Intermittent Fluctuations and Their Interactions with the Particles in the Auroral Zone

Sunny W. Y. Tam[1,2] and Tom Chang[2]

[1]Plasma and Space Science Center, National Cheng Kung University, Tainan, Taiwan

[2]Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, Cambridge, MA, U.S.A.

Abstract

Our simulations show that the efficiency of auroral ion energization due to ion cyclotron resonant heating depends on the degree of intermittency of the electric field fluctuations in the auroral zone. Results of data analyses have demonstrated the intermittent nature of the auroral electric field fluctuations. The intermittency investigation by our simulation model is thus relevance to the real situation in the auroral zone.

Introduction

It has long been recognized that the commonly observed broadband, low frequency electric field fluctuations are responsible for the acceleration of O^+ ions in the auroral zone. In order for the fluctuating electric field to resonantly accelerate the ions continuously as the ions evolve upward along the field lines, they must be in continuous resonance with the ions. There does not seem to be a fully viable mechanism that can generate a spectrum of fluctuations broadband and incoherent enough to fulfill this stringent requirement.

Recently, it has been demonstrated that the sporadic and localized interactions of coherent structures arising from the plasma resonances in magnetized plasmas can be the source for the observed broadband, low-frequency electric field fluctuations (Chang, 2001) as well as co-existing nonpropagating and propagating fluctuations (Chang et al., 2004). Early theoretical studies (Chang et al., 1986; Retterer et al., 1987) have demonstrated that particle interactions with the propagating electromagnetic component of the turbulence can lead to the efficient energization of the auroral ions, which was observed, for example, in early missions such as the Dynamics Explorer and the Viking satellites (Hultqvist et al., 1988).

Traditional theories that considered the resonant interactions between the broadband electric field and the auroral ions assumed that the fluctuating field followed the Gaussian statistics. However, recently broadband fluctuations elsewhere in space, such as the solar wind, were found to be intermittent in nature (Sorriso-Valvo et al., 1999; Bruno et al., 2001). It is therefore conceivable that the turbulent electric field fluctuations in the auroral zone are also intermittent.

Here, we discuss the ion heating and acceleration in the auroral zone due to broadband intermittent fluctuations. Applying a global evolutional model, which treats the auroral O^+ ions as test particles, we show, in particular, that nonpropagating electrostatic fluctuations are as effective as propagating electromagnetic fluctuations in accelerating the ions, and may lead to the frequently observed conic events in the region. We also find that the efficiency of the ion heating depends on the degree of intermittency of the resonating component of the fluctuations. We also discuss how to extend the application of the global evolutional model in order to achieve a self-consistent description that includes the intermittent broadband fluctuations.

Based on the results of the study, it is therefore worthwhile to investigate the intermittency of the electric field in the auroral zone. In fact, data analyses by Tam et al. (2005) have shown that the overall electric field fluctuations in the auroral zone, as measured by the SIERRA sounding rocket, were intermittent. Results of those analyses thus supported the relevance of the intermittency investigation by the global evolutional model to the real situation in the auroral zone.

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