Interpreting measurements of energized ions within the pressure cooker acceleration scenario

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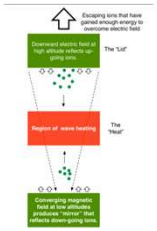
BACKGROUND

- VISIONS (VISualizing Ion Outflow via Neutral atom imaging during a Substorm) was launched into the region of strong fluxes of transversely accelerated ions during the auroral substorm of 2013 to get more knowledge of the ion heating scenario.
- According to Gorney et. al. (1985), the ions in the atmosphere also gets heated by low frequency atmospheric waves which give birth to the pressure cooker scenario. This was also a subject matter of this mission.



Rowland, AGU-2013
Figure-2

picture courtesy: NASA
Figure-1

INSTRUMENTATION

- VISION was equipped with MILENA, EEA/EIA, FTP/SSP, RAI
- Out of all the instruments on board, we are primarily focusing on the data produced by EIA (Electrostatic Ion Analyzer) provided by Clemmons, Lemons from Aerospace corporation and FIELDS instruments provided by Pfaff, Rowland, and Klenzing of GSFC.

MOTIVATION

- The accelerated ions along the up looking pitch angles (0-30 deg) and perpendicular pitch angles(60-120 deg) are plotted below

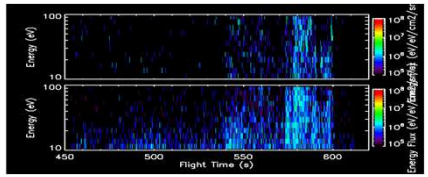


Figure-3

- It is evident that there are higher amount of transversely accelerated ions along the perpendicular pitch angles.
- Interesting fact about them is that they are only heated to the energy of 100eV whereas the solar incoming particles contain (~0.5-10keV) energy.
- When looking downward, we also see a population of transversely accelerated ions, in the near-earth atmosphere.

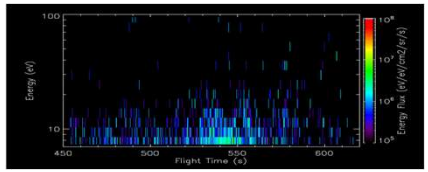


Figure-4

- These two plots show that the atmospheric ions get transversely accelerated, where they gain only a certain amount of energy.

QUESTIONS

- Upon seeing the above two plots, the first thing comes in mind is, what is the source of transverse acceleration of ions?
- Also, the incoming solar particles are so energetic that it seems a bit unreal that the solar particles heat up the atmospheric ions only to this level of energy.
- Therefore, it is an indication of the fact that besides particle-particle interactions, there is an another source of heating is present.
- In the regime of "pressure cooker mechanism", it has been postulated that the low frequency waves present in the atmosphere accelerate these ions. But, to what extent? Is there any direct relation between the wave power and the ion acceleration?

METHODS AND DATA

- We have used power spectrum density analysis to check the wave profiles.
- Usual 2-D plots have been used to interpret the data of ions and waves in some contexts to maintain simplicity of understanding.
- The wave data is provided by GSFC where the ion profiles are provided by Clemmons.

RESULTS

- Driven by the quest, we checked profiles of both the ion flux and wave power.

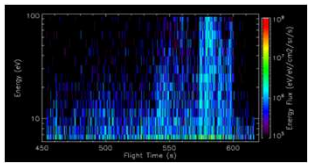


Figure-5

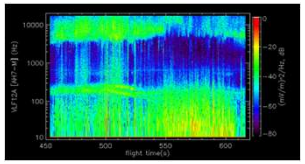


Figure-6

- Upon seeing the presence of VLF waves in Figure-6, 2 second time integration has been taken for both the ion flux and the wave power and compared side by side.

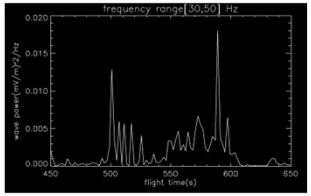


Figure-7

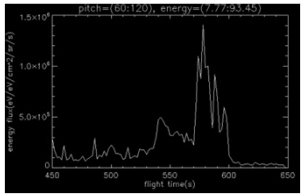


Figure-8

- The average frequency range was taken between 30 and 50 Hz because the calculated O^+ ion gyro frequency was between 38 Hz to 42 Hz.
- Upon comparing Figure-7 and Figure-8 we can infer that the wave power has influence on the energy flux.
- Driven by the relation above, we went on to check the relation between the energy flux and the wave power for the down looking pitch angles, and we get the following plots

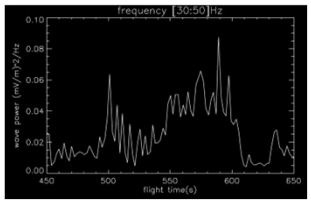


Figure-9

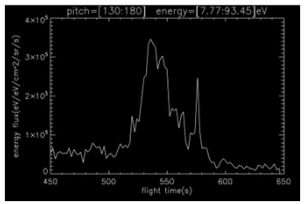


Figure-10

- The above 4 plots, figure-7 to figure-10 shows relation between the wave power and the corresponding energy fluxes.
- Both the perpendicular and downward-looking pitch angle distributions of the ion energy fluxes indicate an influence of wave-driven processes on ion energization..
- Another thing to note here is the absence of one-to-one correspondence between the wave heating and ion energization. The phenomena can be justified in the way that the wave heating is a resonance effect that takes time to heat up the ions.
- The plots clearly show that an increase in wave power corresponds to an increase in energy fluxes. However, a time delay is observed, which will be the focus of future research.

TAKEAWAY AND FUTURE WORK

- We have looked at the wave heating phenomena under the pressure cooker scenario in this current work.
- Increment in ion-energy flux has been observed near wave power increment. Which could be thought of as consequence of wave heating.
- Instead of a one-to-one correspondence between the wave power and the ion-energy flux, a time delay has been observed which would be a matter of our future work.
- A very next step would be to run a correlation analysis. Trying to develop a correlation or linear regression in between wave-power and ion-energy flux would strengthen our inference.
- Apart from the investigation on wave heating in future we will delve into looking for gyro-phase bunching of ions and corresponding relevant works.

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- J. H. Clemmons, C. L. Lemon, J. H. Hecht, D. E. Rowland, R. F. Pfaff, J. H. Klenzing, Accelerated auroral zone ions: Results from the VISIONS mission, AGU Fall Meeting 2013

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