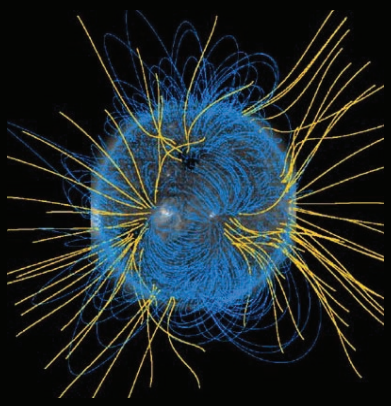
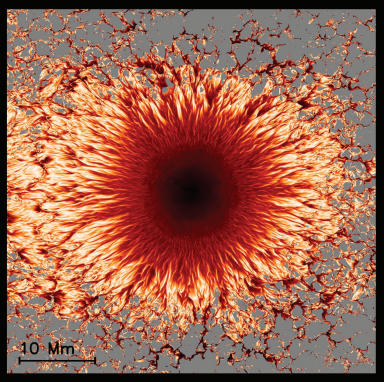
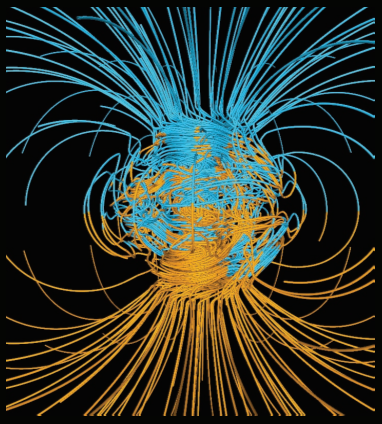
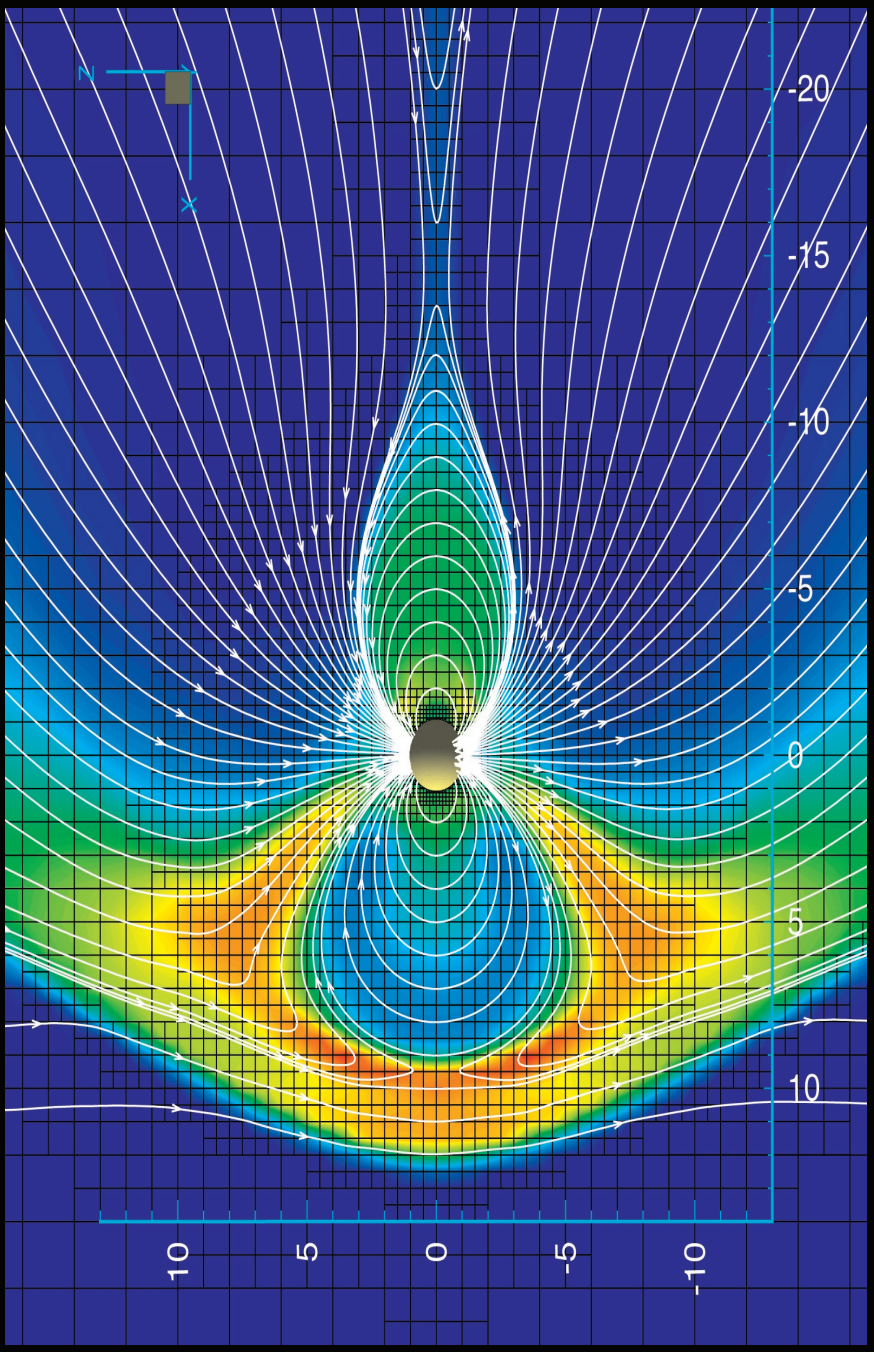
National Aeronautics and Space Administration









$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \mathbf{x} \left(\mathbf{v} \mathbf{x} \mathbf{B} \right) + \eta \nabla^2 \mathbf{B}$$

Get math ?

The front of the flyer shows some of the many applications of mathematics in astronomy.

Top - Model of the magnetic field of the sun based upon data from the Hinode satellite. (*Taro Sakao, ISAS*)

Middle - Mathematical model of a sunspot umbra and penumbra *(Matthias Rempel, NCAR))*

Bottom - Supercomputer model of Earth's dynamo magnetic field at the core. *(Gary Glatzmaier, UCLA*)

Main - Supercomputer model of Earth's magnetic field in space *(Tamas Gambosi, University of Michigan)*

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \mathbf{x}\left(\mathbf{v}\mathbf{x}\mathbf{B}\right) + \eta \nabla^2 \mathbf{B}$$

Advection + Diffusion

This formidable equation describes how the magnetic field, **B**, changes its strength as it is being moved (advected) through space by a charged plasma traveling at a velocity, **v**, and as it diffuses through this plasma the way an odor travels through the air. This equation is very basic to understanding and modeling how real physical systems, such as magnetic fields on the surface of the sun, change in time.

The Hinode satellite observes magnetic fields on the sun at very high resolution. It also measures the speed and density of the plasma through which the magnetic fields move. By mathematically modeling how the plasma and magnetic fields interact using equations like the one above, solar physicists can predict how the magnetic fields will change in time. These predictions can be tested against the data from the Hinode satellite to see just how well our theoretical understanding of solar magnetism, and solar flares, compares to the real thing. With the advent of powerful 'supercomputers' scientists can mathematically model the evolution of solar magnetic fields at nearly all scales that can be observed by satellites.

Modeling a Magnetic Field

Elementary - A simple mathematical model of a magnetic field from a bar magnet is given in the table below for two magnetic 'lines of force' in the First Quadrant. Plot the points for each magnetic line and connect them with colored lines. Then reflect the First Quadrant pattern into each of the other three quadrants to form a complete' dipole' magnetic field model.

Line 1		Line 2		Line 3	
X	Y	X	Y	X	Y
0	0	0	0	0	0
1	2	2	5	3	7
3	4	5	9	8	13
7	7	14	14	22	21
13	8	26	15	39	23
17	6	33	12	50	18
19	3	38	7	57	10
20	0	40	0	60	0

Advanced - The formula for a dipole magnetic field is given in polar coordinates by

$$r = L\cos^2\theta$$

For L= 20, 40 and 60, each representing a particular magnetic field line, graph this function in the First Quadrant of the Cartesian plane (by hand or with Microsoft Excel) using the definitions:

$$x = r\cos\theta$$
$$y = r\sin\theta$$

Reflect the graph into the other three quadrants to complete the mathematical model.

Visit the Space Math @ NASA website at

http://spacemath.gsfc.nasa.gov

to download over 200+ problems that apply math to all types of 'far out' space topics!

Dr. Sten Odenwald