2nd Asia-Pacific Conference on Plasma Physics, 12-17,11.2018, Kanazawa, Japan

PlasmaWaves in the Universe

Vipin K. Yadav
SpacePhysics Laboratory, Vikram Sarabhai Space Centre
e-mail:vipin_ky@vssc.gov.in, vkyadavcsp@gmail.com

Plasma waves are omnipresent and thus are one of the unique features of space plasmas as they propagate energy across different space regions. Plasma waves provide particle transport in the absence of collisions in the form of anomalous resistivity, viscosity, etc. and can accelerate particles to attain high energies. Plasma waves can transmitinformation about the local plasma parameters from regions not accessible for *in-situ* measurements such as solar corona. Electrostatic and electromagnetic plasma waves are observed in almost all the solar system objects such as planets, their satellites, comets[1], interplanetary medium and Sun [2]. Plasma waves are predicted to exist in many other natural plasma systems in the universe such as interstellar medium and supergiant stars [3]. Plasma waves are believed to exist in many other natural plasma systems such as pulsars, quasars and galaxies.

In planetary ionospheres, typical plasma density is between $10^3 – 10^6$ cm^{-3} and plasma temperature is around 0.1 eV. This plasma environment is capable of sustaining basic plasma waves[4].A number of natural plasma waves are observed in planets having an appreciable magnetosphere such as outer planets - Jupiter, Saturn, Uranus, Neptune[5 - 7],Mercuryand Earth [7]. In case of planets deprived of a global magnetic field, such as Venus and Mars, the solar radiation penetrates more deep through the atmosphere to generate a tenuous ionosphere and subsequently basic plasma waves are generated there also. A number of planetary satellites, e.g. Earth's Moon, Jovian satellites – Io, Europa, Ganymede, Callisto and Saturnian satellites – Titan and Enceladus are also found to have plasma waves in their vicinity which are observed by various missions which managed to reach there.

In interplanetary medium, plasma waves such as Alfven waves are observed whose origin is believed to be near the Sun. The plasma in solar core and in corona itself support and sustain almost all types of plasma waves. The Alfven waves are believed to be present in the dusty winds of cooled supergiant stars. An abrupt rise in temperature is observed with increasing distance from the surface of supergiant stars which can be due to the mechanical dissipation of these Alfven waves. In interstellar medium, hydromagnetic plasma waves – Alfven and Magnetosonic waves are predicted to exist. The Alfven waves, in interstellar medium are predicted to exist due to its generation by the incoming anisotropic cosmic rays streaming along the magnetic field lines.The interaction of relativistic cosmic rays with the interstellar plasma having a Maxwellian distribution gives rise to plasma oscillations due to non-linear transfer of energy to the ionized particles which led to the generation of Langmuir waves [3].

The plasma environment around a comet is also capable of sustaining plasma waves. Some of these waves are observed in comets Giacobini-Zinner,Grigg-Skjellerup, Halleyand Borrelly. Some other comets such as Hyakutake, 67P/Churyumov-Gerasimenko and Wirtanen are also supposed to sustain some plasma waves but these waves are yet to be observed [1].

In this paper, plasma waves in the above mentioned universal bodies shall be discussed with emphasis on the plasma wave detection/observation proposed in future space missions.

References

[1]Vipin K. Yadav, R.S. Thampi, A. Bhardwaj, "Plasma Waves in the Solar System", Proceedings of the 27th National Symposium on Plasma Science & Technology", December 10-13, 2012; Pondicherry University, Pudducherry, India; Page: 454-458
[2] Vipin K. Yadav, A. Bhardwaj, R.S. Thampi, "Plasma Waves in and around Sun", Proceedings of Regional Conference on Radio Science, January 2-5, 2014; Symbiosis Institute of Technology, Pune, India; Page: 97-98
[3] Vipin K. Yadav and Anil Bhardwaj, "Plasma Waves beyond the Solar System", Plasma and Fusion Science: From Fundamental Research to Technological Applications; Chapter 15; 231-241; January 2018, Apple Academic Press, USA, ISBN: 978-1-77188-452-2
[4] Vipin K. Yadav and Anil Bhardwaj, "Plasma Waves in Planetary Ionosphere-Magnetoshere System", Proceedings of the conference "Planetary Sciences and Exploration", December 12-14, 2011; Physical Research Laboratory, Ahmedabad, India; Page: 160-161
[5]W.S. Kurth and D.A. Gurnett, "Plasma Waves in Planetary Magnetospheres",Journal of Geophysical Research, 96, 1991, 18,977-18991
[6] P. Zarka, "Radio and plasma waves at the outer planets", Advances in Space Research, 33, 20014, 2045-2060
[7] Roger R. Anderson, "Plasma Waves in Planetary Magnetospheres", Reviews of Geophysics and Space Physics, 21 (2), 1983; 474-494