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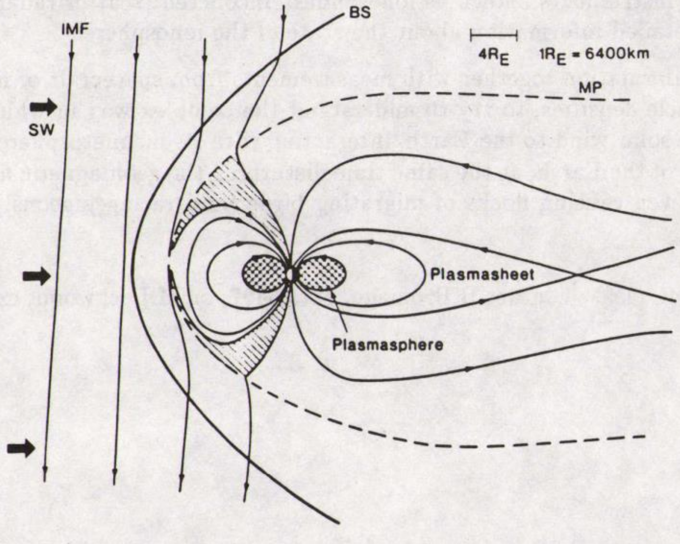
THE SOLAR WIND AND THE EARTH'S MAGNETOSPHERE

The part of the Sun that we can see, called the photosphere, is known to consist of a gaseous material at a temperature of about 6000 degrees Centigrade, which means it radiates mostly 'visible' light. During an eclipse this part of the Sun is covered by the disc of the moon, revealing a fainter, tenuous, outer atmosphere known as the **solar corona.** This region appears faint because it is much hotter, about 2,000,000 degrees, and therefore radiates energy predominantly in the X-ray region of the spectrum, with much less emitted in the visible range.

At these temperatures, the ions and electrons which make up the atmosphere of the Sun are very energetic; in fact they move so rapidly that, just as a rocket is accelerated until it travels fast enough to escape from the Earth's gravitational field, these particles can escape from the influence of the Sun. They stream out continuously from the Sun, past all of the planets in the solar system. As they reach the Earth they have been found to have supersonic speeds between about 300 and 700 km per second. This stream of electrically charged particles (a plasma) is known as the **Solar Wind.** It carries with it, frozen in by the interaction between electricity and magnetism, the magnetic field that was associated with it on the Sun. This is known as the **Interplanetary Magnetic Field (IMF).**



The solar wind (SW), *carrying the interplanetary magnetic field* (IMF), *flows around the Earth's magnetosphere.*

The Earth, with its own magnetic field, similar to that of a bar magnet, acts as an obstacle in the supersonic flow of the solar wind and a bow wave or **Bow Shock (BS)** is created about 15 Earth radii ($\mathbf{R}_E$) sunward of the Earth. The Earth's magnetic field is distorted by the solar wind, compressing it on the sunward side and drawing it out on the dark side of the Earth. The region containing the Earth's magnetic field is known as the **Magnetosphere**, bounded by the **Magnetopause (MP)**. Between the bow shock and the magnetopause, a region of turbulence is generated, called the **Magnetosheath**. The Earth's magnetic field prevents most of the solar wind particles from entering the magnetosphere, which forms a low-density cavity in the solar wind flow. In the inner magnetosphere, a ring of somewhat higher density plasma, the **Plasmasphere**, is held around the Earth by its magnetic field.

In the diagram, the IMF is configured in such a way as to allow **'magnetic reconnection'** to occur at the Magnetopause. That is, geomagnetic field lines passing from the southern to the northern polar regions have broken and re-connected to the IMF. The field lines, and the plasma associated with them, then spring back away from the Sun, across the poles and are swept out behind the Earth by the solar wind, forming part of the **Magnetotail**. Here they reconnect again, propelling plasma into the plasma sheet, increasing the energy of the trapped plasma population in this region. Some of these energetic particles can now escape down the field lines into the Earth's atmosphere, in the polar regions. At about 100 km above the surface of the Earth the atmosphere absorbs the energy of these particles , causing the spectacular display of coloured lights dancing in the sky which we know as the Aurora.

The Aurora is just one example of energy being transferred from the solar wind into the magnetosphere, whence the effect is reflected in the Earth's upper atmosphere. Such disturbances, and changes in pressure in the solar wind at the bow shock, cause variations in the strength and direction of the geomagnetic field. These are continuously monitored by many observatories throughout the world. These data are passed to the World Data Centres, including the World Data Centre C1 at RAL. Other measurements also made regularly and passed to the World Data Centre are observations of the plasma density in the **Ionosphere** (the charged upper atmosphere of the Earth), using radar instruments known as ionosondes. Incoherent scatter radar such as EISCAT, can provide more detailed information about the state of the ionosphere.

Scientists use this information together with measurements from spacecraft of magnetic field, particle flows and particle densities, to try to understand the complex way in which energy from the Sun is carried in the solar wind to the Earth, interacting with its magnetosphere and passing down into the atmosphere of the Earth, at the same time disturbing the geomagnetic field, affecting radio transmissions, and even causing flocks of migrating birds (and racing pigeons!) to be thrown off course.

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