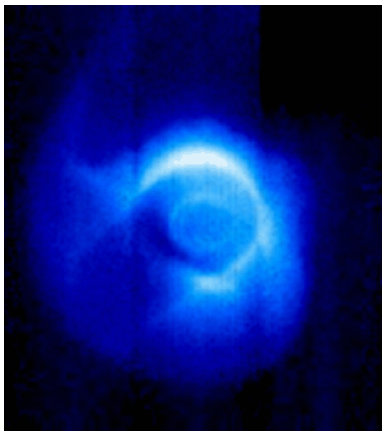

Figure 5-2 The Plasmasphere.
A view from above the North Pole of the plasmasphere illuminated by ultraviolet light from the Sun. The Sun is located beyond the upper right corner.

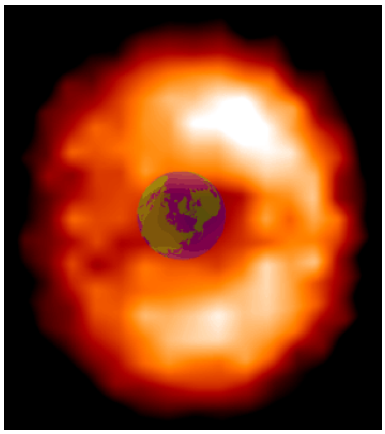

Figure 5-3 The Ring Current.
From above the North Pole, the current is seen flowing around the equatorial regions of the Earth.

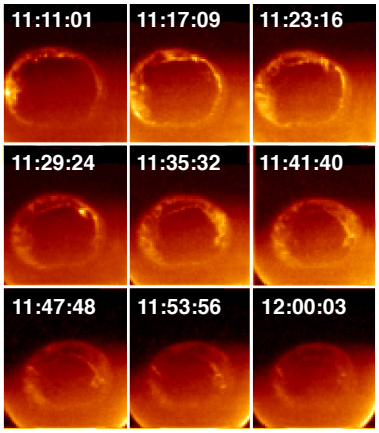

Figure 5-4 The Auroral Oval.
From space, the aurora borealis appears as a ring of light that changes its appearance from minute to minute.

During severe storms, compasses display incorrect bearings as the surface geomagnetic field changes its direction. In the equatorial regions, an actual decrease in the strength of the geomagnetic field can often be measured. This is generally attributed to the existence of a temporary river of charged particles flowing between 30,000 and 60,000 kilometers above ground: the **ring current.** These particles have energies between those within the plasmasphere and those in the Van Allen Belts. They appear to originate within the geomagetic tail as charged particles that are injected deep into the magnetosphere. Most of the time there are few particles in the ring current, but during severe storms, it fills up with a current of millions of amperes, which spreads into an invisible ring encircling Earth. Just as a flow of current through a wire creates its own magnetic field, the ring current generates a local magnetic field that can reduce some of Earth's surface field by up to 2% over the equatorial regions.

In addition to these families of particles, there are also powerful currents of particles that appear during especially stormy conditions and lead to visually dramatic phenomena called the **aurora borealis** and the **aurora australis:** the northern and southern lights.

9.2 The Aurora

For thousands of years humans have been able to look up at the northern sky and see strange, colorful glows of light. By the early 1900's, spectroscopic studies had shown that auroral light was actually caused by excited oxygen and nitrogen atoms emitting light at only a few specific wavelengths. The source of the excitation was eventually traced to currents of electrons and protons flowing down the geomagnetic field lines into the polar regions where they collide with the atmospheric atoms. However, aurora are not produced directly by solar flares. Radio communications blackouts on the day side of Earth are triggered by solar flares as these high-energy particles disturb the ionosphere. When directed toward Earth, expulsions of matter by the Sun called **coronal mass ejections** contribute to the conditions that cause some of the strongest aurora to light up the skies. At other times, a simple change in magnetic polarity of the solar wind from north-directed to south-directed seems to be enough to trigger aurora without any obvious solar disturbance.

Because of the existence of the magnetospheric cusp on the day side of Earth, solar wind particles can, under some conditions, flow down this entryway into the polar regions. This causes daytime aurora, and the diffuse red glows of night time aurora. This is, virtually, the only instance where solar wind particles can directly cause aurora. It is not, however, the cause of the spectacular nightime polar aurora that are so commonly photographed. To understand how these aurora are produced, it is helpful to imagine yourself living inside a television picture tube. We don't see the currents of electrons guided by magnetic forces, but we do see them paint serpentine pictures on the atmosphere, which we then see as the aurora. The origin of these currents is in the distant geomagnetic tail region, not in the direct inflow of solar wind plasma.

When the polarity of the solar wind's magnetic field turns southward, its lines of force encounter the north-directed lines in Earth's equatorial regions on the dayside. The solar wind field lines then connect with Earth's field in a complex event that transfers particles and energy into Earth's magnetosphere. While this is happening near Earth, in the distant geomagnetic tail, other changes are causing the geomagnetic field to stretch like rubber bands and snap into new magnetic shapes. This causes billions of watts of energy to be transferred into the particles already trapped in the magnetosphere out in these distant regions. These particles, boosted in energy by thousands of volts, then flow down the field lines into the polar regions to cause the aurora, like the electrons in a television picture tube that paint a pattern on the phosphor screen.