MEASUREMENT OF ELECTRON AND ION FLUXES NEAR MARS BY THE SLED INSTRUMENT ON PHOBOS-2

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Abstract

SLED is a low energy particle detector which was designed to measure the fluxes of electrons and ions in the energy range from 30 keV to several MeV. It formed part of the ESTER complex aboard the Phobos-2 spacecraft which was launched from Baikonur in July 1988 and which went into orbit around Mars at the end of January 1989. During the first four orbits the spacecraft approached within 867km of the Martian surface. The SLED instrument, which had measured particle fluxes in interplanetary space during the cruise phase, also performed satisfactorily in Martian orbit. A preliminary outline of the observations is presented.

1. Introduction : The Soviet Space Agency's mission to Mars and its moons ended prematurely at the end of March 1989, but not before it had carried out a wide range of observations in interplanetary space and deep in the planet's environment. Almost nine months earlier two spacecraft, Phobos-1 and Phobos-2, had been launched successfully from Baikonur in a major space operation aimed at extending the observations of the Mariner, Mars and Viking missions which were undertaken over the previous two and a half decades.

Following loss of ground contact with Phobos-1 in August 1988, Phobos-2 continued on its cruise phase to Mars and was placed in orbit around the planet on January 29, 1989.

Part of the scientific payload on each spacecraft was a charged particle detector called SLED which was designed to measure the flux of ions and electrons in the energy range from 30 keV to several MeV.

2. The SLED Instrument : The SLED instrument consisted of two particle telescopes (Tl, T2) each of which incorporated two silicon surface barrier detectors. The spacecraft was three axis stabilised but was commanded into a spin mode at certain times during the mission. T1 and T2 viewed in the same direction, namely, in the ecliptic plane at 55° to the west of the sunward direction. Each telescope had a geometric factor of 0.21 cm^2 ster and an FOV apex angle of 40°. T2 was covered with an aluminised mylar foil of thickness $500\mu g/cm^2$ and recorded only high energy ions,($E > 350$ keV for protons, $E > 1.6$ MeV for He, $E > 8$ MeV for oxygen), while still allowing electrons with $E > 30$ keV to reach the front detector.

The back detector of each unit was used to discriminate particles which penetrated the front detector. By use of appropriate discrimination and coincidence/anticoincidence arrangements, six energy channels were defined for each telescope, namely Ch 1 (30 - 50 keV), Ch 2 (50 - 200 keV), Ch 3 (200 - 600 keV), Ch 4 (0.6 - 3.2 MeV), Ch 5 (3.2 - 4.5 MeV), Ch 6 (> 30 MeV). Further details of the SLED instrument are available in McKenna-Lawlor et.al, 1989.

3. <u>Observations around Pericentre</u> : The SLED instruments performed very satisfactorily throughout the lifetime of the Phobos-1 and Phobos-2 spacecraft. Electron and ion intensities were measured in interplanetary space during the cruise phase which coincided with the important period of transition from solar minimum to solar maximum. Observations of particle intensities in the martian environment started at the end of January 1989 when Phobos-2 approached the planet and completed four elliptical orbits with an altitude of 867km above Mars at pericentre. Following a further orbit it was transferred to a higher altitude above Mars where it completed 114 orbits of radius $\sim$ 9700km and period $\sim$ 7 hrs 57 mins.

Approximately one day before the first close approach to Mars (Feb. 01 at 18.40 UT) a dramatic rise in count rates was recorded in channels 1, 2, 3, 4 of T1 and T2 which may have been associated with a corotating event and will be the subject of a later study.

Fig. 1 shows a selection of intensity profiles observed by T1 and T2 around pericentre for elliptical orbits 2, 3 and 4.

Intensity levels had fallen by more than a factor of 20 on the second close approach seen in Fig. 1(a). At pericentre count rates rose by a factor of $\sim$ 50 in T1 (channel 1) for a duration of $\sim$ 8 minutes, accompanied by a less dramatic increase in channel 2 of the same telescope. No significant effect was seen in T2.

Count rates increased again during orbit 3 and Fig. 1(b) shows data for T1, channels 1, 2 around pericentre. Here a significant increase in intensity was observed for about 25 minutes in channel 1, accompanied by a smaller effect in channel 2 with no change observed in T2.

Due to a break in transmission on Feb. 11 the intensity profiles for orbit 4 near pericentre are not complete. However as seen in Fig. 1(c) T1, channel 1 exhibits an intensity which was significantly above background shortly after pericentre.

4. <u>Discussion and Conclusions</u> : The increases in count rates observed at pericentre on Feb. 05 and Feb. 08 indicate the possibility of proton enhancements in the energy region from 30 keV up to at least 200 keV. The limited sequence of data

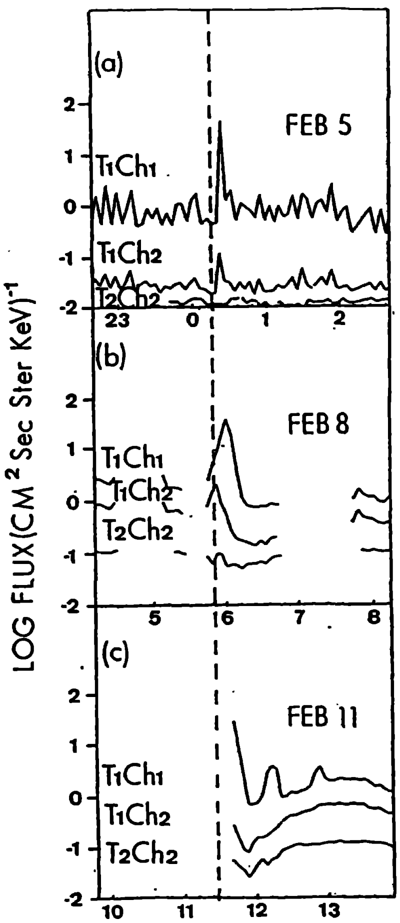

Fig. 1 Fluxes recorded in T1 Ch1 (p,e 30-50 keV), T1 Ch2 (p,e 50-200 keV) and T2 Ch2 (e, 50-200 keV) around pericentre. Time is UT.

for orbit 4 suggests a similar situation, at least in the 30 - 50 keV energy region.

The existence of an intrinsic martian magnetic field and associated magnetosphere could result in the presence of ions and electrons with energies up to several hundred keV in the planet's environment, similar to the situation that exists at Earth. The merging of magnetic field lines of the interplanetary plasma with those of Mars or the compression of field lines close to the planet could lead to particle acceleration (Richter et.al, 1979). Preliminary results of the magnetic field observations (kindly provided by MAGMA experimenters) do, infact, indicate significant compression of field lines around pericentre.

Magnetic field intensities of $\sim$ 30 nT have been observed around pericentre. Thus we would not expect protons in the energy range 30 - 200 keV to be permanently trapped. Their gyroradii would range from 700km to $\sim$ 2000km and consequently they would be quickly absorbed within the dense atmospheric layers of the planet. Indeed, the shift with time, of the maximum of intensity to lower energies near pericentre in orbit 3 may reflect this process.

At present other sources of signal enhancement near pericentre cannot be excluded. For instance, pending the availability of data from the plasma and field experiments on board Phobos-2 we cannot rule out the possibility that they represent the high energy tail of the plasma distribution which would be associated with a bowshock and magnetopause.

Another source which must yet be investigated is the possible activation of the particle sensors by electromagnetic radiation scattered from the planet's atmosphere. It has been observed that particle shadowing similar to that reported by Van Allen and Ness (1969) occured during the circular orbits around Mars (Afonin et.al 1989).

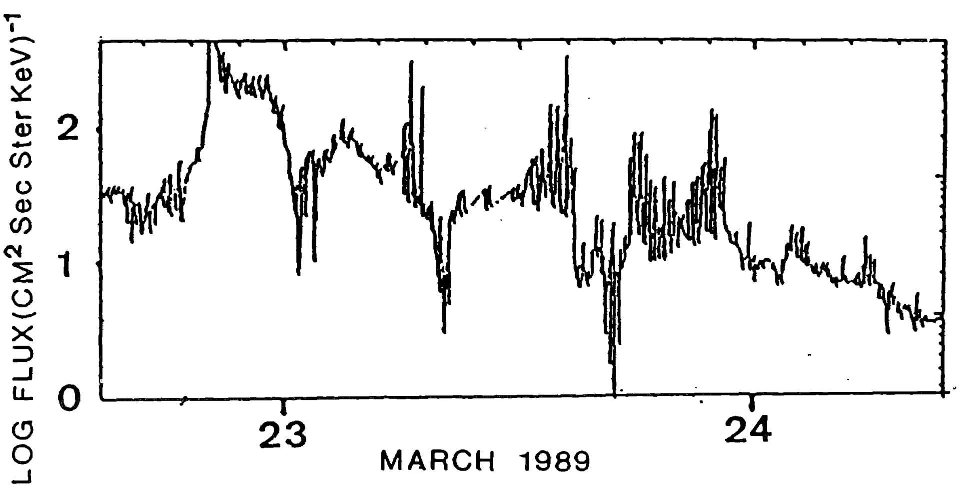

Fig. 2 Profile of particle intensity in T1 Ch2 (e,p 50 - 200 keV) during circular orbits on March 23rd 1989.

Evidence of screening of the aperture of SLED by the body of the planet was seen in several of the 114 orbits (Fig. 2). However in some cases flux enhancements were observed with a similar frequency (period $\sim$ 8 hrs), as seen in Fig.2 and may be partly due to photons entering the detectors at specific times in the spacecraft's trajectory. Further investigation awaits the availability of detailed information on the spacecraft's attitude and spin characteristics.

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