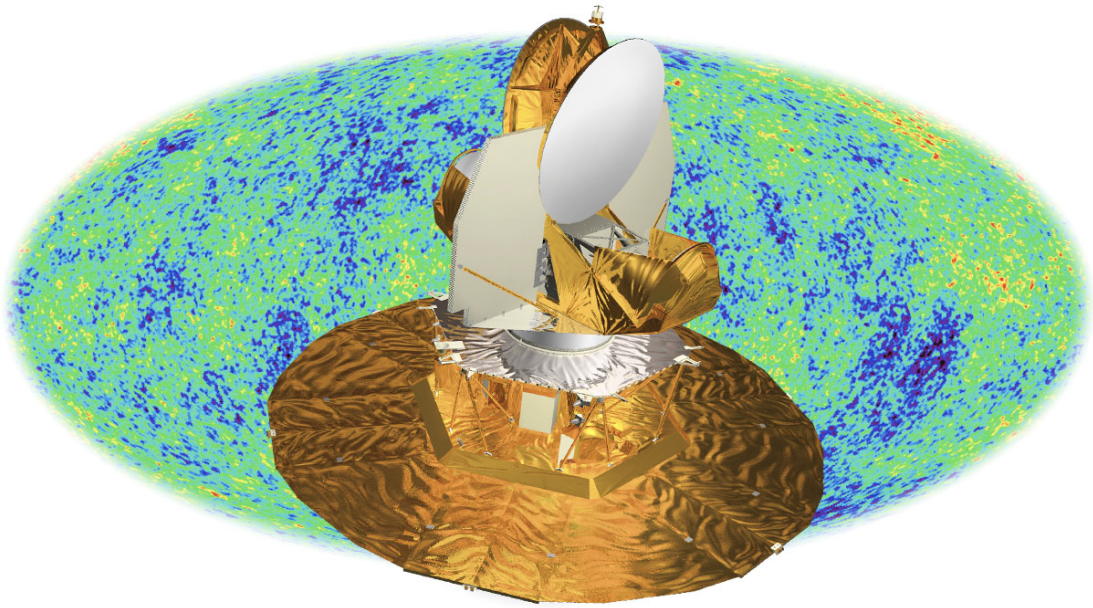
MAP
Microwave Anisotropy Probe



Mission

Microwave Anisotropy Probe is a NASA Explorer Mission that will measure the temperature of the cosmic background radiation over the full sky with unprecedented accuracy. This map of the remnant heat from the Big Bang will provide answers to fundamental questions about the origin and fate of our universe.

Questions MAP was designed to address:

Will the universe expand forever, or will it recollapse?
Is the universe dominated by exotic dark matter?
What is the shape of the universe?
How and when did the first galaxies form?
How rapidly is the universe expanding?

MAP launched succesfully on JUNE 30, 2001

Education and Public Outreach

Visit MAP's series of web sites to learn more about MAP.

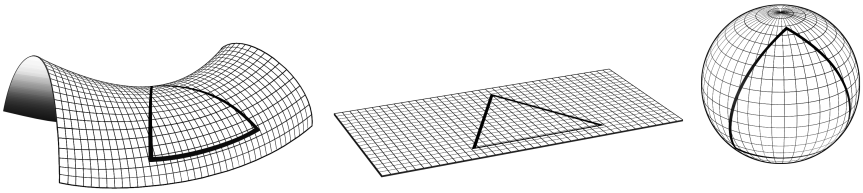
- MAP's Home Page
  http://map.gsfc.nasa.gov
  This site contains general and technical information about the satellite. Look here to find the Scientific goals of the mission.

- MAP's Introduction to Cosmology
  http://map.gsfc.nasa.gov/m_uni.html
  This site contains frequently asked questions about cosmology and answers to these questions. Look here to begin to understand the basics of cosmology.

- MAP's Teacher's Guide to the Universe
  http://www.astro.princeton.edu/~clark/teachersguide.html
  This site was designed specifically for teachers to help them address science standards related to MAP's mission in their classroom. This site contains background information, classroom activities, and online labs for classroom use. Some of the activities from this web site have been presented at NSTA, AAS and GLPA educational workshops. Look on the back for one example of the activities found at this site.

Activity: Geometry in Space

Introduction: The MAP mission strives to measure the curvature of the universe. Even though the universe is at least three dimensional, we can make an analogy to 2 dimensional surfaces to understand the curvature of the universe. For example, if the universe is positively curved, it is curved like the surface of a sphere, and if the universe is negatively curved, it is curved like a hyperbolic surface, which you can make by following the directions below. In this activity, you can discover one measurable difference between positively curved, flat, and negatively curved geometries. The MAP satellite will use this type of measurement to discover if the universe is positively curved, negatively curved or flat.

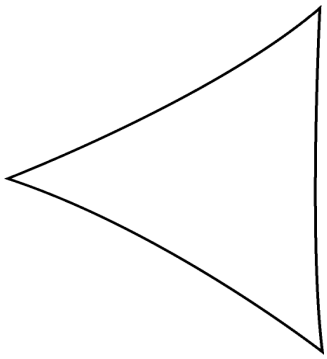


From left to right:
"Negative", "Flat", "Positive"

Materials:

- String cut into several different lengths, a few inches, a foot, three feet etc.
- Protractors
- A globe, or several if possible
- A horse's Saddle, if possible, or try making a hyperbolic surface from paper, cloth or clay as described below.
- Clear tape

Directions for making hyperbolic surface:



- Photocopy the curvilinear triangle pictured here on the right, you may want to enlarge it until the sides are about 5 inches long.
- Make several copies of this figure, at least 35.
- Cut out each curvilinear triangle (you may want to have each student in class cut out two).
- Tape these curvilinear triangles together so there are 7 around each vertex. Note: this model will NOT lay flat.
- These shapes are triangles with curved sides. When they are taped together seven to each vertex they form a surface that has negative curvature. To discover what that means complete the activity below.
- You may also choose to make this surface out of a more durable material such as cloth or paper. Use the picture above as a template to cut shapes, then sew or mold the material as appropriate. Some art supply companies make products that you can mold wet and which then harden to a dry foam rubber like substance. These products work particularly well for the activity found below.

Directions:

1. Have students form small groups.
2. Give each group one of the lengths of string, spreading the different lengths around the room. Have a different length of string for each group.
3. Have the students first make a triangle on a flat piece of paper using the string as the perimeter. Have them tape down the vertices with clear tape.
4. Have them measure the angles of the triangle. They should discover that their angles add to 180 degrees.
5. Have them make new triangles on the paper until they are convinced that not matter what shape triangle they form the total angle summation will equal 180 degrees.
6. Now have them make a triangle on the globe using the string as the perimeter.
7. Have them stretch the string as tightly as they can on the surface of the globe.
8. They may find that the sides of their triangle are not straight lines. This is because on the surface of a sphere the shortest distance along the surface is not a straight line. It is actually a portion of what is called a Great Circle. A Great Circle is a circle on the surface of a sphere that has the center of the sphere as its center. For example all of the lines of longitude are Great Circles, but the only line of latitude which is a Great Circle is the Equator. In general terms the shortest distance along any surface is called a geodesic.
9. Have them measure the angles of their triangle and record the sum of the angles.
10. If you have a saddle or hyperbolic sheet, try the same procedure. The geodesic for a hyperbolic surface is a hyperbola. This may not work as well as for the globe because the curvature is not smooth and may have imperfections. (see 12)
11. Have the students tabulate their results on a chalkboard in the front of the room for each of the surfaces. See if they can find trends based upon the length of the string and the sum of the angles.
12. If a saddle or hyperbolic sheet is unavailable, have students complete the exercise on the globe and flat piece of paper. Explain that a hyperbolic surface has the opposite result from a sphere. The angles of a triangle on a hyperbolic surface add up to less than 180 degrees.
13. Explain that the universe may be curved like one of these surfaces, although scientists do not yet know for certain which way the universe is curved. The MAP satellite will effectively be measuring angles of triangles in the universe to discover the amount of curvature in the universe.