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THE VEGA PLASMAG-1 EXPERIMENT: DESCRIPTION AND FIRST EXPERIMENTAL RESULTS

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In December 1984, two identical spacecraft, VEGA-1 and VEGA-2 were launched to the comet P/Halley with Venus flyby. The plasma on board of VEGA is explored by the sensors of the PLASMAG-1 instrument. The scientific goals of the plasma experiment, the approach to their solution and the basic description of operation were published earlier [1,2] . Here, after a short description of the PLASMAG-1 experiment containing some additional information, the schedule of measurements during the cruise phase and some preliminary early results will be presented.

The main parameters of the six independent sensors of the plasma experiment PLASMAG-1 are given in Table 1. Sensors A_o, A_2 and A_3 are oriented along the spacecraft-comet relative velocity vector, sensors A_1 and A_4 are oriented to the Sun, while sensor A_5 is perpendicular to the ecliptic plane.

Sensor A_o, fixed to PLASMAG-1 by SSD ESA consists of two gilded plane electrodes, the central probe and the guarding ring is at a potential of -17 V. This sensor was designed to observe neutral gas and dust fluxes in the coma.

The potential at the analysing grid of sensor A_1 which is a Faraday cup, can be a) 0 V, b) 15 V or c) 3500 V. The difference between measurements in mode c) and a) is proportional to the solar wind ion flux with energies 0 eV < E < 3500 eV. The comparison of measurements in mode b) and a) will permit to estimate the effect of secondary ions in the spacecraft vicinity.

In sensor A_2, which is a Faraday cup for observing cometary ions relatively thick dust resistant diaphragms are used instead of analysing grids. Sensor A_2 has one additional mode of operation compared with sensor A_1. In this mode the usual negative potential of -60 V at the antiphotoelectron diaphragm is replaced by a positive potential of 40 V. In this case the collector current of the Faraday cup is created by secondary electrons from the collector, produced by cometary neutrals and dust, therefore A_2 as well as A_o sensor can observe their fluxes.

The hemispherical electrostatic analysers A_3 and A_4 were designed to observe the energy spectra of cometary and solar wind ions, respectively. To widen the acceptance angle (see Table 1), quadru-pole electrostatic lenses were installed in front of the apertures of the analysers. The energy spectrum is measured in 120 energy intervals for cometary ions and 60 intervals for solar wind ions. The accumulation time of counts in each energy interval is given Table 2 for the different modes of operation for sensors A_3, A_4 A_5.

The cylindrical electrostatic analyser A_5 is used for electron energy spectra measurements. The energy range of this sensor is divided into two subranges 3 eV - 100 eV and 0.1 keV - 10 keV, where different deflection voltages are used. Within each energy subrange the electron energy spectrum is measured in 15 energy intervals.

The main mode of operation for PLASMAG-1 during the cruise phase the Trassa-1 mode. In this mode only two sensors, A_4 and A_5 are

Parameter	SENSOR					
	A_0	A_1	A_2	A_3	A_4	A_5
Effective aperture	1 cm^2	1.60 cm^2	0.93 cm^2	$1.4 \cdot 10^{-2}$ cm^2	$4.6 \cdot 10^{-3}$ cm^2	$3.6 \cdot 10^{-3}$ cm^2
Energy range	—	> 0,15,3500 eV	> 0,15,3500 eV	15 - 3500 eV	0.05 - 25 keV	0.003 - 10 keV
Energy gain	—	1	1	8.2	8.2	9.3 - 10.3
Energy resolution, $\frac{\Delta E}{E}$)*	—	—	—	5.5%	5.6%	7.5%
Angle of acceptance*)	$168^0 \times 168^0$	$84^0 \times 84^0$	$25^0 \times 25^0$	$14^0 \times 32^0$	$38^0 \times 30^0$	$7^0 \times 7^0$

* Full width at 0.1 of maxima

Table 1: Parameters of the sensors of PLASMAG-1

MODE	SENSOR		
	A_3	A_4	A_5
TRASSA - 1	—	0.08 s	0.16 s
TRASSA - 2	1.3 s	1.3 s	5.2 s
COMETARY	0.005 s	0.005 s	0.020 s

Table 2: Accumulation time of the electrostatic analysers of PLASMAG-1 in different modes of operation

operating except for the calibration cycles. Two energy spectra are measured for both solar wind ions and electrons in every 20 minutes. This measurement is completed in about 10 seconds.

After opening the protecting cups of the analysers A_3, A_4 and A_5 and after the continuous outgassing period, the PLASMAG-1 instrument was switched on onboard of both VEGA spacecraft on March 5, 1985. Simultaneous operation on board of both spacecraft in Trassa-1 mode was continuing until the middle of April 1985, when the temperature inside both PLASMAG-1 instruments began increasing; therefore they were switched off. The increase in temperature occured because the spacecraft were approaching the Sun and relatively large unthermoshielded surfaces were continuously illuminated by the Sun. Onboard of VEGA-1 A_3 and A_5 sensors were operating only during the communication session in cometary mode on March 5. There was no scientific information from these sensors later, probably due to the failure of the charge-sensitive CEM amplifiers.

After the Venus flyby, the distance between the Sun and the VEGA spacecraft was increasing and the plasma experiments were switched on July 22-25 in Trassa-1 mode and the instruments were operating until August 8-13. At this time VEGA-1 and VEGA-2 passed the probable distant magnetotail of Venus and therefore, the scientific instruments were switched to the more informative Trassa-2 mode. Since the set of digital command sent to PLASMAG-1, was not complete this experiment was not operating in Trassa-2 mode.

On September 10, Trassa-2 mode was switched on again to observe the interplanetary medium in more detail during the ICE encounter with comet Giacobini-Zinner. Data recorded in Trassa-1 mode from the middle of August until Sept 10 were not telemetred. The PLASMAG-1 experiments were operating in Trassa-2 mode on both VEGA spacecraft for a few hours in the beginning of the session, then, after some interruptions of unidentified nature, no more information came from the PLASMAG-1 experiment on VEGA-1. The instrument on VEGA-2 was normally operating during the whole communication session.

At present, (end of November, 1985), the PLASMAG-1 instrument is switched off on board of VEGA-2 in order to save the resources of the plasma experiment, since on September 22, the solar wind ion component was observed by VEGA-1 only in Trassa-1 mode. It should be mentioned here that during the cruise phase, in addition to the Trassa-1 and Trassa-2 modes, there are communication sessions also in cometary mode with both spacecraft under the slow and fast telemetry rates.

Figure 1 shows the energy spectra of the solar wind ion component measured by the A_4 analyser onboard VEGA-2 on March 10, 1985. The spectra presented are plotted in a logarithmic scale. For the whole period, distinctly separated H^+ and He^{++} maxima can be observed. For some periods a third maximum of higher energy is observable, probably produced by O^{6+} ions. The interesting peculiarity of the data presented in Figure 1 is that during ~6 hours from 9 UT up to 15 UT, the essential expansion of solar wind spectra was observed (which corresponds to temperature increase) under practically unchanged solar wind velocity (see for energy of most abundant ions in Fig. 1). At present, we do not know about any publications distinguishing and analysing similar events in solar wind plasma.

The estimated hydrodynamical parameters - bulk velocity, temperature and density - are presented in Fig. 2 for the expansion of time interval shown by Fig. 1. Dots show data from VEGA-1 and continuous lines present the data from VEGA-2. These parameters were estimated supposing a Maxwellian distribution for protons and using a limited number of experimental points close to the H^+ maximum. The results of A_4 calibration with monoenergetic ion fluxes (performed on the MPAE, Lindau facility) and the results of comparison of A_4 readings with simultaneous Faraday cup A_1 readings in the solar wind were used for the calculations. Some minor changes in the parameters in Fig. 2 probably originate from the instability of the simple computer code applied.

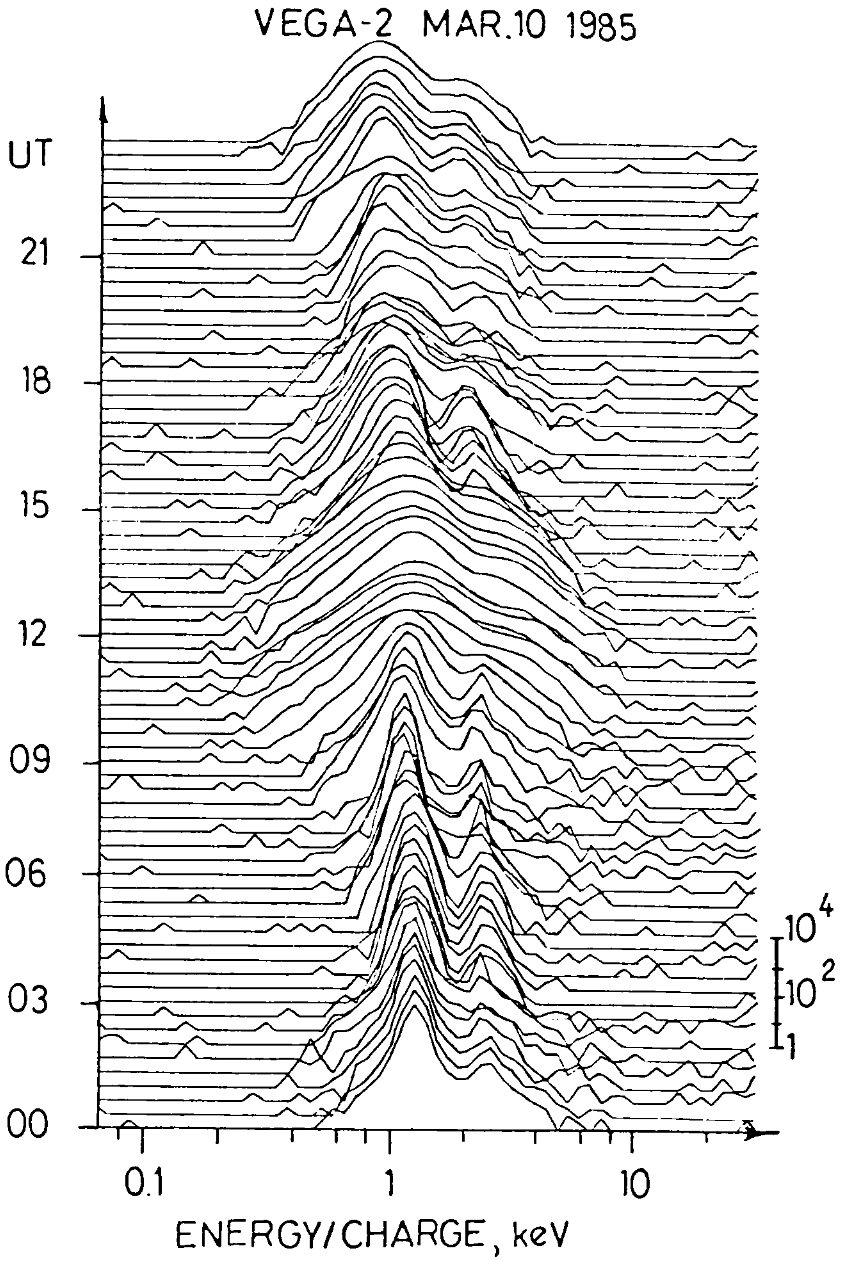

Fig. 1: Spectra of the solar wind ion component as measured by the PLASMAG-1 experiment on board of VEGA-2 during March 10, 1985

As can be seen from the data shown in Fig. 2, the values of bulk velocity, density and temperature of protons measured onboard of the VEGA-1 and VEGA-2 spacecraft are in reasonable agreement, with the exception of essentially different densities estimated from VEGA-1 and VEGA-2 data between 18 UT and 24 UT on March 10. (The reasons for this difference, possibly connected with the solar wind space nonuniformity, should be thoroughly analysed and will not be discussed further). The expansion of solar wind spectra observed from 9 UT to 15 UT (Fig. 1) corresponds to an 6-8 times increase of proton temperature T_p from ~5.10^4 K up to ~$3-4.10^5$ K while solar wind velocity V_p varied unsignificantly decreasing form ~460 km/sec to ~420 km/sec. For an interpretation of such a considerable local increase of the solar wind internal energy, we should find the source of this energy. Furthermore, we will discuss only one of the possible explanations for the rather unusual event observed.

As one can see from Fig. 2 just before (after) and on the leading (trailing) front of the region with enhanced proton temperature, the zone with increased proton density n_p is observed. The regions with enhanced n_p in the solar wind are usually forming as a result of dynamic compression by high speed solar wind stream of surrounding low speed plasma as well as in the vicinity of the heliospheric current sheet (NCDE) [3,4] . Both enhanced n_p regions often overlap. In Fig. 3 the results of V_p, T_p and n_p estimations for the solar wind high speed stream, which was observed onboard of VEGA-1,2 from April 1 to April 6, are shown. The V_p, T_p and n_p variations are typical of an isolated high speed stream event; no detailed discussion will be given here. Similar high speed streams were observed during the declining phase of the previous 20th solar cycle [5,6] and also earlier in the declining phase of the 21st cycle [7].

As we can see from Fig. 3, and as of course is well known from multiple solar wind high speed streams observations (see e.g. [4]), the n_p maximum values are observed before solar wind velocity V_p increasing, but a significant T_p enhancement just followed n_p

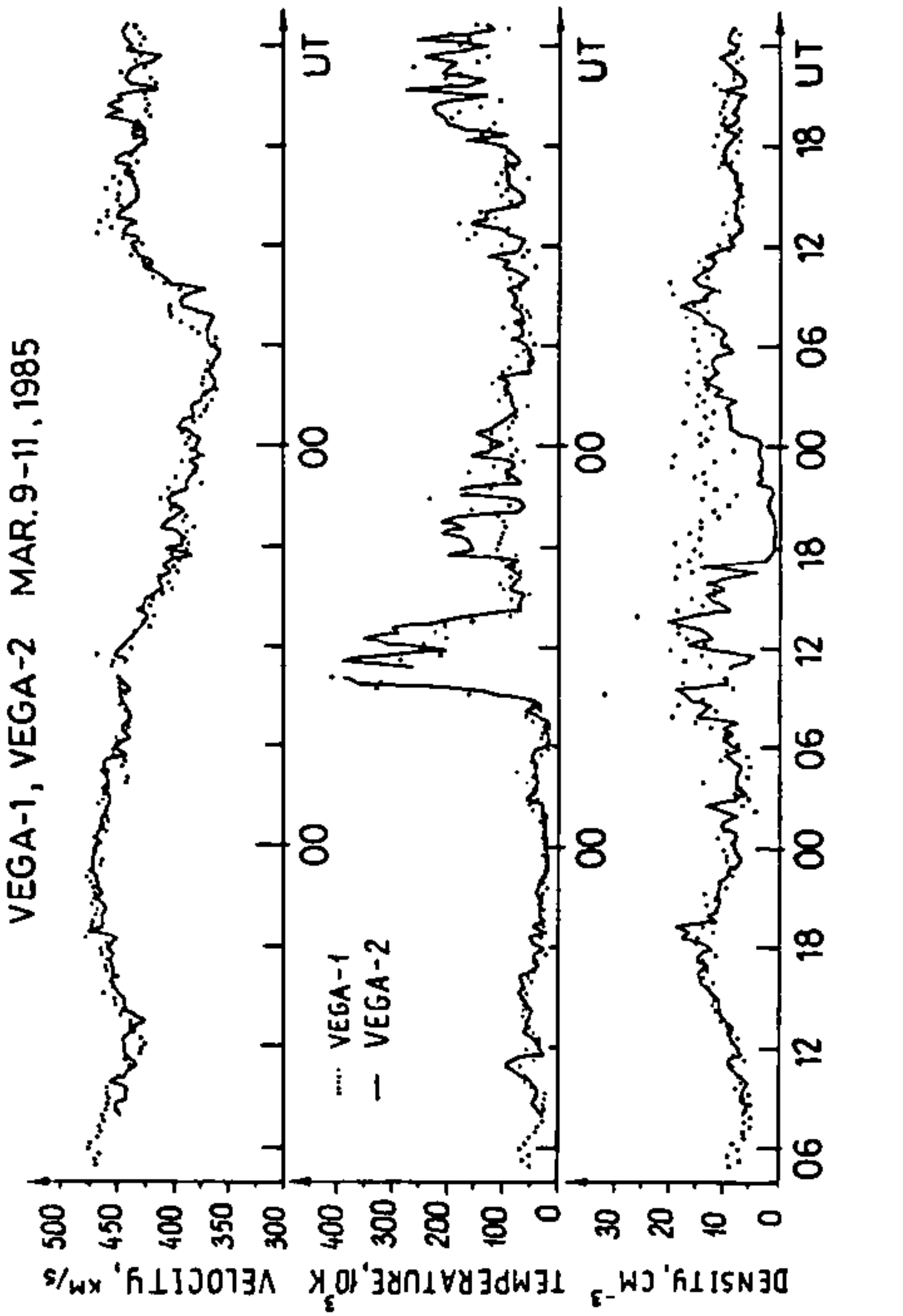

Fig. 2: Bulk velocity, density and temperature of solar wind protons according to simultaneous measurements on board of VEGA-1 and VEGA-2 for the expansion of period as on Fig. 1.

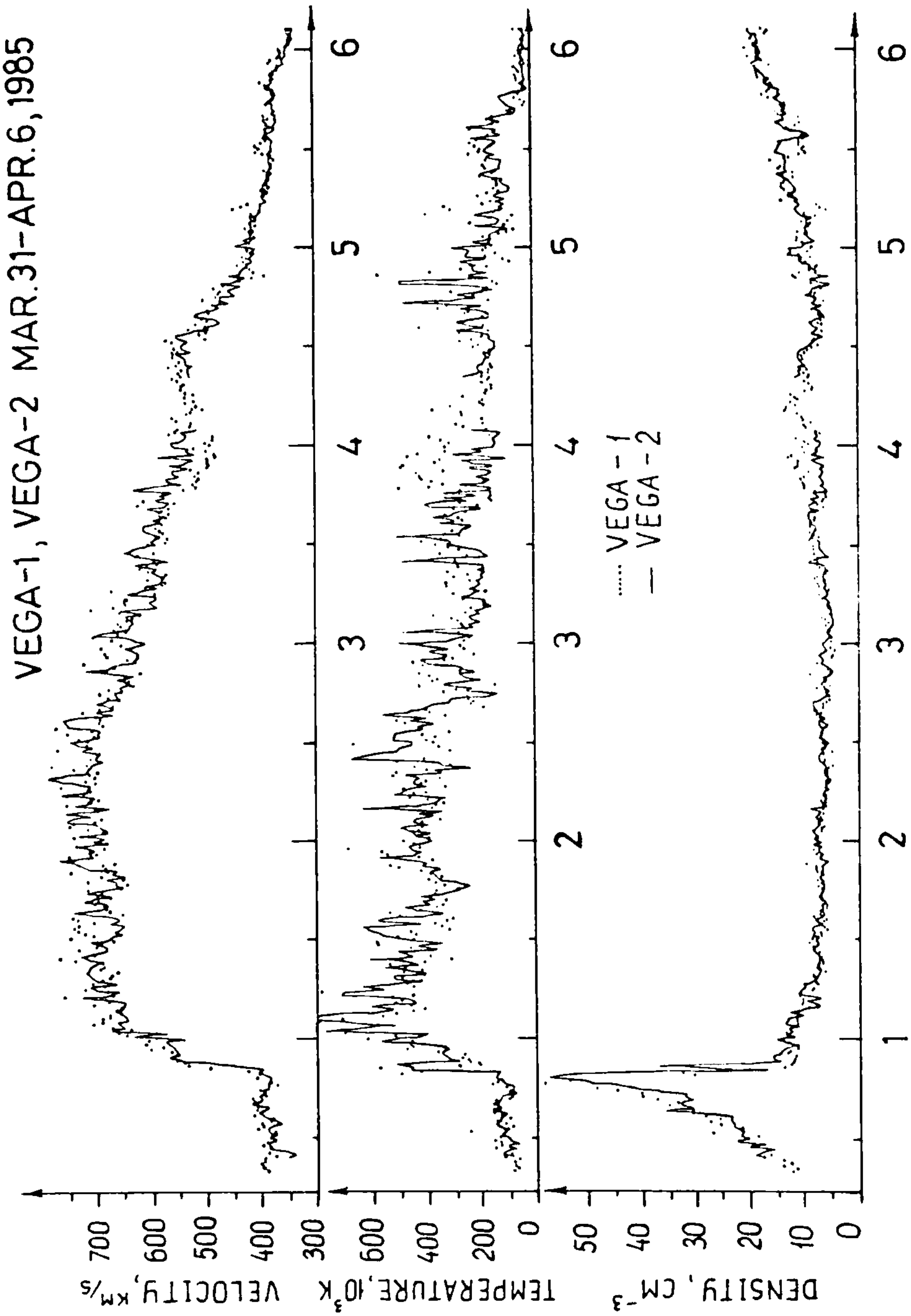

Fig. 3: The same as on Fig. 2, but for solar wind high speed stream observed on board of VEGA-1,2 on April 1-6, 1985.

maximum under still low V_p values in the early beginning of increase of this parameter. Similar n_p and T_p variations (but not of V_p) were observed at the leading edge of the "hot" solar wind region from 8 UT to 11 UT on March 10, 1985 (Fig. 2). When the spacecraft leave "hot" region from 12 UT to 17 UT, the n_p and T_p variation occur in reverse order. Thus, we can suppose that the VEGA-1,2 spacecraft were approaching the solar wind high speed stream on March 10, 1985 and passed in the vicinity of it measuring n_p and T_p enhancements but not a V_p one.

Such an event could occur in the vicinity of the heliospheric current sheet in case of VEGA's intersecting this formation twice. In such a case, the region with enhanced n_p in 8-10 UT (Fig. 2) could be caused by overlapping of high density regions in the vicinity of the heliospheric current sheet, and at the leading edge of the hypothetical high speed stream (the increasing of V_p in this stream was not observed). Naturally the second region with the enhanced n_p in the period 12-18 UT is interpreted as a result of second current sheet intersecting by both VEGA spacraft.

The preliminary comparison of plasma data with the results of simultaneous magnetic field measurements by the MISCHA magnetometer (E. Eroshenko, K. Schwingenschuh, private communication) does not seem to contradict the possibility of a double heliospheric current sheet intersection by both spacecraft during time interval discussed. In order to find sufficient evidence in favour or against the interpretation proposed above, a detailed joint analysis of a full set of PLASMAG-1 plasma sensors data, together with the MISCHA magnetic field data is required. In case the proposed interpretation is correct, the energy source providing high T_p values in period 9-15 UT is the dynamic compression by high speed solar wind stream of surrounding low speed plasma.

Furthermore, the results of solar wind measurements performed in Trassa-2 mode on September 10-11 will be presented here. In this mode of operation, 7 energy spectra of solar wind ions are measured every 20 minutes. The accumulation time of counts is essentially longer than in Trassa-1 mode (see Table 2). As mentioned above, the September 10-11 period of Trassa-2 measurements include the time interval of ICE encounter with the comet Giacobini-Zinner. In addition, according to J. Simpson and D. Rabinowitz (private communication) computation produced in order to find possible dust particles at some comets or meteoroid streams, on September 10, VEGA-1, 2 spacecraft was located in the neighourhood of Leonid meteoroid stream trajectory.

In Fig. 4 the results of solar wind measurements performed during the Trassa-2 mode of PLASMAG-1 on September 10-11, 1985, are presented. These results support the ICE observations and possibly the dust experiment observations. As we can see from the data shown on Fig. 4 from 9 UT Sept. 10 to 22 UT Sept. 11, the bulk velocity of solar wind protons was very low and varied between 260 and 280 km/sec. The proton temperature was also low and varied between 20×10^3 and 60×10^3 °K. In this period VEGA-2 was located ~60 ° west of ICE and at approximately 1 AU.

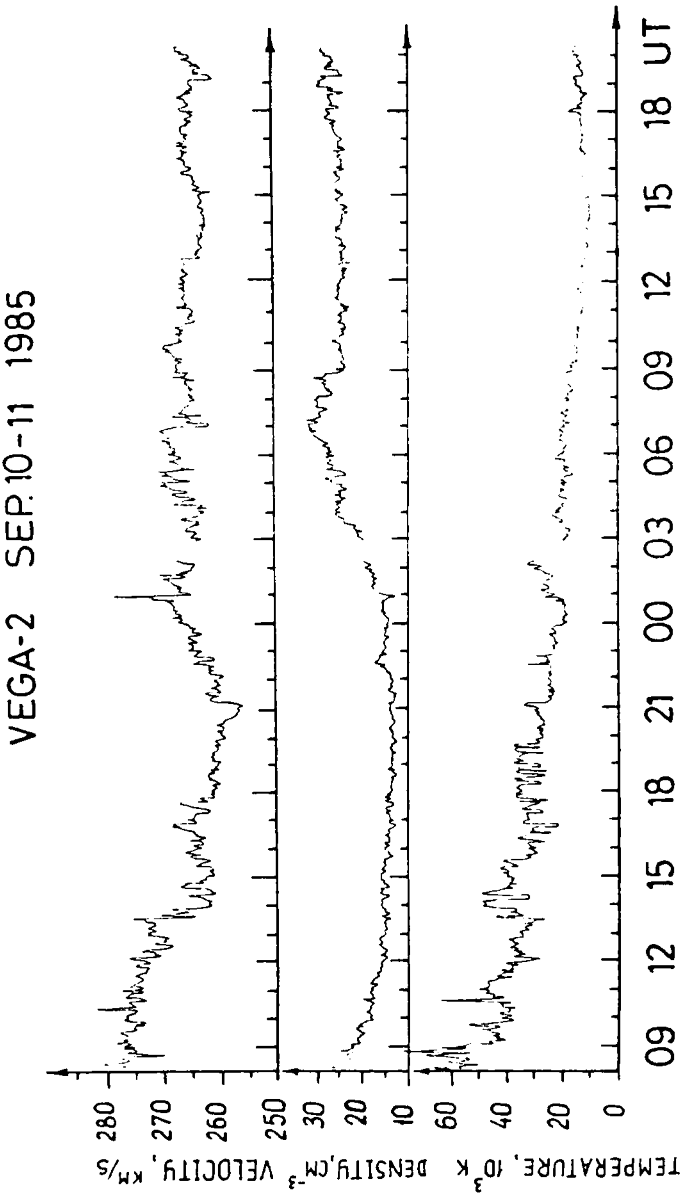

Fig. 4: The results of solar wind parameters estimations according to VEGA-2 PLASMAG-1 data measured simultaneously with ICE Giacobini-Zinner encounter

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