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The Role of Kinetic Alfven Waves in Turbulent Plasma Heating and Particle Acceleration

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Kinetic Alfven waves play a key role in the plasma heating and particle acceleration in a number of important space and astrophysical plasma environments. Astrophysical plasma turbulence at MHD scales appears to be largely non-dissipative, but when the turbulent cascade of energy reaches the plasma kinetic length scales, collisionless interactions between the electromagnetic fields and plasma particles can lead to significant heating of the plasma species or acceleration of particles. After briefly reviewing the wide range of space and astrophysical plasmas where kinetic Alfven waves contribute to the plasma dynamics and transport of energy, I will focus on two exciting recent findings involving kinetic Alfven waves. First, applying the recently developed field-particle correlation technique[1,2,3] to Magnetospheric Multiscale observations in Earth's turbulent magnetosheath, we have shown that electron Landau damping of kinetic Alfven waves plays a significant, and sometimes dominant, role in the dissipation of the turbulent energy[4]. Second, using laboratory experiments, we have experimentally confirmed the proposed mechanism of auroral electron acceleration by inertial Alfven waves in the Earth's magnetosphere[5]. In Figure 1 below is shown an overview of the region in the Earth's auroral magnetosphere, about 2–3 Earth radii in altitude, where Alfven waves can accelerate electrons up to energies of 1 keV down towards the ionosphere. These electrons collide with and excite the atoms and molecules in the upper atmosphere, ultimately leading to the fascinating glow of the aurora.

References
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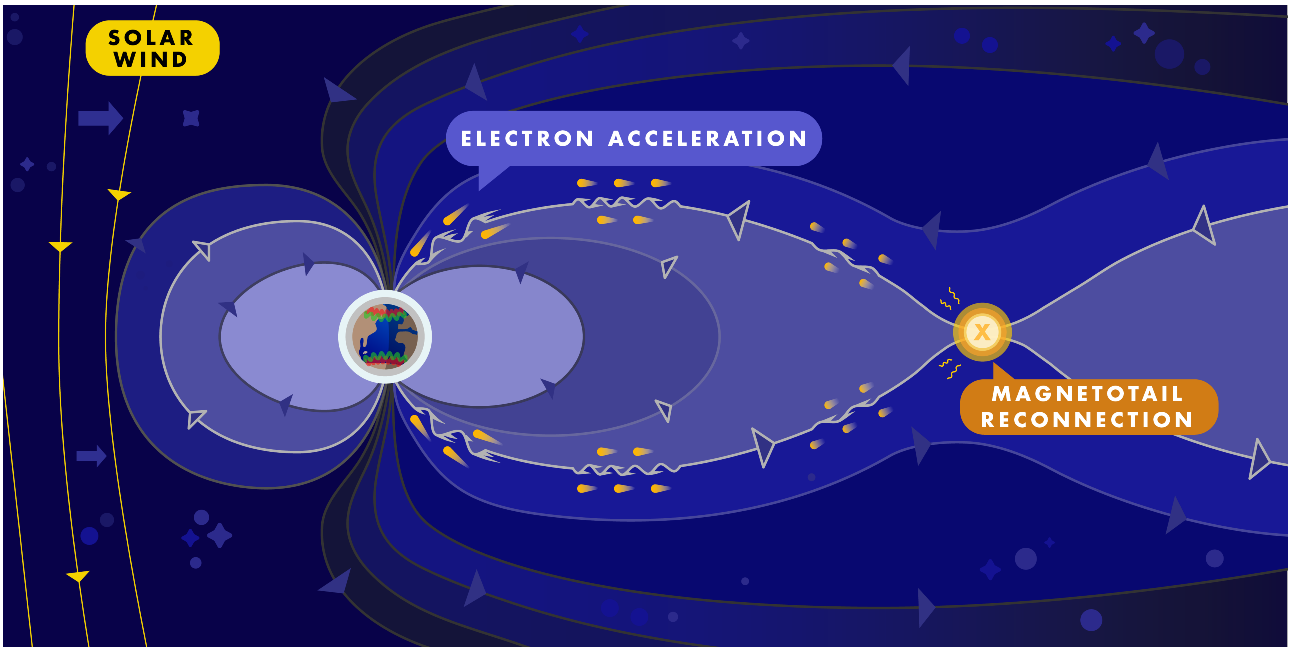

Figure 1. During geomagnetic storms, oppositely directed magnetic field lines in the Earth's extended magnetotail are pushed together, driving magnetic reconnection. As reconnected field lines (light gray field lines) snap back towards the Earth, they launch Alfven waves. Those Alfven waves gain speed as they travel along the magnetic field lines towards the Earth at high latitudes. Electrons (yellow dots) moving with speeds similar to the wave speed are picked up and "surf" on the wave, accelerating up to speeds of around 45 million mph. These electrons stream down towards the Earth and collide with the atoms and molecules in the thin upper atmosphere, causing them to emit the green or red light that is characteristic of the aurora.