COMRESSIVE LOW FREQUENCY WAVES AT THE MAGNETIC PILEUP BOUNDARY OF MARS: MGS MAG/ER OBSERVATIONS

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ABSTRACT

We use Mars Global Surveyor MAG/ER data to study the properties of compressive, low frequency waves, at the magnetic pileup boundary (MPB). On both sides of this thin and sharp plasma boundary, the waves are linearly polarized with respect to the background magnetic field. However, cross-correlation analyses reveal that on the upstream side, these are mirror-mode waves, while downstream, they are large-amplitude, quasi-monochromatic fast-mode waves. We analyze the properties of these waves (also reported at comets) and present the results of a statistical study on their occurrence. Their source mechanism and their role on the plasma dynamics are also discussed.

SUMMARY

The magnetic pileup boundary (MPB) is a thin, sharp and permanent plasma boundary located between the bow shock and the ionosphere of Mars and comets. This boundary separates the magnetosheath, which displays a high level of wave activity, from the magnetic pileup region (MPR), where the magnetic field is less disturbed, more intense, and draped around the ionospheric obstacle. In this work, we study the properties of low frequency (LF) waves at the MPB from Mars Global Surveyor Magnetometer and Electron Reflectometer (MGS MAG/ER) data for a large set of orbits.

Two types of compressive LF waves are observed at the Martian MPB. On the upstream side, the waves are linearly polarized, their wave vector is quasi-perpendicular with respect to a very steady background magnetic field and cross-correlation analyses show an anticorrelation between the magnetic and the electron data. On the downstream side, the waves are also linearly polarized and have a quasi-perpendicular wave vector, however, they are quasi-monochromatic, they have large wave amplitudes and the magnetic field and electron data are correlated. From the characteristics mentioned above, we identify the waves upstream the MPB as mirror mode waves, and the waves downstream the MPB as fast magnetosonic waves. A statistical study on the occurrence of these waves from a set of 240 orbits shows that mirror mode waves are present in at least 54% of the observations, fast magnetosonic waves are present in at least 30%, and both types of waves are detected simultaneously in at least 20% of the observations. Mirror mode waves are driven by anisotropies in the plasma pressure ($\beta_\perp / \beta_{//} > 1+1/\beta_\perp$) especially when β is high. In this case, their presence is independent of the nature of the shock, and they always seem to be "attached" to the boundary. We can expect anisotropy from the heating of the ion population downstream quasi-perpendicular shocks and from ring beam distributions of picked-up newborn ions. On the other hand, the presence of fast mode waves downstream the MPB is difficult to explain from locally growing magnetoplasma microinstabilities, taking into account the large wave amplitude and the small scale of the MPR. This latter issue requires further theoretical investigation.

The presence of these two types of low frequency waves at the MPB represents a new feature in the Mars-Solar Wind interaction. Surprisingly, this feature has also been observed at comets.