

Space Science SMART Projects
June 28 – July 23, 2004

1. ACE Transit of the Magnetosphere

Project Advisors: Chuck Smith, Charlie Farrugia, and Vania Jordanova

Students: Heather Briggs & Travis Glines

As a first approximation the Earth's magnetic field can be represented as a the dipole. This is the strongest and the longest-ranging contribution to the large-scale field of the Earth. However, when it interacts with the solar wind, the dipole is compressed on the dayside of the planet and extended on the nightside. This is known from many spacecraft flights that can be combined to produce a picture of the local magnetic field within the region known as the "magnetosphere". However, when the ACE spacecraft was launched the magnetic field instrument was turned on almost immediately. The transit of the ACE spacecraft through the magnetosphere on its way to the interplanetary (L1) orbital station provided a unique measurement of the dayside magnetosphere. The purpose of this project is first to render these measurements into pictorial form and then to compare the measured magnetic field with the uncompressed dipole. We will extract a measure of the compression. From there we will begin to explore what was happening in the magnetosphere and what was observed by other spacecraft in a search for the causes of the compression and new and interesting physics.

2. The Earth's Bow Shock: The Outermost Terrestrial Boundary

Project Advisors: Harald Kucharek and Pamela Puhl-Quinn

Students: Cayle Castor & Megan Schulz

The solar wind is a continuous stream of charged particles originating from the Sun, and approaches the Earth with a speed of 300 – 800 km/s. This stream also carries the magnetic field of solar origin known as the interplanetary magnetic field. The first sign of an interaction of the solar wind with the Earth's magnetic field is a standing shock wave in space on the Sun-facing side. This shock wave is like the sonic shock wave caused by an aircraft flying with supersonic speed. This bow shock slows down the solar wind, deflects particles around the Earth's magnetosphere, which acts as a gigantic shield against cosmic particles.

In this project we will analyze data from spacecraft crossing the Earth's bow shock on their orbit around the Earth. We will investigate the properties of this outermost boundary to interplanetary space. In particular, we will study the reflection and deflection properties of the bow shock which prevent the charged particles in the solar wind from directly penetrating the Earth's magnetosphere.

3. Study the Impact of Shocks on the Magnetosphere

Project Advisors: Jimmy Raeder and John Dorelli

Students: Rebecca Kolia & Michelle LeBlanc

Interplanetary shock waves occur quite often in the interplanetary medium. Often they are a precursor of a coronal mass ejection that is about to hit Earth. Such shocks can have severe effects on the Earth's space environment. In this project global simulations of the Earth's magnetosphere will be used to examine how an interplanetary shock interacts with the magnetosphere. In particular, we will look at how the shock front reaches different parts of the magnetosphere depending on the shock orientation in the solar wind.

4. Wave and Plasma Simulations

Project Advisor: Bernie Vasquez

Student: John Lazos

Rapidly moving streams of plasma emanate from the Sun and team with long magnetized waves which are called Alfvén waves. The waves have sharp edges showing evidence of nonlinear wave steepening. They are also arc-polarized wherein the total magnetic intensity is a constant but the magnetic field direction sweeps back and forth along a circular arc like a wiper-blade. The solar-wind plasma is nearly collisionless and shows evidence of preferred ion heating. There are also distinct beams of various atoms which stream relative to the main component of solar-wind protons. The detailed individual motions of the ions are important to follow in order to understand the behavior of the plasma and waves. We will employ hybrid numerical simulations using particle ions and fluid electrons. We shall undertake 3 simulation projects which will demonstrate how small but resonant forces can cumulatively lead to large changes: (1) Small amplitude and linearly polarized Alfvén waves propagating parallel to the background magnetic field will nonlinearly steepen. We will determine the time of steepening as a function of the ratio of plasma to magnetic pressure, especially for ratios of order unity where analytical calculations cannot determine the steepening time. (2) Arc-polarized Alfvén waves can propagate without changing form, but small disturbances can lead to their decay into new waves. We will determine the ratios of plasma to magnetic pressure where decay occurs and the type of waves which are generated. (3) Beams of ions streaming relative to one another can drive up waves from the smallest starting disturbances which then decelerate the relative streaming speed below a threshold where the speed becomes steady. We will find this threshold and determine the type of waves which are driven up.