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Diffuse Whistler Mode Waves Detected by Kaguya in the Lunar Polar Orbit

Tomoko Nakagawa[(1)], Futoshi Takahashi[(2)], Hisayoshi Shimizu[(3)], and Yoshifumi Saito[(4)]
(1) Tohoku Institute of Technology, Miyagi, 982-8577, Japan; e-mail: nakagawa@tohtech.ac.jp
(2) Kyushu University, Fukuoka, 819-0395, Japan; e-mail: takahashi.futoshi.386@m.kyushu-u.ac.jp
(3) University of Tokyo, Tokyo, 113-0032, Japan; e-mail: shimizu@eri.u-tokyo.ac.jp
(4) Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Kanagawa, 252-5210, Japan; e-mail: saito@stp.isas.jaxa.jp

The solar wind interaction with the moon produces variety of plasma wave activities [1]. As the moon is not shielded by global magnetic field like the Earth, the solar wind particles can access the lunar surface or the local crustal magnetic field. Although most of them are absorbed by the lunar surface, a small fraction are scattered back into the solar wind and become an energy source of wave activities. The solar wind particles that came into the area of intense local crustal magnetic field (so called magnetic anomaly) are more strongly reflected back forming a ring beam injected into the solar wind, or accelerated by local electric field generated by difference of penetration depth of ions and electrons [2]. Protons reflected by the magnetic anomalies are responsible for generation of monochromatic ultra-low frequency (ULF) waves or extreme low frequency (ELF) waves through cyclotron resonance with magneto-hydrodynamic (MHD) waves [3] or whistler mode waves [4, 5]. Mirror-reflected electron beams along the magnetic field connected to the magnetic anomaly are thought to be the source of non-monochromatic whistler mode waves in the frequency range from 0.1 to 10 Hz [6]. Detection of the non-monochromatic whistler waves depends on magnetic connection between the spacecraft and the magnetic anomalies

Another type of ELF whistler waves were found by Kaguya. The frequency range was broad (1-16 Hz) like the non-monochromatic whistlers generated by field-aligned electrons, while their detection was less sensitive to the magnetic connection as well as the waves generated by reflected protons. They were preferentially observed above the polar region of the moon. The detection site was off the magnetic anomaly. They were found when the incident solar wind density was high.

The generation mechanism of such diffuse whistler mode waves is not yet understood. Dense solar wind flux incident to lunar surface unshielded by the crustal magnetic field is likely to cause scattering of solar wind protons in the form of ions or neutral atoms to be re-ionized. Scattered protons with less collimated velocities might account for the broad frequency range and the occurrence property less sensitive to the magnetic connection to the lunar surface.

References

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