appeared on 30th Apr 2009

Cluster and Double Star

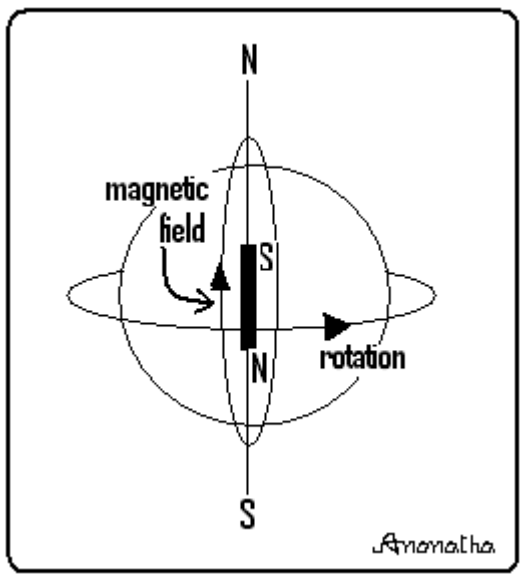
There is a sparring match of magnetic fields going on around the earth, writes S Ananthanarayanan

If the earth did not have a magnetic field, it would have got fried and scorched by the barrage of charged particles that the sun (mainly) and the cosmos propel towards it. But the magnetic field deflects the current of charges, just like the magnet in an electric motor spins the motor round, and forms a protective umbrella. Only, once in a way, violent bursts of activity on the sun can disrupt the magnetic field and also damage the layer of charged particles that surrounds the earth and serves as a second line of defence!

The European Space Agencies' ***Cluster***, an arrangement of four satellites, and the ***Double Star*** programme, which the ESA conducts along with the Chinese space agency have acted in concert and have collected valuable information about the effect of solar activity on the earth and its surroundings

Earth's magnetism

The earth behaves as it were a bar magnet, with its magnetic N pole at the geographic South Pole and the magnetic S pole at the geographic North Pole. The North Pole of a bar magnet, like a magnetic compass, suspended on the earth's surface would then point towards the magnetic South Pole of the earth, which is at the geographic North Pole. The source of the magnetic field is believed to be the circulation of the iron rich and molten core of the earth, which partly explains why the magnetic axis of the earth is almost the same as its rotational axis.



The earth's magnetic field extends far out into space and there is a region around the earth where it is this field that mainly controls the motion of gas and fast moving charged particles. This

region, which is above the ionosphere, or the layer of the atmosphere which is rich in ionized gas is called the earth's ***magnetosphere***. Despite its name, it is not spherical but is roughly bullet shaped and facing the sun. That the magnetosphere dominates the effect on the motion of charged particles in the ionosphere is to say that while it is too weak further out in space, it is also not equally active nearer the earth because, first, there are less charged particles and second the effect of the atmosphere itself is dominant nearer the surface of the earth.

Solar wind

This is a stream of charged particles from the sun's outer atmosphere that is propelled out into space to an extent because of the hot corona, or outer shell of the sun, and also because of processes not yet understood. The outer atmosphere of the sun, being so fiercely hot, is all ionized gas and the stream that arises is mostly high energy protons, or the positively charged nuclei of hydrogen atoms.

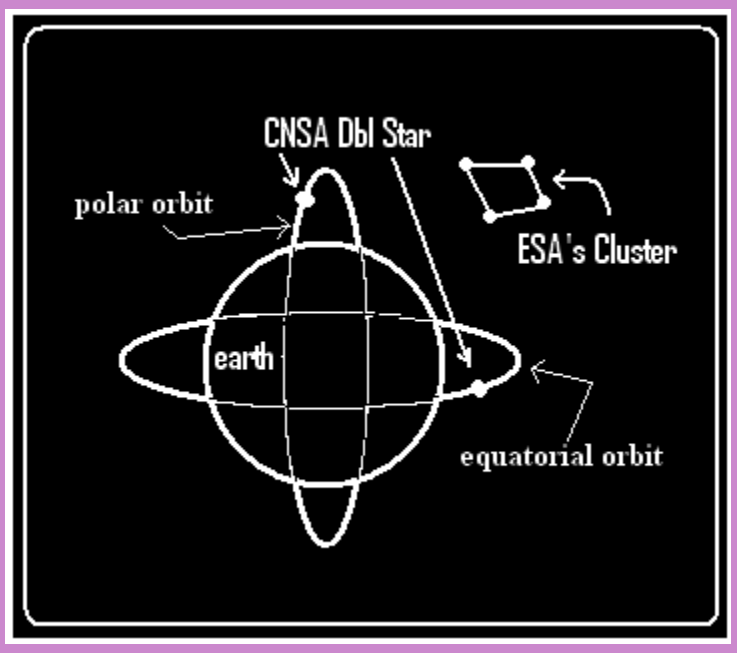
A stream of charged particles is effectively like an electric current and when it encounters a magnetic field it experiences a transverse force, the principle of the electric motor. The solar wind is thus pushed to one side by the earth's magnetic field, or parried, to use the term of boxers who push aside the blow aimed by an opponent. This effect protects the earth from the bulk of charged radiation and the part that does manage to come nearer the earth gets blocked by the ionosphere, a shell of ionized gas that envelopes the earth. What is still left then gets neutralized by interactions with the lower atmosphere.

Solar flares

Every once in a way, it could be less than once a week to several times a day, there are violent magnetic storms on the sun, which whip up the solar wind. A storm on the sun extends deep to within the atmosphere and heats the ionised gases to tens of millions of degrees and accelerates electrons, protons and heavier ions to near the speed of light. The burst in particles speeding towards the earth is accompanied by X-rays and gamma rays and their effect is to temporarily alter the structure and composition of the magnetosphere and the ionosphere. These areas experience the hazards of high radiation levels and the effect down on the earth is on long range radio communications.

Cluster and Double Star

The magnetosphere itself was discovered only in 1958 by ***Explorer 1***, the first US earth satellite. There has been much research and investigation since then, but studies by single satellites or ground observations of aurora phenomena only record how things are at one place at a time. Understanding the dynamics of the interaction requires mapping the action over different and separated points at the same time, which needs a set of observation posts at vantage points and in communication with each other. The ESA's Cluster is a group of four satellites that have been placed in orbit in precise formation to make synchronised measurements. The information that the four satellites relay can then be processed to obtain 3D images of magnetosphere and to analyse the effects of solar disturbances in real time. The Cluster has been working since 2001 and will remain active till December 2009.



Double Star is a pair of satellites, one in an equatorial orbit and the other in a polar orbit, launched and operated by the China National Space Administration in collaboration with the ESA. Launched soon after Cluster, Double Star supplements the data collected and the two systems enable simultaneous data of the changing magnetic fields and ion population in different regions of the magnetosphere.

The result of coordinated in situ measurements is that increased solar activity drastically compresses the magnetosphere and changes the mix of ions in the space near the earth. The effect is that artificial satellites, including GPS satellites, which are usually protected within the magnetosphere, get exposed to increased activity. Communications and navigation systems then go out of gear and this is a continued problem for not just aircraft operations but also for different activities down on the ground, which depend on communication satellites. The Cluster-Double Star project is now trying to develop a model of the effect of solar activity on satellites to better understand and control the disturbance caused.

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