6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Intermittent plasma turbulence in the Martian magnetosheath

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Planetary magnetosheaths are permeated by several plasma wave and turbulence activity. This also occurs for the induced magnetosphere of Mars where both upstream and locally generated waves have been observed in the region between its bow shock and magnetic boundary layer. Due to the absence of an intrinsic magnetic field at Mars, the ionosphere cannot deflect completely the high energy particles and some of them can penetrate into the upper atmosphere [1]. There is evidence that transients from the Martian upstream bow shock and fluctuations in the magnetosheath can propagate through the magnetic pile-up region (MPR) and accelerate ionospheric ions [2,3,4].

In order to characterize wave activity among different scales within the magnetosheath of Mars, a statistical study was conducted using 12 years (2005-2016) of MEX magnetosheath crossings. Electron density (N_e) and temperature (T_e) measured by the electron spectrometer (ELS) of the plasma analyzer (ASPERA-3) experiment on board of MEX spacecraft were used in this study. The kurtosis parameter has been calculated for these plasma parameters. This value indicates intermittent behavior in the data when it is higher than 3 (the value for a normal or Gaussian distribution). The variation of wave activity occurrence has been analyzed in relation to solar cycle, Martian orbit and distance to the bow shock. From the results [5], non-Gaussian properties was observed in the magnetosheath of Mars on all analyzed scales, especially in those near the proton gyrofrequency in the upstream region of the Martian magnetosphere.

A significant influence of the solar cycle was also observed, where the kurtosis parameter is higher during declining and solar maximum phases, where the presence of disturbed solar wind conditions, caused by large scale solar wind structures, increases. The kurtosis decreases with increasing distance from the bow shock, which indicates that the intermittence level is higher near the bow shock.

Different results were obtained for N_e and T_e in the analysis of the solar longitude dependence. In the N_e data, the kurtosis is higher in the $120 \leq L_s < 2010$, range that includes the Northern Hemisphere Autumn Equinox. For T_e higher values of kurtosis were observed in the range which include the perihelion and lower values for the aphelion range. This difference may be caused due to the higher incidence of EUV when the planet is closer to the Sun, which causes a more extended exosphere, and consequently increases the wave activity in the magnetosheath and upstream region. Table 1 shows the main results that were found in this work summarized, where the scale/range with higher kurtosis parameter for each analysis is presented. Their possible causes it is also shown in the table.

References

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Table 1- Higher kurtosis parameter scale/range and their possible causes.

	N_e		T_e	
	Higher kurtosis parameter scale/range	Possible cause	Higher kurtosis parameter scale/range	Possible cause
Fluctuation scale (whole interval)	40 mHz	Near the proton gyrofrequency in the upstream region. Upstream events can transfer energy to the inner magnetosphere.	40 mHz	Near the proton gyrofrequency in the upstream region. Upstream events can transfer energy to the inner magnetosphere.
Solar cycle Phase	Declining/ Maximum	Frequent occurrence of large scale structures in the solar wind (CIRs and ICMEs).	Declining/ Maximum	Frequent occurrence of large scale structures in the solar wind (CIRs and ICMEs).
Martian orbit	$120 \leq L_s < 210$	unknown	$210 \leq L_s < 300$	proton cyclotron wave activity and the extension of the hydrogen exosphere.
Bow shock distance	$0 > BSD \geq 0.5$	Higher input of energy into the Martian system, which promotes the Kolmogorovian cascades of energy dissipation.	$0 > BSD \geq 0.5$	Higher input of energy into the Martian system, which promotes the Kolmogorovian cascades of energy dissipation.