

Fig. 1.5. Average auroral oval and polar cap.

1.3. Magnetospheric Currents

The plasmas discussed in the last section are usually not stationary but move under the influence of external forces. Sometimes ions and electrons move together, like in the solar wind. But at other occasions and in other plasma regions, ions and electrons move into different directions, creating an electric current. Such currents are very important for the dynamics of the Earth's plasma environment. They transport charge, mass, momentum and energy. Moreover, the currents create magnetic fields, which may severely alter or distort any pre-existing fields.

Actually, the distortion of the terrestrial dipole field into the typical shape of the magnetosphere is accompanied by electrical currents. As schematically shown in Fig. 1.6, the compression of the terrestrial magnetic field on the dayside is associated with current flow across the magnetopause surface, the *magnetopause current*. The tail-like field of the nightside magnetosphere is accompanied by the *tail current* flowing on the tail surface and the *neutral sheet current* in the central plasma sheet, both of which are connected and form a \ominus -like current system, if seen from along the Earth-Sun line.

Another large-scale current system, which influences the configuration of the inner magnetosphere, is the *ring current*. The ring current flows around the Earth in a westward direction at radial distances of several Earth radii and is carried by the radiation belt particles mentioned above. In addition to their bounce motion, these particles drift slowly around the Earth. Since the protons drift westward while the electrons move in the eastward direction, this constitutes a net charge transport.

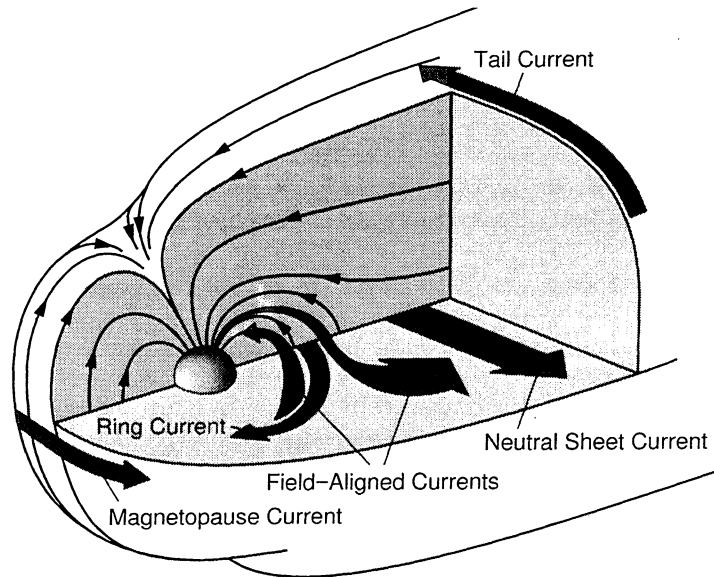


Fig. 1.6. Synopsis of magnetospheric currents.

A number of current systems exist in the conducting layers of the Earth's ionosphere, at altitudes of 100–150 km. Most notable are the *auroral electrojets* inside the auroral oval, the *Sq currents* in the dayside mid-latitude ionosphere, and the *equatorial electrojet* near the magnetic equator.

In addition to these perpendicular currents, currents also flow along magnetic field lines. As shown in Fig. 1.6, the *field-aligned currents* connect the magnetospheric current systems in the magnetosphere to those flowing in the polar ionosphere. The field-aligned currents are mainly carried by electrons and are essential for the exchange of energy and momentum between these regions.

1.4. Theoretical Approaches

The dynamics of a plasma is governed by the interaction of the charge carriers with the electric and magnetic fields. If all the fields were of external origin, the physics would be relatively simple. However, as the particles move around, they may create local space charge concentrations and thus electric fields. Moreover, their motion can also generate electric currents and thus magnetic fields. These internal fields and their feedback onto the motion of the plasma particles make plasma physics difficult.