8. T. G. Northrop, C. K. Goertz, M. R. Thomsen, *ibid.* **79**, 3579 (1974).
9. R. L. McNutt, Jr., J. W. Belcher, J. D. Sullivan, F. Bagenal, H. S. Bridge, *Nature (London)* **280**, 803 (1979).
10. F. M. Neubauer, *Geophys. Res. Lett.* **5**, 905 (1978).
11. A. L. Broadfood *et al.*, *Science* **204**, 979 (1979).
12. M. G. Kivelson and G. R. Winge, *J. Geophys. Res.* **81**, 5853 (1976).
13. J. Belcher and H. S. Bridge, personal communication.
14. We thank our colleagues in the Voyager Project for discussions of these early results and the entire Voyager team for the success of this experiment. We also thank G. Sisk, E. Franzgrote, M. De Gyurky, and C. Brower of JPL for their support; C. Moyer, J. Scheifele, J. Seek, and E. Worley for contributions to the design, development, and testing at GSFC of the experiment instrumentation; and G. Burgess, T. Carleton, C. Cressy, P. Harrison, D. Howell, W. Mish, L. Klein, L. Moriarty, A. Silver, M. Silverstein, K. Simms, and T. Volmer of the data analysis team at GSFC. Finally, we thank J. W. Belcher and H. S. Bridge for allowing us to refer to their plasma data in regard to the Ganymede-related perturbations. The possibility that these disturbances might extend over a relatively large distance from Ganymede was noted by one of us in a discussion with J. Belcher concerning a plot of plasma data which he prepared. One of us, F.M.N., was supported financially by the German Ministry of Science and Technology.

26 September 1979

Plasma Observations Near Jupiter: Initial Results from Voyager 2

Abstract. *The first of at least nine bow shock crossings observed on the inbound pass of Voyager 2 occurred at 98.8 Jupiter radii* (R_J) *with final entry into the magnetosphere at 62* R_J. *On both the inbound and outbound passes the plasma showed a tendency to move in the direction of corotation, as was observed on the inbound pass of Voyager 1. Positive ion densities and electron intensities observed by Voyager 2 are comparable within a factor of 2 to those seen by Voyager 1 at the same radial distance from Jupiter; the composition of the magnetospheric plasma is again dominated by heavy ions with a ratio of mass density relative to hydrogen of about 100/1. A series of dropouts of plasma intensity near Ganymede may be related to a complex interaction between Ganymede and the magnetospheric plasma. From the planetary spin modulation of the intensity of plasma electrons it is inferred that the plasma sheet is centered at the dipole magnetic equator out to a distance of 40 to 50* R_J *and deviates from it toward the rotational equator at larger distances. The longitudinal excursion of the plasma sheet lags behind the rotating dipole by a phase angle that increases with increasing radial distance.*

This is a preliminary report of results obtained by the Voyager plasma experiment during the encounter of Voyager 2 with Jupiter from about 100 R_J before periapsis to about 300 R_J after periapsis. The instrument is identical to that flown on Voyager 1 (*1*) and has been described in detail in (*2*). We discuss here (i) the crossings of the bow shock and magnetopause observed on the inbound and outbound passes, (ii) the radial variation of plasma properties in the magnetosphere, (iii) variations in plasma properties near Ganymede, (iv) corotation and composition of the plasma in the dayside magnetosphere, and (v) plasma sheet crossings observed on the inbound and outbound passes.

It is interesting to compare the Voyager 2 results with those of Voyager 1, and in this regard some differences between the trajectories of the two spacecraft should be borne in mind as well as some limitations of the preliminary analysis used for both data sets. Figure 1 shows the trajectories of the two spacecraft projected onto the equatorial plane of Jupiter. The closest approach to Jupiter was 4.9 R_J for Voyager 1 and 10.1 R_J for Voyager 2. A second significant difference is the angle between the asymptote to the outbound trajectory and the Jupiter-sun line, ~ 115° for Voyager 1 and ~ 133° for Voyager 2. As a consequence of these differences in the trajectory, Voyager 2 did not penetrate the dense plasma of the Io torus and data were obtained only in the region referred to in (*1*) as the outer magnetosphere. It is apparent from Fig. 1 that the trajectory of Voyager 2 was better suited to study a possible Jovian magnetotail than that of Voyager 1 and this fact is evident in some observations discussed below.

A detailed analysis of the positive ion and electron data obtained during the Voyager encounters with Jupiter is in progress, but definitive results for plasma parameters will not be available for some time. We have used a crude first-order analysis that gives a lower limit for the number density of positive ions and a good estimate of the variation of the electron intensity with distance. The ion densities in this report and in (*1*) should be taken as lower limits since two important effects have been neglected in the preliminary analysis: first, the geometrical response which depends on the Mach number and direction of the flow has been treated in a very approximate way and, second, calculation of the number density, n, depends on the composition of the ions. We have computed n assuming that the positive ions are protons, but most of the low-energy ions have $A/Z^* > 8$ (*3*) (A is atomic mass number and Z^* is effective charge number); hence the actual density has been underestimated by about a factor of 3. The positive ion number densities and electron intensities computed in this way for Voyager 1 and 2 are believed to be directly comparable, and relative values at the same radial distance are probably accurate to better than a factor of 2.

Table 1 includes all boundary crossings separated by an interval greater than 96 seconds that occurred on the inbound pass, and is complete for the outbound pass to 1703 UT on day 215. Many of the observed bow shock crossings, as well as all the bow shock crossings observed by Voyager 1, were of the laminar type. However, the first bow shock crossing observed by Voyager 2 was of the pulsation type (*4*); as expected for a pulsation shock, wave disturbances were observed upstream of the shock. These upstream waves had periods of the order of 5 minutes and were evident in the plasma density and other parameters.

The number of boundary crossings was large, and it was not possible to show individual events along the trajectory plot of Fig. 1. Thus the locations of the first and last bow shock crossings observed along the inbound trajectory of Voyager 2 are shown on the appropriate trace in Fig. 1, and the first and last magnetopause crossings are shown in a similar way. For comparison, similar first and last locations of the boundaries seen during the Voyager 1 encounter are indicated on the Voyager 1 trajectory. Data for magnetopause and shock crossings observed on the outbound trajectory of Voyager 2 are not yet complete; the first magnetopause and shock crossings are shown but there may be additional crossings after day 215. Although there are boundary layer effects, normal magnetosheath plasma is observed on the outbound pass; for example on day 206 at 1030 UT the shocked solar wind in the magnetosheath had an ion number density of 0.7 cm^{-3}, a flow speed of 325 km/sec from 15° east of the spacecraft-sun line, a thermal speed of ~ 100 km/sec, and a momentum flux density of ~ 770 eV/cm^3. Most of the ions in the magnetosheath are protons.

All the magnetopause crossings, with the exception of two during the outbound pass, occurred at subspacecraft system III (1965.0) longitudes ranging from 225° to 33°, with 9 out of 14 crossings in the range 225° to 351°, in fair

0036-8075/79/1123-0972$01.25/0

agreement with the prediction of 290° ± 65° by Dessler and Vasyliunas (5). Because this prediction was not verified by Voyager 1—in fact, all the Voyager 1 magnetopause crossings lay outside the predicted range (1)—it is not clear whether this is more than a statistical fluke.

The dynamic pressure of the incident solar wind during the Voyager 2 encounter has been predicted by using data from Voyager 1. We have not yet attempted to predict boundary crossings with these data, but because it is of general interest the pressure profile is reproduced in Fig. 2. A typical delay time from Voyager 2 to Voyager 1 is about 42 hours.

The variation of positive ion "number density" as a function of radial distance for the inbound pass of Voyager 1 was shown in figure 3 of (1); the result for Voyager 2 computed in the same way is, within a factor of 2, indistinguishable from the curve for Voyager 1. Minor differences are caused by the current sheet crossings occurring at different radial distances on the two trajectories. Inside 35 R_J on the inbound pass of Voyager 2 our lower limit for the number density of protons and heavy ions was comparable to electron densities reported by Gurnett *et al.* (6) on the basis of results from the plasma wave experiment. A similar result was obtained on Voyager 1.

Both sets of positive ion data were obtained mainly from the D sensor, which was mounted on the spacecraft so that a corotating supersonic plasma would flow directly into the sensor; that is, the plasma velocity vector would be nearly parallel to the axis of symmetry of the detector. During most of the inbound magnetospheric passes of Voyager 1 and 2, signals were observed in the D sensor and not in the A, B, and C sensors of the main cluster, indicating a general tendency of the low-energy magnetospheric plasma in the sunward hemisphere to move in the direction of corotation. These observations do not show that there is no other component of velocity—inward, outward, or along the field—but they do show that there exists a component in the direction of corotation, shown by further analysis (1, 7) to be comparable to or smaller than that expected on the basis of rigid corotation of field and plasma.

Figure 3 shows the variation of low-energy electrons with distance. The data are for the inbound passes and the curve for Voyager 1 has been displaced upward by two decades to avoid confusion of the data sets. Crossings of the magnetic dipole equator are indicated by arrows; there are more crossings for Voyager 2

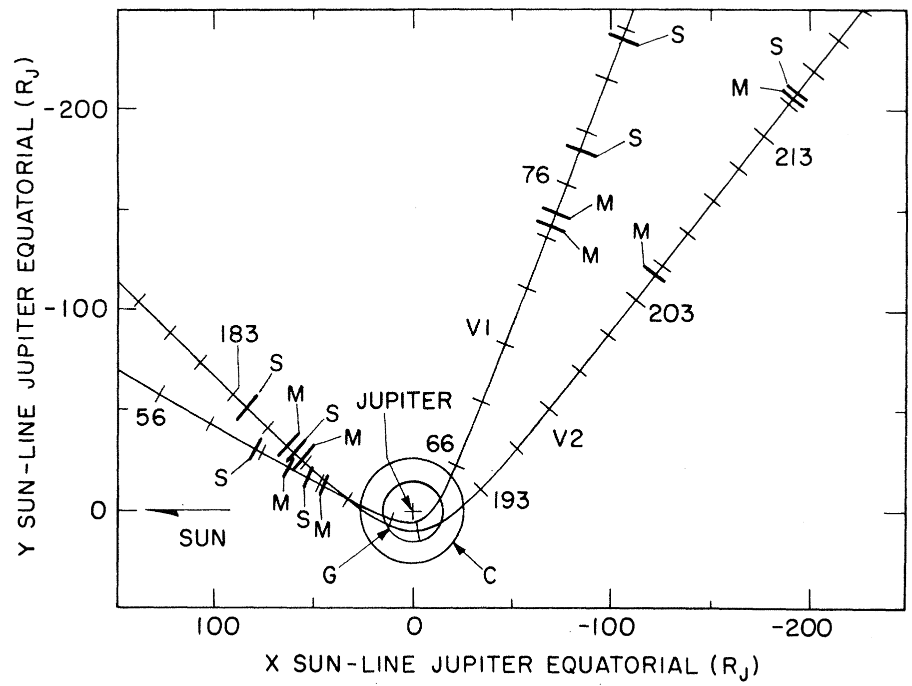
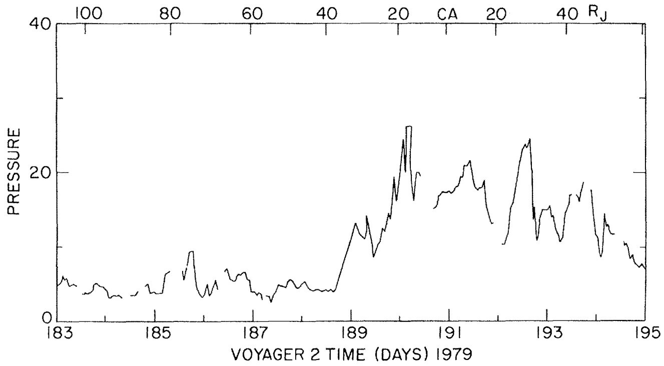


Fig. 1. Voyager 2 and 1 trajectories during their encounters with Jupiter. The trajectories of the spacecraft and the orbits of Callisto (*C*) and Ganymede (*G*) are shown as projections onto the equatorial plane of Jupiter. Tick marks are shown every 2 days. Bars on the trajectories labeled *S* indicate the first and last bow shock crossings observed on the inbound and outbound portions of the trajectory; bars labeled *M* have a similar meaning for crossings of the magnetopause. Distances are in units of Jupiter radii where 1 R_J = 71,398 km.

Table 1. Bow shock (S) and magnetosphere (M) boundaries observed by the Voyager plasma experiment (DOY, day of year; 1 January is day 1).

Boundary*	Spacecraft event time: DOY	Hours and minutes	Distance (R_J)	System III longitude
		Inbound pass		
S-Sh	183	1619	98.8	99°
S-Ip	183	1622	98.8	100°
S-Sh	183	1643	98.6	113°
S-Ip	183	1650	98.5	117°
S-Sh	183	1651	98.5	118°
S-Ip	183	1924	97.3	210°
S-Sh	184	1736	86.6	294°
M-Ms†	185	2335	71.7	299°
M-Sh	186	0113	70.9	358°
S-Ip	186	0519	68.8	146°
S-Sh	186	0955	66.5	312°
M-Ms	186	1843	61.9	270°
		Outbound pass		
M-Sh	> 204	1522	> 169.1	
	< 204	2340	< 172.8	
M-Ms	205	~ 0135	~ 173.7	~ 107°
M-Sh	205	~ 0516	~ 175.3	~ 235°
M-Ms	205	0559	175.6	262°
M-Sh	205	0927	177.1	26°
M-Ms	206	0051	183.9	225°
M-Sh	206	0409	185.3	345°
M-Ms	208	~ 1837	212.5	90°
M-Sh	> 212	1733	> 253.1	
	< 213	0605	< 258.4	
M-Ms	213	~ 1515	262.3	359°
M-Sh	213	~ 1545	262.5	17°
M-Ms	215	0621	278.8	337°
M-Sh	215	0722	279.2	14°
M-Ms	215	0733	279.3	21°
M-Sh	215	0754	279.4	33°
S-Ip	215	1441	282.3	279°
S-Sh	215	1625	283.0	342°
S-Ip	215	1703	283.3	5°

*After the boundary crossing the spacecraft was in the: Ip, solar wind; Sh, magnetosheath; or Ms, magnetosphere, as indicated. †The period between day 185 at 2335 and day 186 at 0113 UT includes about ten magnetopause crossings or near crossings.



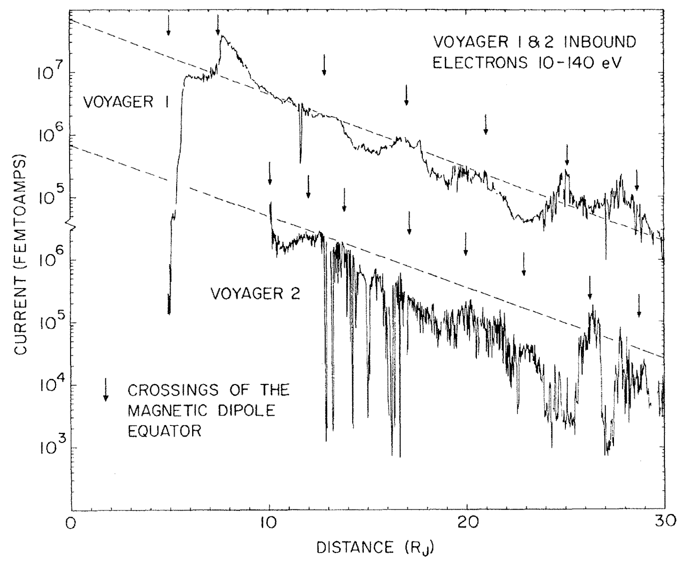


Fig. 2 (left). The solar wind pressure at Voyager 2 predicted on the basis of solar wind data measured at Voyager 1. Voyager 2 time is the spacecraft event time at Voyager 2; *CA*, closest approach. The pressure is in units of 10^{-10} dyne/cm^2. Fig. 3 (right). Electron "intensities" observed during the inbound passes of Voyager 1 and 2 as a function of radial distance. The abscissa gives the zenocentric distance in units of Jupiter radii; the ordinate gives the measured current produced by plasma electrons in the energy interval 10 to 140 eV. The upper curve refers to Voyager 1 and has been offset vertically by two orders of magnitude (note the broken scale on the ordinate). Arrows indicate crossings of the equatorial plane of the magnetic dipole.

because of its lower speed. Superficially at least, the two curves are remarkably similar; the intensities of low-energy electrons measured by Voyager 1 and 2 appear to be roughly equal at the same radial distance. Moreover, this is also true on the outbound pass out to at least 30 R_J.

A possible difference between the data sets is evident in the large short-time decreases in density that occur in both the positive ion and the electron data of Voyager 2. These decreases occur on the inbound pass between 40 and 20 R_J and represent signal "dropouts" to the noise level of the instrument. They were not seen on Voyager 1 and their origin is not yet understood.

In contrast, the signal decreases between 17 and 12 R_J show quantitative differences from those just discussed and may be related to a Ganymede wake as suggested by Ness *et al.* (*8*). To visualize the experimental situation more clearly we show in Fig. 4 the regions of depleted plasma in a Ganymede-centered isometric projection. The spacecraft passed 17 Ganymede radii (R_G) downstream of Ganymede in the sense of corotational flow and 18 R_G below the Ganymede orbital plane. Figure 4 shows that the central plasma dropout is almost precisely at the expected position (in the orbital plane projection) of the Ganymede wake, and the others occur nearly symmetrically on both sides out to a lateral distance of about 60 R_G (2.2 R_J). The close spatial association of the dropouts with the location of Ganymede and the fact that they have not been observed elsewhere strongly suggest that the dropouts are a feature of the interaction of Ganymede with the magnetospheric plasma. They could, of course, represent either a true absorption of particles or a shift of the energy spectrum to unobservable values. However, the interaction must be considerably more complicated than simple formation of a cavity by absorption (as, for example, the interaction of the moon with the solar wind) if it is to produce the observed large effects at distances of up to 60 R_G from the expected wake axis.

A major result of the Voyager 1 encounter was that throughout the Jovian magnetosphere the plasma is composed of various atomic and molecular species moving in the general direction of corotation (*1, 3, 7*); the Voyager 2 observations support and extend that result. A high-resolution (M mode) spectrum from Voyager 2 is shown in Fig. 5. This spectrum was taken at 22 R_J on the inbound pass at a magnetic latitude of $-7.7°$ and is atypical in that it shows well-resolved peaks, that is, the plasma is unusually cold. This spectrum was analyzed by fitting it to a sum of convected isotropic Maxwellian distribution functions with a common component of velocity along the sensor axis. We obtain an acceptable fit to this spectrum if the sum includes components at $A/Z^* = 1, 2, 8, 10^2/_3$, and 16; limits for the contribution to the sum from components at $A/Z^* = 4$, 23, and 32 have not yet been established. The $A/Z^* = 2$ component, shown by the shoulder at about 400 V, is probably He^{2+} which has not been seen in any Voyager 1 spectra that we have yet analyzed. A comparison of this spectrum and its analysis with a Voyager 1 spectrum taken in essentially the same location 4 months earlier shows that the ion kinetic temperature measured by Voyager 2 is about three times higher than that seen with Voyager 1. This difference may reflect a temporal change or possibly the approximately 0.8° difference in latitude between the spacecraft. The highly resolved positive ion spectra occasionally seen within 30 R_J on Voyager 1 were not observed on Voyager 2. In agreement with the Voyager 1 results (*3*), the mass density of the magnetospheric plasma seen with Voyager 2 is dominated by heavy ions with a ratio of about 100/1 relative to hydrogen.

The fit to the data of Fig. 5 gives a common component of velocity for all species of ~ 210 km/sec, which is significantly below the value of ~ 263 km/sec expected on the basis of exact corotation. This result is in good agreement with the Voyager 1 observations reported by McNutt *et al.* (*7*) that between 11 and 22 R_J the proton bulk speed into the D sensor was consistently less than the corotation value. A theoretical interpretion of these results has been given by Hill (*8a*). A similar analysis has been carried out on low-resolution (L mode) Voyager 2 spectra between 18 and 25 R_J inbound and around 23 R_J outbound (in the latter case the spacecraft was reoriented so that the D sensor faced into the corotation direction); the results concerning corotation are essentially the same as those of (*7*) and furthermore confirm the ~ 100/1 mass density ratio of heavy ions to hydrogen obtained from the spectrum of Fig. 5.

Superimposed on the overall radial profile of the plasma electron and ion intensities is a modulation by the rotation of Jupiter, peak intensities being observed once or twice per rotation period. The simplest interpretation associates the peak intensities with the spacecraft's traversals of a region of enhanced plasma intensity (often called the plasma sheet) which is centered around the current sheet and hence lies in a surface whose normal is tilted by an angle λ_c from the planet's rotation axis; if the spacecraft latitude λ is less in magnitude than λ_c, two crossings of the plasma sheet (or current sheet) per planetary rotation are expected, at longitudes ϕ given by the two roots of the equation

$$\cos(\phi - \delta) = \cot \lambda_c \tan \lambda \qquad (1)$$

If $|\lambda| > \lambda_c$, only an approach to the plasma sheet once per rotation, without a crossing, is expected. The phase angle δ is constant if the center of the plasma sheet lies rigidly in the dipole magnetic equatorial plane; $\delta = 22°$ in system III (1965.0) coordinates for the O4 model (*9*). However, if the information about the rocking magnetic dipole propagates to the outer magnetosphere at a finite speed (*10, 11*) δ will increase with increasing radial distance; from an empirical fit to the Pioneer 10 outward pass, Kivelson *et al.* (*10*) found for $R > 14\ R_J$ that $\delta = 22° + 0.85° (R - 14)$.

Modulation of the plasma electron intensity with peaks occurring twice per planetary rotation was observed during the inbound passes of both Voyager 1 and 2, out to approximately 80 R_J during the outbound pass of Voyager 1 (*1*) and out to some 80 to 100 R_J during the outbound pass of Voyager 2. Here we present an analysis of the combined data set from all four Voyager passes. Crossings of the center of the plasma sheet were identified by peaks in the 140- to 6000-eV electron intensity, to an estimated accuracy of $\pm 1/2$ hour in time or approximately $\pm 20°$ in longitude. For each (nonoverlapping) pair of crossings, the average and the difference of the two longitudes were computed. It is readily shown that the average of the two roots of Eq. 1 is equal to δ, while their difference $\Delta\phi$ is independent of δ and is related to the maximum latitude λ_c of the current sheet or plasma sheet center by

$$\cos(\Delta\phi/2) = \cot \lambda_c \tan \lambda \qquad (2)$$

Figure 6A shows the average longitude of each pair as a function of radial distance, compared with the prediction based on a rigid current sheet model (R) and on the model of Kivelson *et al.* (*10*) (K). For both the Voyager 1 and 2 outbound passes, the agreement with the Kivelson model is excellent all the way to distances 80 to 100 R_J, the difference between the model and any one observation never exceeding the observational uncertainty. (The curve K is simply a representation of the Kivelson *et al.* formula and is not a fit to the present data set.) For the two inbound passes, five of the six points are in good agreement with either the K or the R models; the difference between the two models is slight over the limited range of radial distances covered by the inbound passes.

Figure 6B shows the maximum latitude λ_c reached by the center of the plasma sheet during a planetary rotation, calculated from the observed differences of longitudes for each pair of crossings by means of Eq. 2. The error bars shown correspond to the $\pm 20°$ uncertainty in identifying the longitude of a crossing. (Large error bars are associated with values of $\Delta\phi$ near 180°, which occur typically at low spacecraft latitudes; three inbound points with error bars exceeding 50° have been omitted from the figure.) Out to a distance of about 40 to 50 R_J, the inferred maximum latitudes are generally consistent, given the large error bars, with a dipole tilt of 9.6°. Beyond 50 R_J, the maximum latitudes are lower than 9.6°, as noted already for Voyager 1 in (*1*); the Voyager 2 results are remarkable in displaying a nearly constant maximum latitude $5° \pm 1°$ from 55 R_J to 95 R_J. Beyond 90 R_J, adjacent pairs of plasma sheet crossings are observed only sporadically or not at all, suggesting that λ_c lies below the latitude of the spacecraft (shown by the lines marked V1 and V2 for Voyager 1 and Voyager 2, respectively).

It thus appears that the plasma sheet is fairly well centered about the magnetic dipole equatorial plane out to about 40 to 50 R_J, but beyond that distance it tilts out of that plane toward lower latitudes, that is, closer to the rotational equatorial plane. A simple model for such a configuration is a "hinged" sheet (*12, 13*) that coincides with the magnetic equator out to a fixed distance R and then becomes parallel to the rotational equator. The maximum latitudes predicted by this model for the hinge distances R = 40, 60, and 80 R_J are shown by dotted lines in Fig. 6B. The model with $R = 40\ R_J$ provides a fairly reasonable (although far from perfect) fit to the data set as a whole.

Possible reasons for the deviation of the plasma sheet or current sheet out of the magnetic dipole equator have been mentioned (*1*). Another possibility that has been suggested is a solar wind interaction leading to the formation of a magnetotail similar to that of the earth's magnetosphere, so that the plasma sheet at large distances should be aligned with

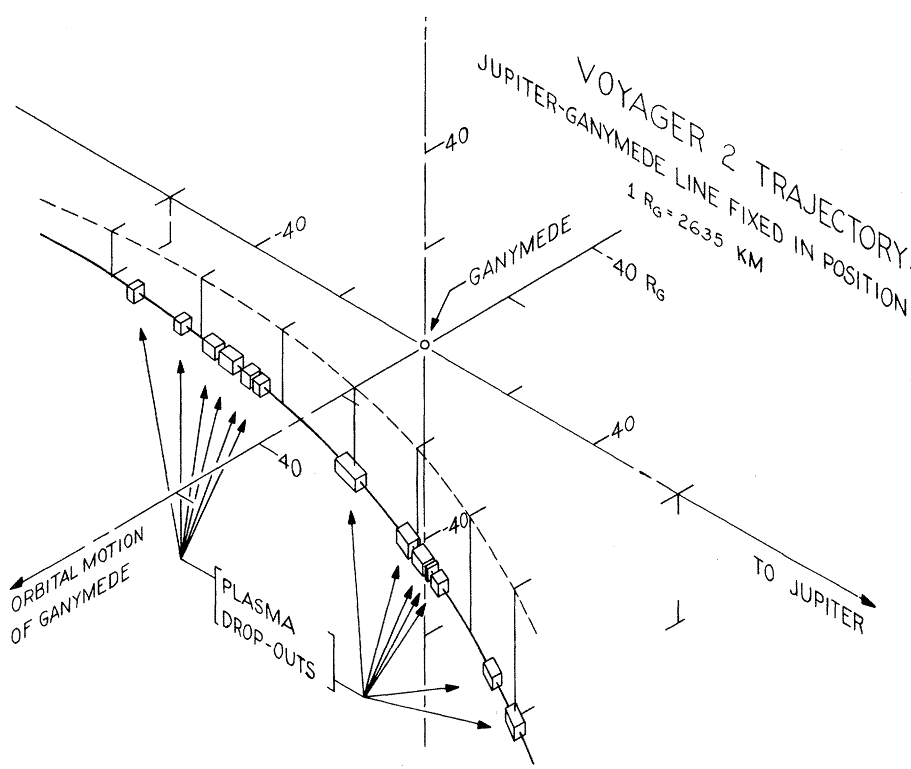


Fig. 4. Isometric view of the Voyager 2 trajectory near Ganymede. The solid line represents the trajectory in space; boxes indicate the locations of the observed plasma dropouts. The dashed line is the projection of the trajectory on the orbital plane of Ganymede; 27.1 R_G = 1 R_J.

solar wind flow; that Voyager 1 did pass through a Jovian magnetotail was argued by Ness *et al.* (*14*) on the basis of magnetic field observations. Another possibility is centrifugal effects, which would tend to bring the distant plasma sheet closer to alignment with the rotational equator. Simple theories for the structure of a static, centrifugally dominated current sheet have been given by Hill *et al.* (*15*) and by Goertz (*16*). These theories predict a maximum latitude not less than 6.4°, but in view of their many simplifications [for example, assumption of a dipolar field and neglect of the finite propagation effects implied by the experimentally verified model of Kivelson *et al.* (*10*)] it is not clear whether the discrepancy with the 5° ± 1° observed by Voyager 2 is serious; furthermore, possible dynamical effects such as centrifugal instability [see, for example, Hill and Michel (*17*)] have not been quantitatively modeled. A distinction between solar wind and centrifugal effects is difficult to make on geometrical grounds, since the solar wind flow direction is, within a few degrees, parallel to Jupiter's rotational equator.

H. S. BRIDGE, J. W. BELCHER
A. J. LAZARUS, J. D. SULLIVAN
F. BAGENAL, R. L. MCNUTT, JR.
Center for Space Research, Massachusetts Institute of Technology, Cambridge 02139

K. W. OGILVIE
J. D. SCUDDER
E. C. SITTLER
Laboratory for Extraterrestrial Physics, Goddard Space Flight Center, Greenbelt, Maryland 20771

V. M. VASYLIUNAS
C. K. GOERTZ
Max-Planck-Institut für Aeronomie, D-3411 Katlenburg-Lindau, West Germany

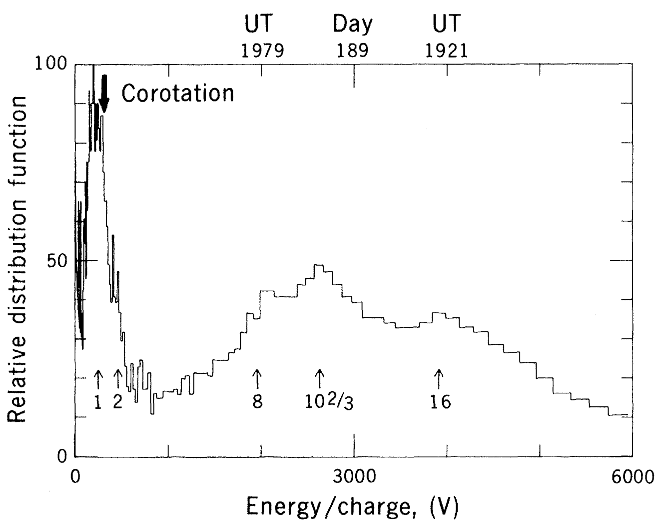


Fig. 5. The energy per charge spectrum obtained by the D sensor on day 189 at 1921 UT when the spacecraft was at 22 R_J and at a magnetic latitude of −7.7°. The heavy arrow labeled *Corotation* marks the expected location of a peak that would be produced by protons moving with the geometrically expected corotation velocity. The light arrows mark the locations of various A/Z^* values, assuming the lowest peak is due to protons.

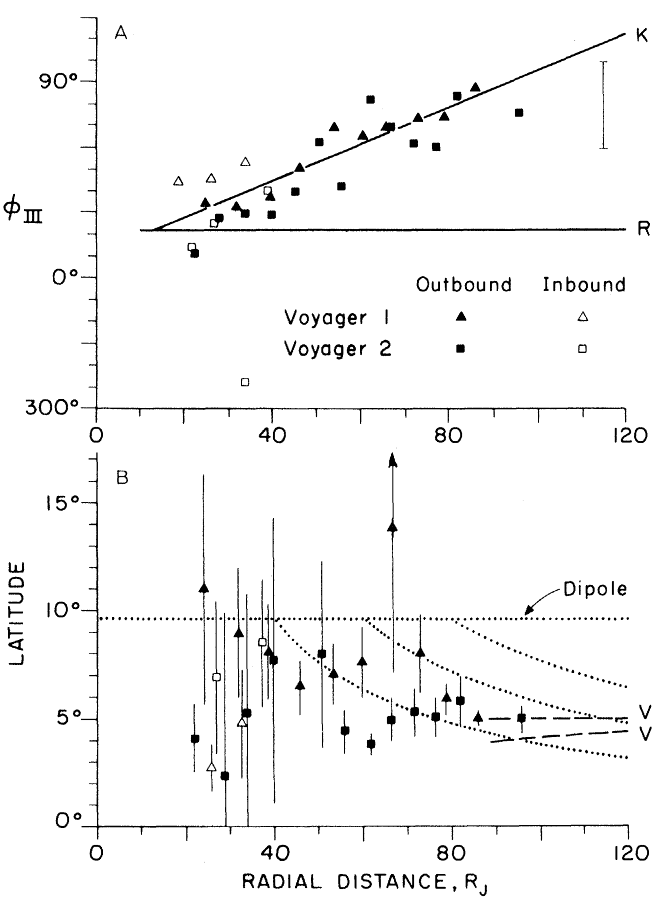


Fig. 6. (A) The average longitude of pairs of plasma sheet crossings as a function of radial distance, for all Voyager passes. The uncertainty in each point of ± 20° is indicated by the error bar in the upper right. (B) Maximum latitude (measured from the rotational equator) reached by the center of the plasma sheet during one planetary rotation, inferred from the longitude difference in pairs of plasma sheet crossings, as a function of radial distance. See text for further details.

References and Notes

1. H. S. Bridge *et al.*, *Science* **204**, 987 (1979).
2. H. S. Bridge *et al.*, *Space Sci. Rev.* **21**, 259 (1977).
3. J. D. Sullivan and F. Bagenal, *Nature (London)* **280**, 798 (1979).
4. N. F. Ness, personal communication.
5. A. J. Dessler and V. M. Vasyliunas, *Geophys. Res. Lett.* **6**, 37 (1979).
6. D. A. Gurnett, W. S. Kurth, F. L. Scarf, *Science* **206**, 987 (1979).
7. R. L. McNutt, Jr., J. W. Belcher, J. D. Sullivan, F. Bagenal, H. S. Bridge, *Nature (London)* **280**, 803 (1979).
8. N. F. Ness, M. H. Acuña, R. P. Lepping, L. F. Burlaga, K. W. Behannon, F. M. Neubauer, *Science* **206**, 966 (1979).
8a. T. W. Hill, *J. Geophys. Res.*, in press; *Science*, in press.
9. N. F. Ness, M. H. Acuña, R. P. Lepping, L. F. Burlaga, K. W. Behannon, F. M. Neubauer, *Science* **204**, 982 (1979).
10. M. G. Kivelson, P. J. Coleman, L. Froidevaux, R. L. Rosenberg, *J. Geophys. Res.* **83**, 4823 (1978).
11. T. G. Northrop, C. K. Goertz, M. F. Thomsen, *ibid.* **79**, 3579 (1974).
12. C. T. Russell and K. J. Brody, *ibid.* **72**, 6104 (1967).
13. E. J. Smith, L. Davis, Jr., D. E. Jones, P. J. Coleman, Jr., D. S. Colburn, P. Dyal, C. P. Sonett, A. M. A. Frandsen, *ibid.* **79**, 3501 (1974).
14. N. F. Ness, M. H. Acuña, R. P. Lepping, K. W. Behannon, L. F. Burlaga, F. M. Neubauer, *Nature (London)* **280**, 799 (1979).
15. T. W. Hill, A. J. Dessler, F. C. Michel, *Geophys. Res. Lett.* **1**, 3 (1974).
16. C. K. Goertz, *J. Geophys. Res.* **81**, 3368 (1976).
17. T. W. Hill and F. C. Michel, *ibid.*, p. 4561.
18. We thank the entire Voyager team at NASA headquarters and Jet Propulsion Laboratory for support of this experiment. We have benefited from discussions with A. Nishida, G. L. Siscoe, and other Voyager investigators. The possibility that the plasma dropouts between 12 and 17 R_J inbound might be associated with Ganymede was suggested by L. F. Burlaga. The plasma data analysis involves a joint effort between the magnetometer and plasma experimenters; we especially thank the Goddard Space Flight Center scientific staff who participated in this effort and the GSFC programming staff under W. Mish. The JPL data records group did an outstanding job on the Voyager 2 encounter. The continued support of E. Franzgrote, our experiment representative at JPL, has been invaluable. The pressure profile of Fig. 2 was provided by C. Goodrich of Massachusetts Institute of Technology. We express our gratitude to the MIT programming staff under the direction of G. Gordon, Jr., and to the computer staff of the MIT Laboratory for Nuclear Science. This research was sponsored by NASA contract 953733 with the JPL.

26 September 1979