Density estimation utilizing the group-standing frequency of upstream whistlers in the solar wind

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Upstream whistlers, so-called 1 Hz waves, have been observed in upstream regions of most solar system bodies including Mercury, Venus, Earth, the Moon, Mars, Saturn, and Uranus [e.g., Orlowski and Russell, 1995; Russell, 2007]. Their frequencies in the spacecraft frame concentrate around 1 Hz at 1 AU and slightly decrease with distance from the Sun. They exhibit similar spectral properties even in different situations, suggesting that common generation and propagation processes are responsible for the waves throughout the solar system.
Based on statistical and comparative studies, we proposed that the waves are essentially group-standing, i.e., their group velocities become rather small in the body's rest frame [Tsugawa et al., JGR 2014]. In the group-standing condition, the waves can behave as if they are at a resonance frequency because the group refractive index approaches infinity in the spacecraft / solar system body rest frame. This suggests that the group-standing frequency can be utilized as an indicator of plasma parameters, in analogous to the upper-hybrid resonance frequency, which is used to determine the plasma density in the magnetosphere. We propose a method to estimate the plasma density utilizing the group-standing frequency and evaluate the feasibility of the proposed method by using Geotail in-situ observations. The method possibly estimates the absolute value of number density with an accuracy of <~0.1, although there remains some considerable difficulties. We discuss pros and cons of the proposed method.

