



Physics of Auroral Emissions

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Abstract:-

This article is about formation of aurora after electrons gets accelerated in the last part of their journey by alfvén waves. The recently done experiment shows that there is a clear casual relationship between alfvén waves and acceleration between Alfvén waves and accelerated waves that directly effect auroral emissions.

Formation of aurora:-

Auroras are one of most spectacular and beautiful natural phenomenon, caused due to suns effect. They are seen in the earth's poles, hence are also called polar lights. Auroras in the north pole of the earth called aurora borealis and in the south pole are called aurora australis.



They are caused due to disturbances in earth's magnetosphere by solar winds. Solar winds are consists of lot if electrons and energised particles. They get hit the magnetic field and gets trapped there and speed down into the earth's upper

atmosphere down the earth's magnetic field lines. In that atmospheric region they collide with nitrogen and oxygen molecules and make them excited. When these molecules return to their ground state, leading

to various kinds of auroral emissions. There is difference between day side and night side auroral emissions along with different magnetic timeline suggests that there are different region of sources as well as different mechanism. The three main drivers being

- The boundary of the magnetosphere layer on the day side precipitate highly energetic magneto sheath particles or plasma electrons on the night-time from the boundary.
- quasi-static, field-aligned currents
- energetic electrons that are accelerated by Alfvén waves.

Note:-

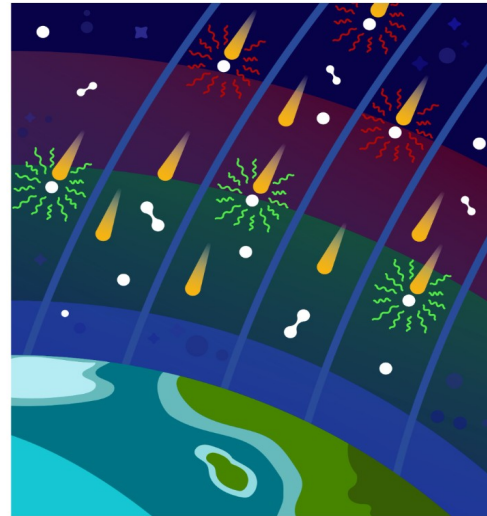
here a very brief discussion of Alfvén waves are required. They are basically a type of transverse magnetic tension waves named after Hannes Alfvén who deduced the existence of such waves from the equations of electromagnetism and hydrodynamics. All these topics are subjected to huge research and on going study. The third point, that electrons are being accelerated by Alfvén waves was a very popular theory to answer the mechanism of how the electrons got accelerated in the last part of their journey reaching the speed upto 45 million mph. To confirm the theory, the space physics community scientists has pursued a combination of statistical and conjunction studies by special spacecrafts of the spatial distribution of Alfvén waves and precipitating electrons. From the Data by the polar



spacecraft, it was found that between the altitude of $6R$ and $4R$, R being the radius of the earth, it was found that downward poynting flux (consider it as energy or power) of Alfvén waves was enough to power the auroral emissions. Subsequent conjunction studies also show that wave energy of Alfvén waves were lost over the intervening altitude ranges through the acceleration of electrons. This picture is also relevant in other planets.

The experiment in brief and results:-

These studies gave a strong hints towards the success of the theory. But there were certain limitations and many uncertainties in the spacecraft measurements. To have a complete understanding of the kinetic plasma physics governing the situation, a laboratory experiment was done on Large Plasma Device (LPD) at UCLA's plasma science faculty, mimicking earth's auroral magnetosphere. Alfvén waves were launched down the LPD's 20 metre long chamber. This experiment required critical measurement of the very small population of electrons moving down the chamber of LPD at nearly the same velocity as the Alfvén waves. The result of the experiment reveals that the small group of electrons gets accelerated by resonance from the electric field of Alfvén waves, thus confirming the theory and serving a deep insight to the mechanism of the plasma kinematics.



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Electrons streaming toward Earth as they surf on Alfvén waves (yellow) collide with nitrogen and oxygen molecules (white); in upper altitudes, these collisions result in the emission of red light, while in lower altitudes the emitted light is green.

Reference:-

- UCLA newsroom
- Laboratory measurements of the physics of auroral electron acceleration by Alfvén waves:- nature communications.

Images:-

- Wikipedia
- UCLA newsroom