

地球磁気圏における Dual-band chorus の生成条件の検討

幅岸 俊宏 [1]; 八木谷 聡 [2]; 大村 善治 [3]; 小嶋 浩嗣 [3]
[1] 金沢大・自然科学・電情; [2] 金沢大; [3] 京大・生存圏

Generation condition of the Dual-band chorus in the Earth's magnetosphere

Toshihiro Habagishi[1]; Satoshi Yagitani[2]; Yoshiharu Omura[3]; Hirotsugu Kojima[3]
[1] Electrical and Computer Eng., Kanazawa Univ.; [2] Kanazawa Univ.; [3] RISH, Kyoto Univ.

We have statistically analyzed the chorus emissions observed by the frequency sweep analyzer (SFA) onboard the Geotail spacecraft in the Earth's magnetosphere. On the basis of the nonlinear growth theory [1], a rising-tone chorus is initially generated continuously in the frequency range from 0.1 to 0.7 fce0, where fce0 is the gyrofrequency in the generation region. Because of the nonlinear damping mechanism the rising-tone chorus is separated into upper and lower bands at half the local gyrofrequency for the quasi-parallel propagation toward higher latitude (i.e. toward larger gyrofrequencies). Thus the lower cutoff of the upper-band chorus indicates half-gyrofrequency at the observational point (1/2 fce), whereas the upper cutoff of the lower-band chorus indicates half the gyrofrequency in the generation region (1/2fce0). Actually we found an observational evidence of such characteristics of upper-band and lower-band chorus observed by the wave form capture (WFC) and SFA onboard Geotail [2].

Mainly "lower-band-only chorus" (only the lower-band chorus exists) is observed and occasionally "dual-band chorus" (both the upper-band chorus and the lower-band chorus) is observed by Geotail. In this study, we statistically analyze the difference between the lower-band-only chorus and the dual-band chorus by using the SFA data. It has been found that the dual-band chorus is generated because of the nonlinear damping at half the local gyrofrequency during the propagation. When the dual-band chorus propagates toward higher latitudes, if the upper-band chorus is completely damped at half the local gyrofrequencies, the dual-band chorus would become the lower-band-only chorus. We assume that the upper cutoff frequency of the lower-band chorus equals to the half-gyrofrequency in the generation region. It is found that when 0.7 fce0 (i.e. upper limit frequency of the chorus generation) is higher than local 1/2 fce, dual-band chorus is observed because the higher-frequency part of the upper-band chorus would not be damped, whereas when 0.7 fce0 is lower than local 1/2 fce, the lower-band-only chorus is observed because the upper-band chorus would be completely damped. Thus we suggest that the observation of either the dual-band chorus or the lower-band-only chorus is dependent on the relationship between the gyrofrequency in the generation region and the gyrofrequency at the observational point.

Geotail 搭載の周波数掃引受信機 (SFA) で観測された周波数スペクトルデータを用いて, chorus emission の統計解析を行なっている. chorus の非線形成長理論 [1] に基づくと, rising-tone chorus の場合, 発生領域のジャイロ周波数の 0.1 ~ 0.7 倍の帯域内で一続きのスペクトルが発生し, 磁力線に沿ってジャイロ周波数が増大する高緯度方向に伝搬することにより, ローカルの 1/2 ジャイロ周波数の成分が減衰され, upper-band chorus と lower-band chorus に分けられることが理論的に報告されている. このとき, upper-band chorus の下端カットオフ周波数が観測点での 1/2 ジャイロ周波数, lower-band chorus の上端カットオフ周波数が発生領域での 1/2 ジャイロ周波数と一致することが考えられる. 実際, 我々は Geotail 衛星搭載の波形捕捉受信機 (WFC) と SFA で観測された chorus に対して理論と矛盾のないことを示した [2].

Geotail 衛星で観測される rising-tone chorus のほとんどは lower-band chorus のみであるが, ときおり lower-band と upper-band を持つ dual-band chorus が観測されることがある. 本研究では lower-band chorus のみが観測されるときと dual-band chorus が観測されるときの違いを SFA データを用いて統計的に解析した. Dual-band chorus は伝搬過程でローカルの 1/2 ジャイロ周波数の成分が減衰することにより生じることが分かっている. Lower-band のみの chorus はこの dual-band chorus がさらに高緯度方向に伝搬することで, upper-band chorus がローカルの 1/2 ジャイロ周波数の減衰によりすべて消えてしまうことで生じると考えられる. SFA データより, lower-band chorus の上端カットオフ周波数が発生領域での 1/2 ジャイロ周波数 (1/2 fce0) を示すと仮定して, chorus の周波数の上限を示す発生領域でのジャイロ周波数の 0.7 倍が観測点でのジャイロ周波数の 1/2 倍 (1/2 fce) よりも低ければ (0.7fce0 < 1/2fce) upper-band chorus の全てが減衰され lower-band のみの chorus が観測される. 一方, 高ければ (0.7fce0 > 1/2fce) upper-band chorus の一部が残るため dual-band chorus が観測される可能性が高いことが分かった. したがって, lower-band のみの chorus と dual-band chorus のどちらが観測されるかは発生領域と観測点との相対的なジャイロ周波数の関係によって決まると考えられる.

References

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