Anti loss cone plasma and wave interactions in geomagnetosphere

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Geomagnetosphere is the region around earth well covered by satellite observations. Data from the space probes and from various ground-based observatories have helped a lot to improve our understanding of this dynamic domain. External factors like the solar wind, interplanetary magnetic field (IMF), etc. have definite control over the structural and phenomenological features of the region. Phenomena like geomagnetic substorms and storms contribute to the occasional changes in the geometry of various sub regions in the magnetosphere namely magnetopause, plasma sheet, plasma sphere, etc. Presence of various waves and their interaction with different particle distributions make the geomagnetosphere an ideal place to study space plasma behaviour.

An essential role in the stability of a plasma wave results from the shape of the electron distribution function. A special class of plasma known as anti loss cone plasma (ALC) are characterized by particle distributions having deficit of particles with $v_{||} \approx 0$. In any plasma confinement, some particles will be lost if they do not satisfy the required pitch angle conditions. In the magnetopause, the actual loss cone will not be completely empty because some fraction of the loss cone electrons will be scattered back by the atmosphere into the loss cone itself. In addition, new electrons may continuously enter the loss cone through convection or pitch angle diffusion. In such a situation, an expression for loss cone distribution (LCD) is very difficult to obtain. In this context, it is suggested that an approximation to LCD with a partially filled loss cone could be constructed by the two- Maxwellian distribution function. This new approximation to the LCD is the anti loss cone distribution.

In this paper, low frequency whistler waves interacting with an assumed ALC distribution was shown to become highly unstable at times of substorm onsets. This establishes the presence of ALC electrons at onset time Plasma Sheet (PS) at geosynchronous site. The stability analysis proved that the whistler instability resulting from ALC interactions arises at frequencies greater than the electron cyclotron frequency. This is a new result and is shown to be possible at specific conditions of velocities and ALC parameter. Thus, the anti loss cone instability is shown to occur in a frequency range where loss cone instability is not possible (loss cone instability exists below electron cyclotron frequency). The study also proves that for an assumed higher velocity ratio, the instability is maximum for a particular ALC parameter. Also it is found that a lower β parameter enhances instability, which implies that plasma β is a factor determining the extent of whistler instability even at times of highly disturbed conditions such as substorm onsets. The analysis brings out that a major part of free energy available at PS during substorm onsets is the contribution due to the anisotropy of the ALC distribution function. The effect of a few cold electrons along with the hot ALC electrons is also investigated. Presence of cold electrons has proved to cause wave decay rather than wave growth.

The study reported is the first of its kind and can be used to explain various triggering mechanisms of magnetospheric substorms