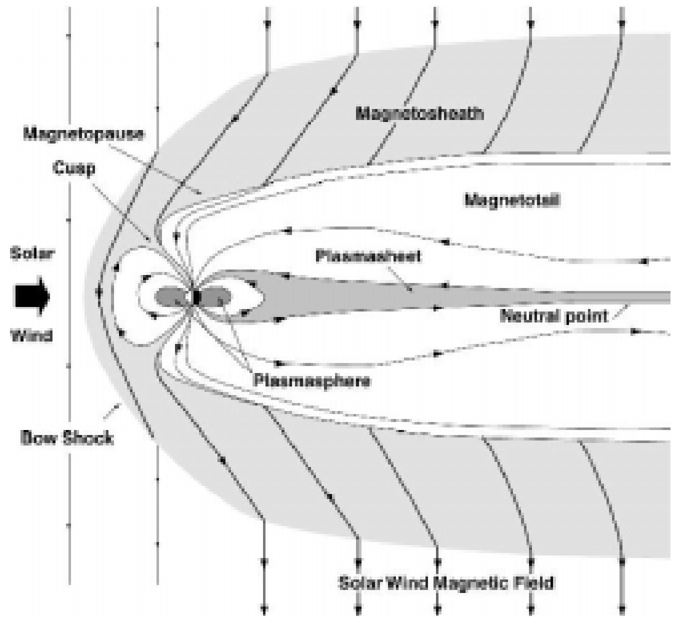
National Aeronautics and
Space Administration

Educational Product	
Educators & Students	Grades 9-12

Educational Brief

Exploring the Magnetopause with IMAGE

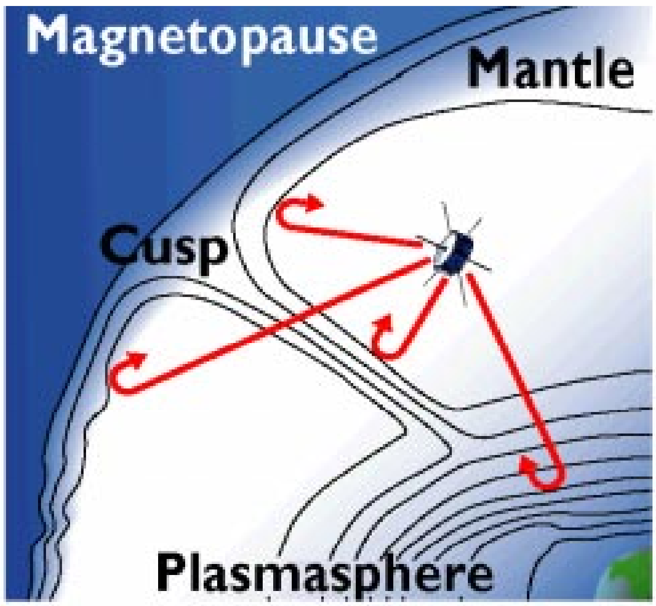


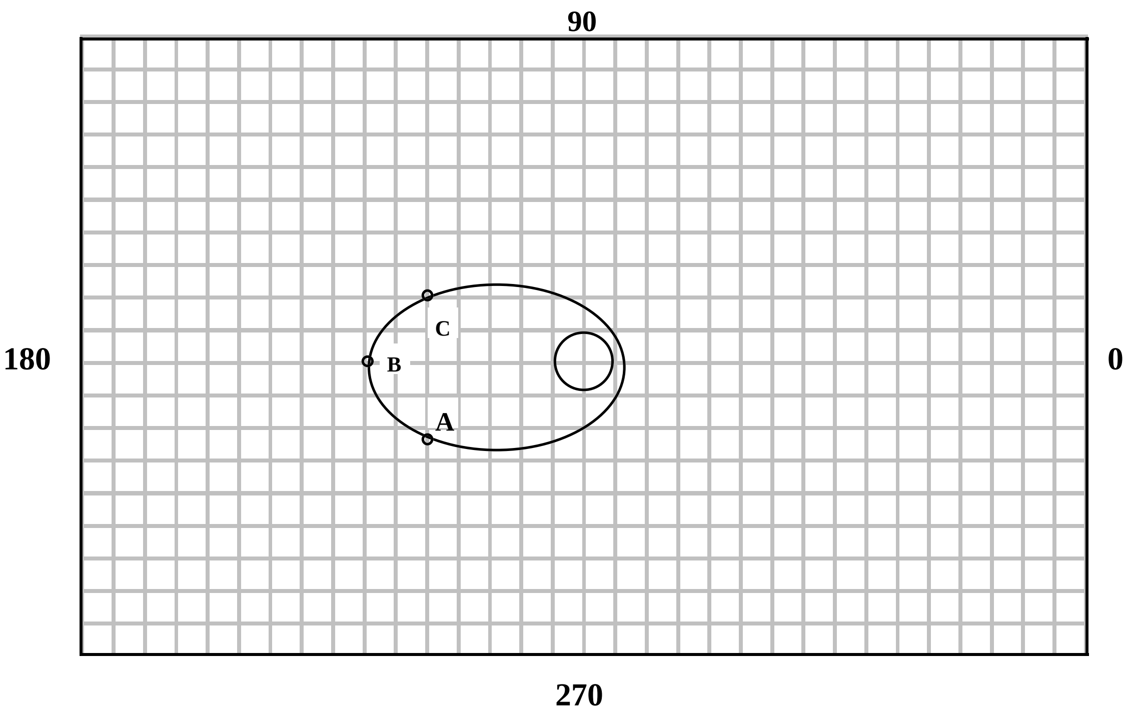
The Earth is surrounded by an invisible, and complex, region called the *magnetosphere,* in which charged particles, called *plasmas,* are affected by the terrestrial magnetic field. This field changes in complex ways when the Sun is active and ‘stormy’. Space scientists have identified a number of important parts to the magnetosphere as you can see in the diagram to the left. The van Allen radiation belts occupy a region called the *plasmasphere.* The magnetosphere is stretched out into a comet-like region, called the *magnetotail.* Like a boat making headway in the water, a bow wave or *bow shock* forms in the incoming solar wind. Behind this *bow shock* is a complex region of turbulent gas called the *magnetopause.*

The Imager for Magnetosphere-to-Auroral Global Exploration (IMAGE) will study this region using an instrument called the Radio Plasma Imager.

Radio Plasma Imager (RPI)

The RPI instrument onboard the IMAGE satellite works like a policeman’s radar speed detector, but on a much bigger scale. Every 5 minutes, RPI emits a series of radio pulses between 3 kiloHertz and 3 MegaHertz using its 10-watt transmitter. The 500-meter tip-to-tip antennas detect the returning echos from the pulses after they have been reflected by distant clouds of plasma. By studying the intensity and timing between the outgoing and incoming signals, scientists can ‘take a snapshot’ of the charged particle clouds, and their movements around the earth. This is the first time such an instrument has been flown into space. Space scientists expect that by imaging and tracking the motions of these clouds of plasma, they will be able to understand much better how the earth’s environment in space is affected by solar storms. These storms can cause electrical blackouts and satellite malfunctions.





RPI Data Table

RPI scientists recorded six echos from the magnetopause at three locations along the IMAGE satellite's orbit. The location of the satellite is identified by 'A', 'B' and 'C' in the figure, and makes two soundings at each location as shown in the table. Each square in the grid equals the radius of the earth (6378 kilometers). The numbers 0, 90, 180 and 270 define specific satellite viewing directions in degrees, in a coordinate system centered on the satellite's location. All times are given in seconds.

Location	Transmit Time	Receive Time	Direction (Degrees)
A1	19.187	19.461	255
A2	20.397	20.587	210
B1	7256.848	7256.986	190
B2	7393.217	7393.397	130
C1	14513.802	14514.014	120
C2	14681.379	14681.697	80

1) Compute the difference between the transmit and return times to determine the round-trip signal delay. (Example: 19.461 - 19.187 = 0.274 seconds)

2) Divide the round-trip times by 2 to get the one-way time for the signal to echo from the cloud and return to the satellite. (Example 0.274 seconds/2 = 0.137 seconds)

3) Multiply the answer in #2 by the speed of light in kilometers/sec to get the distance traveled from the point of reflection (Example: 0.137 sec x 300,000 km/sec = 41,100 km) Divide by the radius of the earth to convert to grid units in the above graph. (Example: 41,100 km/6378km = 6.4 earth radii)

4) Place a protractor on Point A in the diagram above, and place a dot on the map along the direction given in the table entry, and mark it at a distance from the satellite equal to the number of earth radii computed in Step 3.

5) Repeat Steps 1-4 for each of the 6 echo measurements in the table, and when finished, connect the dots with a smooth line to show where the RPI instrument found the magnetopause.