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Backward Propagating Source as a Mechanism of Rising Tone Whistler Mode Chorus

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Radio waves in the ELF/VLF band (3-30 kHz) propagate in the Earth's magnetosphere as whistler mode waves and play an important role in radiation belt dynamics [1]. Of particular interest is the generation of naturally occurring whistler-mode waves known as chorus. Chorus is well-known to play a vital role in the acceleration of electrons to relativistic energies and in the loss of energetic electrons from the radiation belts via precipitation. As such, understanding the physical mechanism by which chorus is generated is highly valuable for space weather modeling.

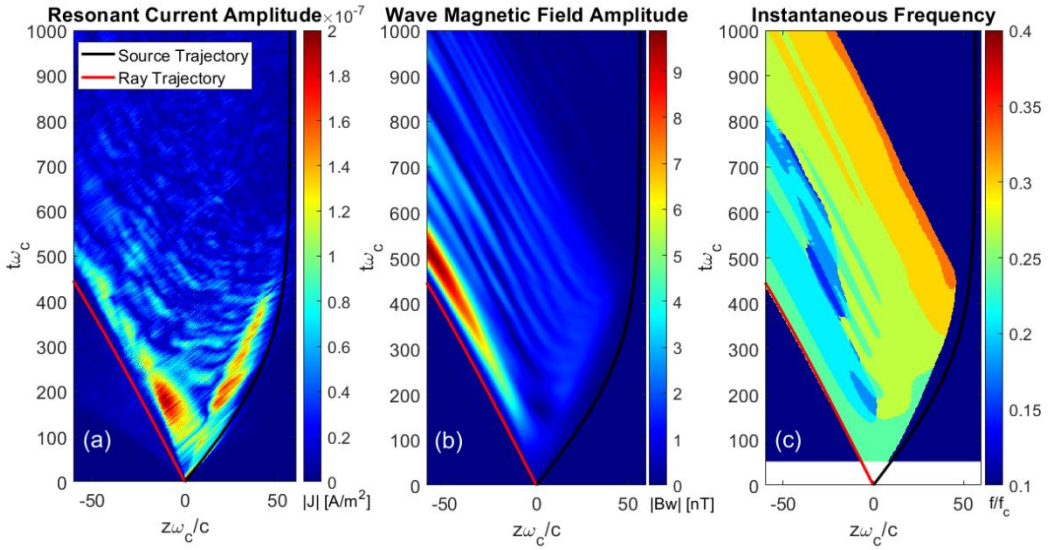

Figure 1: Space-time profiles of the (a) hot current density magnitude, (b) wave magnetic field magnitude, (c) wave magnetic field instantaneous frequency. The source trajectory (equation 8) and the ray trajectory of a wave-front are superimposed as the black and red curves respectively.

To simulate chorus generation, a new envelope particle-in-cell code is introduced [2]. The model successfully produces a rising tone chorus element in a parabolic geomagnetic field. Figure 1 (a) shows the space-time profile of the current density, (b) shows the wave magnetic field amplitude, and (c) shows the instantaneous frequency of wave. As shown, the initial chorus element "embryo" frequency is shown to initialize near the equator; the embryo frequency corresponds to that of maximum linear growth. A backward resonant current is then observed to propagate upstream of the equator. The backward current iteratively radiates a rising tone element where the highest frequency components are generated furthest upstream. It is postulated that the backward current trajectory follows a superposition of a backward adiabatically "falling" electron and forward motion at the group velocity. This theoretical trajectory is superimposed on all the panels of Figure 1, and demonstrates a close correspondence to the backward moving profile. The work provides new advancements in modeling chorus and corroborates other recent work that has also demonstrated a backward-moving source during the generation of coherent whistler mode waves.

References

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[2] Harid, V., Golkowski, M., Hosseini, P., & Kim, H. (2022). Backward Propagating Source as a Component of Rising Tone Whistler Mode Chorus Generation. *Frontiers in Astronomy and Space Sciences*, 232.