# Waves at the proton cyclotron frequency at Mars

***Christian Mazelle***[1,2]

[1]Université de Toulouse; UPS-OMP; IRAP; Toulouse, France (christian.mazelle@cesr.fr)

[2]CNRS; IRAP; 9 Av. colonel Roche, BP 44346, F-31028 Toulouse cedex 4, France

## Abstract

Waves have been measured by Mars Global Surveyor at the local proton cyclotron frequency in the solar wind around Mars [1,2]. We present new analyses of high resolution measurements of Mars Global Surveyor magnetometer and electron spectrometer during the aerobraking hiatus. Comparison with observations by Mars Express SPICAM instrument helps to obtain new insights in the connection between the spatial distribution of these waves and the geometry of the Martian hydrogen exosphere. Implications for the future Maven observations are discussed.

## 1. Introduction

The presence of waves measured by the Mars Global Surveyor magnetometer and electron reflectometer (MAG/ER) at the local proton cyclotron frequency in the solar wind revealed the presence of an extended exosphere at Mars [1,2]. These waves are produced by the plasma microinstabilities arising from the unstable velocity distributions of newborn ions from the ionization of the planetary neutral atoms [3] as in the case of comets [4, 5]. Some previous studied cases have shown some intermittent observations which have been interpreted as consistent with the crossing of a disc distribution of energetic neutral atoms (ENAs) formed by recombination or charge exchange with pickup ions produced closer to the planet [6]. We present new analyses of high resolution measurements of Mars Global Surveyor which show inconsistency with this interpretation.

## 2. Results

Our analysis deals with high resolution measurements of Mars Global Surveyor magnetometer and electron spectrometer during the aerobraking hiatus (science phasing orbits). The observed waves can have large amplitude even at large distances. This disc distribution proposed by [6] is supposed to depend on the local IMF direction where energetic neutral atoms have been created. However our analysis show that there are numerous cases showing continuous waves along many orbits with the same orientation in space while the IMF orientation obviously can be very different. This makes very unlikely the possibility for the spacecraft to remain inside the ENA disc to explain the long duration observations. Comparison with observations by Mars Express SPICAM instrument reveals that the local neutral hydrogen densities from the planetary exosphere can be sufficient to explain the production of these waves.

## 3. Conclusion

These results will have implications for the future Maven observations which will be made in a different phase of the solar cycle. Similar observations have been made recently around Venus from Venus Express observations [7, 8].

## 4. References

1. Acuña, M.H., J.E.P. Connerney, N.F. Ness, R.P. Lin, D. Mitchell, C.W. Carlson, J. McFadden, K.A. Anderson, H. Rème, C. Mazelle, D. Vignes, P. Wasilewski, P. Cloutier, The Magnetic Field of Mars : Summary of Results From the Aerobraking and Mapping Orbits, *J. Geophys. Res*., *106*, E10, 23,403-23,418, 2001 [and references therein].

978-1-4244-6051-9/11/$26.00 ©2011 IEEE

2. Brain, D.A., F. Bagenal, M.H. Acuña, J.E.P. Connerney, D.H. Crider, C. Mazelle, H. Rème, and D.L. Mitchell, Observations of low frequency electromagnetic plasma waves upstream from the Martian shock by MGS MAG, *J. Geophys. Res.(A), 107*, *A6*, 148 – 227*,* 2002.

3. Gary, S.P., Electromagnetic Ion/Ion Instabilities and Their Consequences in Space Plasmas: A Review, *Space Science Reviews*, *56*, 373-415, 1990.

4. Brinca, A. L., Cometary linear instabilities: from profusion to prospective, in *Cometary Plasma Processes*, A.D. Johnstone ed., *Geophys. Monogr. Ser.* 61, pp. 211-221, AGU, Washington, D. C., 1991.

5. Mazelle, C., and F.M. Neubauer, Discrete wave packets at the proton cyclotron frequency at comet P/Halley, *Geophys. Res. Lett.*, *20*, 153-156, 1993.

6. Wei, H.Y. and C.T. Russell (2006), Proton cyclotron waves at Mars: Exosphere structure and evidence for a fast neutral disk, *Geophys. Res. Lett., 33*, doi:10.1029/2006GL026244.

7. Delva, M., M. Volwerk, C. Mazelle, J.Y. Chaufray, J.L. Bertaux, T.L. Zhang, Z. Vörös (2009), Hydrogen in the extended Venus exosphere, Geophys. Res. Lett., 36, L01203, doi:10.1029/2008GL036164.

8. Delva, M, C. Mazelle, C. Bertucci, M. Volwerk, Z. Vörös, T.L. Zhang, Proton Cyclotron Wave Generation Mechanisms Upstream of Venus, *J. Geophys. Res.*, in press, 2011.