Nonlinear structures in the Martian magnetosheath

Steffy Sara Varghese[1], Kuldeep Singh[2], Ioannis Kourakis[1,2]

[1] *Space and Planetary Science Center, Khalifa University, Abu Dhabi*

[2] *Department of Mathematics, Khalifa University, Abu Dhabi*

The Martian environment provides a compelling laboratory for the study of space plasma physics. Mars does not naturally possess a magnetic field, but the Martian atmosphere's mass loading and conductive ionosphere function as barriers to the solar wind, creating the bow shock and the induced magnetosphere. In this rich plasma environment a variety of plasma processes have been reported, including the occurrence of Electrostatic Solitary Waves (ESWs). In Space plasmas, the signature of ESWs are usually recorded as bipolar electric field fluctuations of short duration moving predominantly parallel to the magnetic field. Very recently Kakad et al. [1] reported the existence of ESWs in the Martian magnetosheath plasma. Motivated by this observation, we have explored the dynamics of localized electrostatic structures from first principles.

In the plasma environment encountered in the Mars's quasi-magnetosphere, along with the solar wind injected protons and electrons there are also traces of the coexistence between positive and negative ions [2, 3]. In this regard, we have formulated a negative ion multi-fluid plasma model and analyzed the structure and the propagation characteristics of various kinds of potential pulses using the reductive perturbation technique. An extended Korteweg-de Vries (eKdV) i.e. a Gardner equation can be derived for a certain plasma configuration, giving rise to various types of analytical solutions. The relation to large amplitude (i.e. Sagdeev theory based) models is investigated. Our results are corroborated upon critical comparison with the solitary structures observed in the Martian magnetosphere [1].

References

[1] Kakad, B., Kakad, A., Aravindakshan, H. and Kourakis, I., 2022. Debye-scale solitary structures in the Martian magnetosheath. *The Astrophysical Journal*, **934** (2), p.126.

[2] Jones, N., Halekas, J., Girazian, Z., Mitchell, D., & Mazelle, C. (2022). MAVEN observations of H− ions in the Martian atmosphere. *Journal of Geophysical Research: Planets*, **127**, e2021JE006999.

[3] Halekas, J. S., et al. (2015), MAVEN observations of solar wind hydrogen deposition in the atmosphere of Mars, *Geophys. Res. Lett.*, **42**, 8901– 8909.

Acknowledgements

Authors SSV and IK gratefully acknowledge financial support from Khalifa University's Space and Planetary Science Center (Abu Dhabi, UAE) under Grant no. KU-SPSC-8474000336. Authors KS and IK acknowledge support from KU via the Faculty Start-Up project FSU-2021-012 (8474000352). IK acknowledges support from KU via the CIRA (Competitive Internal Research Award) project CIRA-2021-064 (8474000412).