Search of energy source of 1-16Hz Whistler Mode Waves Detected by Kaguya in the Lunar Polar Orbit

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The moon is exposed to the solar wind or magnetospheric plasmas due to the lack of global magnetic field or the dense atmosphere like those of the Earth. Most of the incident plasmas are absorbed by the lunar surface, but a small fraction of protons are scattered back into the solar wind in the form of ions, or neutral atoms to be re-ionized through charge exchange. The solar wind particles that came across intense local crustal magnetic field so called as the magnetic anomalies are more strongly reflected back due to the Lorentz force. Electrons that came into the region near intense magnetic anomalies are mirror reflected and/or accelerated by local electric field generated by difference of penetration depth of ions and electrons.

These plasmas have energy that can generate various wave activities (Harada and Halekas, 2016). Protons reflected by the magnetic anomalies are responsible for generation of monochromatic ULF waves or ELF waves through cyclotron resonance with MHD waves or whistler mode waves. 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. 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

Harada, Y., and J. S. Halekas, Chapter 18: Upstream waves and particles at the Moon, in "*Low-Frequency Waves in Space Plasmas*", 2016, pp. 307-322, American Geophysical Union, doi: 10.1002/9781119055006.

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