

Substorm Energy Storage and Release Processes in Magnetosphere

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The sun continuously emits plasma particles (solar wind) and radiation. High energy radiation (EUVs and X-rays) is absorbed mostly by the Earth's upper atmosphere. Most solar particles are deflected by Earth's magnetic field, but some find their ways into the magnetosphere and are stored mostly in the magnetotail. As the stored plasma energy becomes larger than some critical value, plasma processes (instabilities) take place to form turbulence and transport and release the plasma particle and energy both downward into the ionosphere and tailward into the interplanetary space. The most important energy storage and release process is the substorm. During the substorm growth phase the plasma pressure increases in the central plasma sheet, and the magnetic field stretches outward to become more tail-like, and both the magnetic and plasma energies increase dramatically in the night side. The plasma beta becomes $\gg 1$ and reaches $\sim 40-60$ in the central plasma sheet at $\sim 8-10$ Earth radii. Then, kinetic ballooning instabilities (KBIs) can be excited to produce Pi2 waves (~ 1 min period) and their parallel electric field accelerates electrons into the ionosphere to produce substorm auroral arcs with bead-like structure along the arc. As KBIs grow to large amplitude, higher frequency Pi1 instabilities are also excited and together they form turbulence and cause plasma transport in the central plasma sheet, which is the substorm expansion phase. In the ionosphere the auroral arc breaks up and forms vortex structure and expands poleward, earthward and in the east-west directions. In the magnetosphere, the plasma pressure gradient relaxes in the near-Earth plasma sheet, and the magnetic field becomes more dipole-like (called the dipolarization), and the cross-tail current is greatly reduced (called current disruption). After the substorm expansion, the plasma and magnetic field of the magnetosphere return to a quiet-time state. Observations and theories will be presented.