

R008-07

C 会場 : 11/26 PM2 (14:50-16:20)

14:50~15:05:00

地球バウショックにおけるコヒーレントな平行伝播ホイッスラー波の生成

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Generation of coherent quasi-parallel whistler waves at Earth's bow shock

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Collisionless shocks have been known as the zoo of plasma waves and instabilities. Plasma waves of all sorts, both electrostatic and electromagnetic, with wavelengths ranging from Debye length to much longer than the ion inertial length, have been found in observations and simulations. Since the dissipation in collisionless shocks has to be provided by collective interaction between particles and electromagnetic field fluctuations, the presence of these plasma waves is indeed essential. The roles of the individual waves on the heating and acceleration of particles have been the topic of active research.

Recent theory and observations indicate that whistler waves may be a crucial agent in regulating the acceleration of nonthermal electrons sometimes observed by spacecraft at the Earth's bow shock (Amano et al. 2020, Amano and Hoshino 2022). In-situ spacecraft observations show that high-frequency quasi-parallel propagating whistler waves (with typical frequencies comparable to ~10% of the local electron cyclotron frequency) often appear within the shock transition layer as coherent wave packets in a sporadic manner (e.g., Oka et al. 2017). Furthermore, comparison between different spacecraft in the MMS (Magnetospheric Multiscale) constellation implies that the wave packets seem to have very small spatial scales transverse to the wave propagation direction, perhaps on the order of ~10 electron inertial lengths, corresponding to a few wavelengths. It is not known how and why such coherent, small-scale wave packets are spontaneously generated in the shock.

In this study, we perform two-dimensional (2D) particle-in-cell (PIC) simulations of quasi-perpendicular shocks with moderate Mach numbers (Alfvén Mach number of 5-10), relevant to the Earth's bow shock. We find that coherent high-frequency whistler waves are indeed reproduced in the simulated shocks. They appear around the overshoot and ramp regions, with nearly parallel propagation with respect to the local magnetic field direction. On the other hand, the waves have a relatively narrow transverse (i.e., perpendicular to the magnetic field) scale, comparable to the wavelength. They often appear and disappear in response to low-frequency compressional magnetic fluctuations, which are likely to be driven by the ion dynamics. All these characteristics seen in PIC simulations are qualitatively consistent with spacecraft observations.

We will present the result of an ongoing investigation that quantifies the wave properties for more detailed comparison with observations, including wave frequency, propagation angle, amplitude, and packet size. We will also analyze the anisotropy of the local velocity distribution function, which may provide a clue to identify the wave generation mechanisms and the reasons for the sporadic wave appearance.