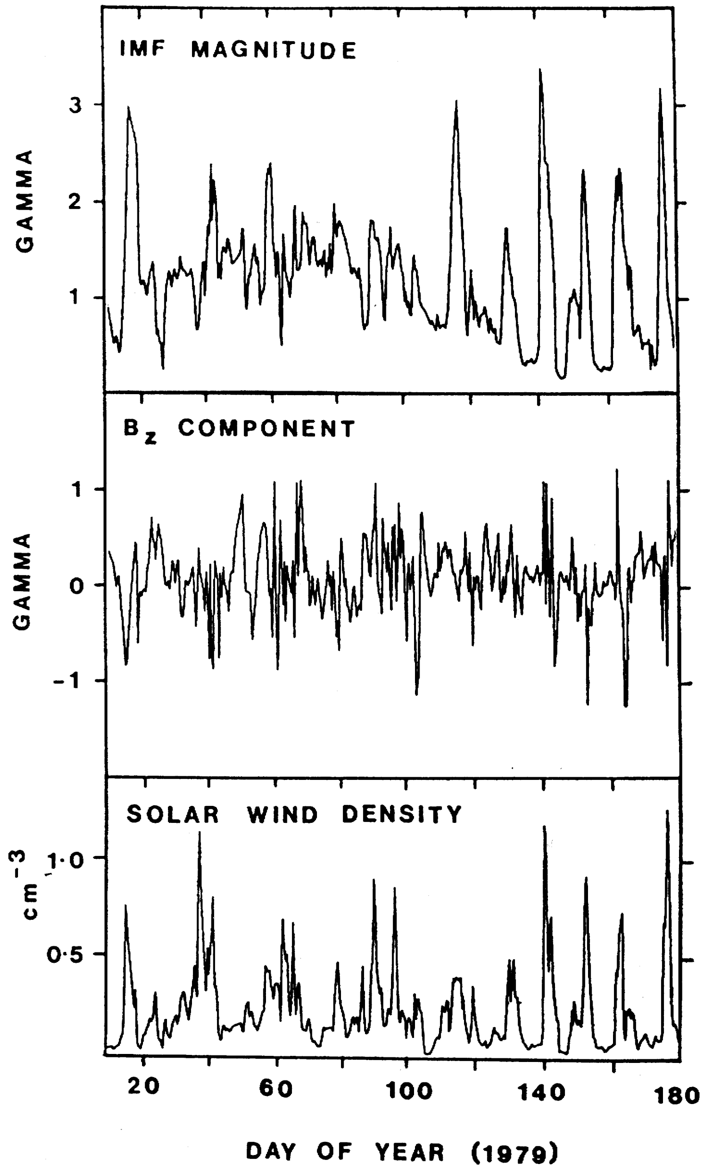

Figure 16: Variation of the the magnitude, the B_z component and the solar wind density observed by Voyager–2 during the six–month period preceeding encounter.

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Discussion

Question:

It seems that the solar wind correlates better with the Saturn kilometric radiation than with the Jovian hectometric radiation. How do you explain this?

Barrow:

I don't think that there can be any explanation until the two radio emission mechanisms are better understood.

Question:

You have done correlation studies between the Jovian hectometric radiation and the solar wind density and velocity. Did you also try to correlate with the ram pressure and the energy flux?

Barrow:

We started off with the ram pressure, because this showed the best correlation result with the Saturn kilometric radiation. In the case of Jupiter, however, we found that the solar wind density gave the best result, in fact the only really significant result.