EASY SCIENCE

Earth and Beyond

The Universe

The Universe is everything that we know exists – from our planet Earth, to the furthest point in space.

People used to believe that the Earth was the centre of the Universe with everything else revolving around it. Now we know that our planet is only one of many. Nine planets travel in orbits around the Sun. The Sun is just one of millions of stars in our galaxy, the Milky Way, and many of these stars have their own planets too. Our galaxy and countless others like it make up the Universe.

The Universe is changing and getting bigger all the time. American astronomer Edwin Hubble (1889 – 1953) was the first to discover that the galaxies are moving away from each other. He also discovered that the farther away a galaxy is, the faster it seems to be moving away from us. The explanation for this is that space itself is expanding.

If space is expanding, it means that everything we see around us in space must once have been squashed together in a small, incredibly hot, dense ball. This started expanding about 14 000 million years ago, in what astronomers call the "Big Bang". This marked the beginning of the Universe as we know it.

See for yourself

To demonstrate how galaxies may be moving, collect the following:

- Round balloon
- Black marking pen
- Mirror

Blow up the balloon until it is about as large as an apple. Use the marking pen to make scattered dots on the balloon. It does not really matter where the dots are. These dots represent bodies in space, such as galaxies.

Stand in front of a mirror and look closely at the dots while you inflate the balloon some more. The dots will move away from each other, some farther than others. No dots will get closer together.

Astronomers believe that galaxies are moving away from each other in the way the dots move on the balloon.

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EasyScience is produced by the South African Agency for Science and Technology Advancement (SAASTA), an operational unit of the National Research Foundation. SAASTA's mission is to promote the public understanding, appreciation and engagement with science and technology among all South Africans.
Visit the website: www.saasta.ac.za for more information.

SAASTA

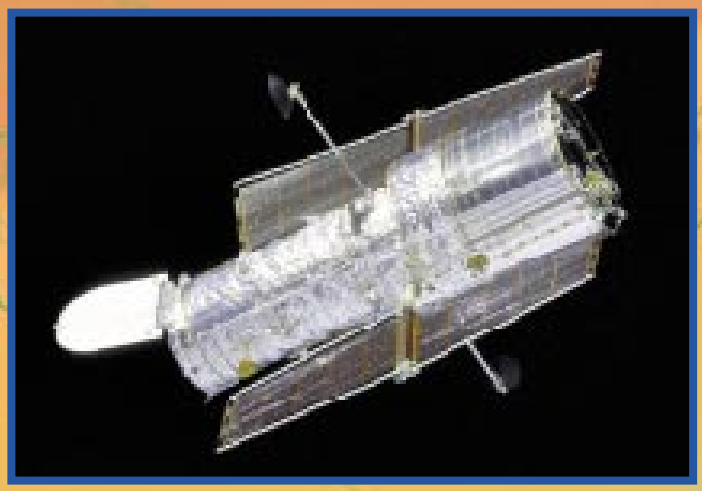
Measuring in light years

Astronomers do not use distances like kilometres to measure the big distances between galaxies and stars. They measure in light years. A light year is the distance a ray of light travels in one year, which is 9,46 million million kilometres!

Light takes one day to cross our Solar System, 100 000 years to cross our galaxy, and 10 000 million years to reach us from the furthest galaxies. The Sun is just over eight light minutes away, and our next nearest star is 4,3 light years away.

The galaxies furthest away from Earth are so far away that their light takes thousands of millions of years to reach us. Many of the stars in those galaxies do not even exist any more, so what we are seeing when we look at them is a picture from the past.

For truly amazing Hubble space telescope images of galaxies, visit the NASA website at **http://hubble.stsci.edu** and look in the library of images.



The Earth's atmosphere blurs the view of the Universe, but the Hubble space telescope (named after Edwin Hubble) looks from outside our atmosphere to give a clear picture.

Milky Way Galaxy

Our Sun and about 100 000 stars like it form our galaxy, called the Milky Way. Scientists believe that the Milky Way formed about 1 000 million years after the Big Bang. Our Sun and its planets formed much later, about 5 000 million years ago, in a collapsing cloud of gas in the Milky Way. New stars and planets continue to form in this way.

To get an idea of how big the Milky Way is, think of it as being the size of the African continent. Then our Solar System is the size of your fist!

On a clear, dark night you can see the Milky Way if you are far away from the glare of city lights. It looks like a hazy band across the night sky. The light is actually from billions of stars so far away that their light blurs together.

See for yourself

To see why the Milky Way looks like a hazy cloud, collect the following:

- Paper hole punch
- White paper
- Glue
- Black paper
- Masking tape

Use a punch to cut about 20 little circles from the white paper. Glue these circles very close together, but not overlapping, in the centre of the black paper. Tape the paper onto a tree, or somewhere else outside. Stand close to the paper and look at it.

Then slowly walk backwards until you cannot see the separate circles any longer. See how the little circles now blend together to look like a large, white shape.

Our eyes cannot distinguish separate points of light that are close together. Just like the little white paper circles, the light of the stars of the Milky Way seem to blend together.

If you use binoculars or a telescope, you will be able to see the stars more clearly.

Earth in space

Do you believe that the Earth is shaped like a ball, even though it is flat from where you stand? Let's see if we can find out for ourselves...

In the past, people had many strange ideas about the shape of the Earth. In about 250 B.C. a Greek, Eratosthenes, used geometry to prove that the Earth is a globe. He made amazingly accurate measurements about the circumference and diameter of the Earth.

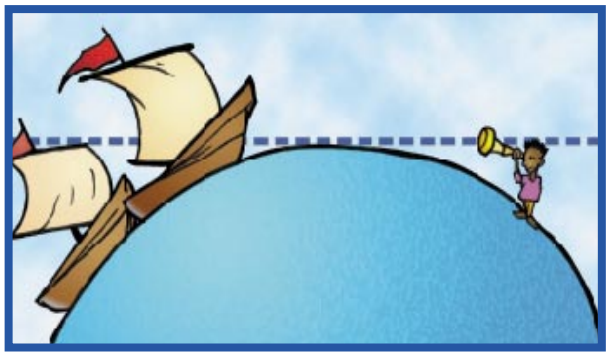
Eratosthenes's ideas could not have been very popular, because the ancient Greeks believed that the Earth floated in the ocean like a cork in water. Not only the ancient Greeks had strange ideas about the shape of the Earth. The Babylonians, who lived about 5 000 years ago, believed that the Earth was a hollow mountain supported and surrounded by the sea. The ancient Egyptians saw the Earth as a resting god and the heavens as a gracefully bent goddess. Between them sat the god of the atmosphere, supporting the skies. The Sun god, in a boat, sailed each day across the heavens into the night.

Today there are still people who believe the Earth is flat. They even have a society, called the Flat Earth Society. How can we prove to them that they are wrong?

Have you ever visited the coast and watched the ships as they travel towards the horizon? What did you notice?

The lower part of the ship (the hull) slowly disappears. Later only the highest structures of the ship (the chimney stacks, sails or masts) are visible above the horizon, and they also eventually disappear.

If the Earth were flat, a ship would look smaller and smaller as it sailed away, but it would not disappear in the way you see it really happen.



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The Antenna at Hartebeesthoek *(see page 22)*

Over the last 50 years, radio telescopes have led to some amazing discoveries. They now allow us to look at the universe as it was just 400 000 years after the Big Bang - almost a billion years before the first galaxies were formed.

In fact, radio telescopes have made possible the discovery of radiation from the Bing Bang itself - the cosmic microwave background (CMB) - the oldest radiation in the universe. In the last few years, studies of the CMB have revealed to astronomers that the Big Bang happened 13,7 billion years ago.

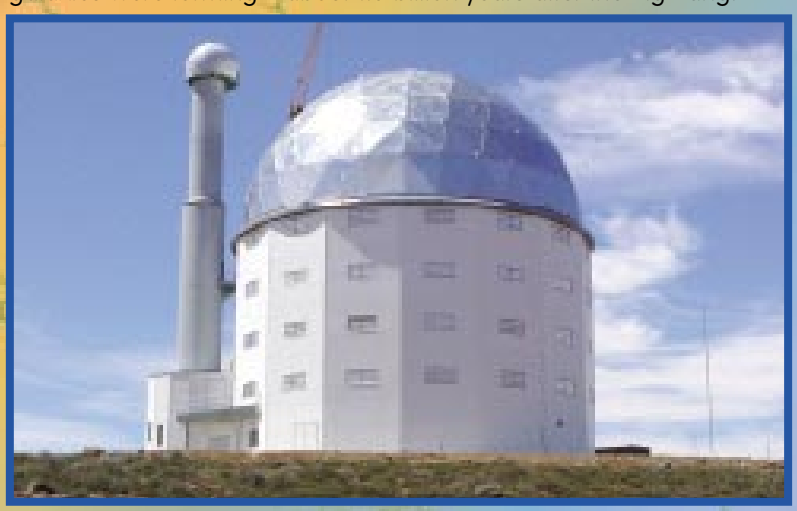
Photo: California Institute of Technology

The Cosmic Background Imager in the Chilean Andes mountains is one such telescope studying the CMB. South African astronomer Tny Readhead is part of the CMI team. A number of very important discoveries have been made with the aid of this imager, such as the seeds that were the beginning of the formation of all structures in the universe, from clusters of galaxies down to life on earth.

On the drawing board for the next generation of even more powerful radio telescopes is an international project, the Square Kilometre Array (SKA). The South African government is bidding to host the core of this radio telescope locally (see **www.ska.ac.za**).

Why do we want a more powerful radio telescope? Between the period of microwave background radiation (about 400 000 years after the Big Bang) and the appearance of the first galaxies (about 750 million years after the Big Bang) was a period known as the "Dark Ages" of the universe. There is no telescope yet that can penetrate this period in time of the Universe. Astronomers believe that the SKA radio telescope will be able to look into the Dark Ages.

The Southern African Large Telescope (SALT) is being built at Sutherland in the Karoo and will be the largest single telescope in the southern hemisphere when it starts operating next year (see **www.salt.ac.za**). SALT will be able to see back to a time when the Universe was 10% of its current age. This was the time when the first galaxies were forming – about 1.5 billion years after the Big Bang.



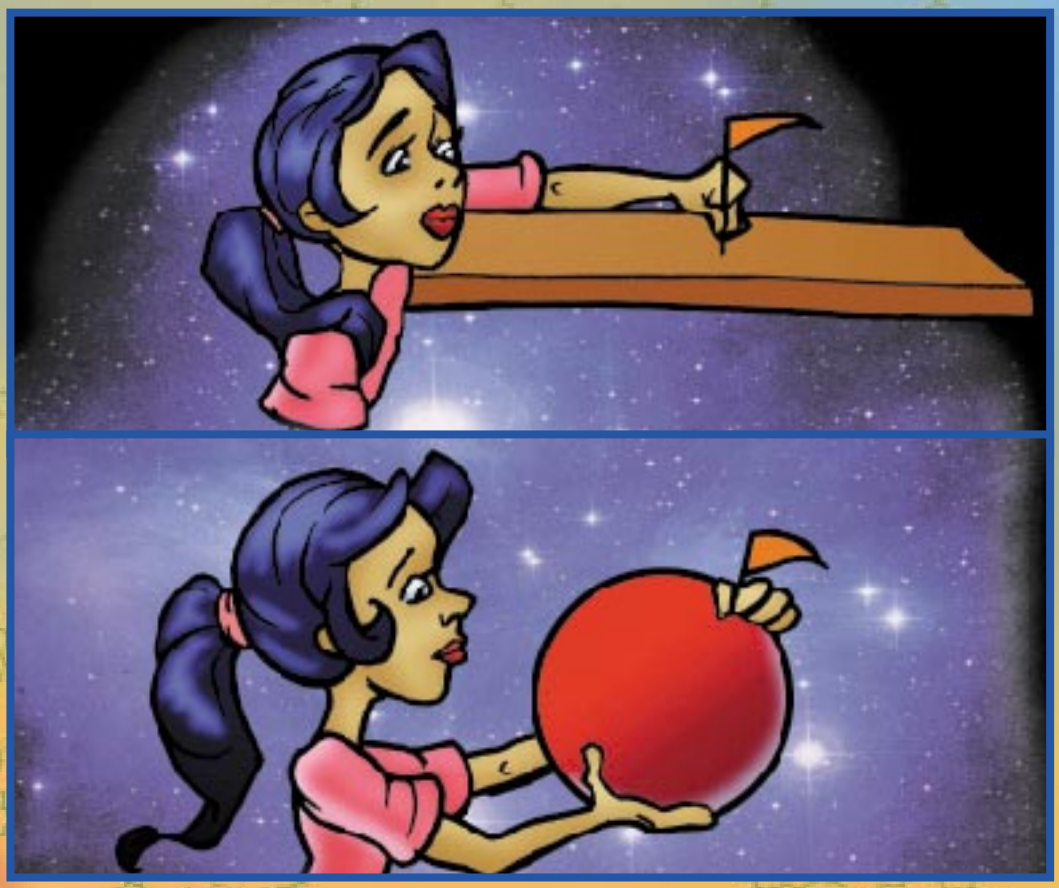
See for yourself

You will need:

- Paper
- Scissors
- Sticky tape
- Toothpicks
- The largest ball or balloon you can find

Make a flag out of the paper, and toothpick. Move the flag further away from you along a flat table, with your eyes just above the edge of the table. What do you see? What happens to the flag?

Now place the flag on the ball and move it slowly away from you, following the curve of the ball. Can you see the whole flag as it moves backward over the ball?



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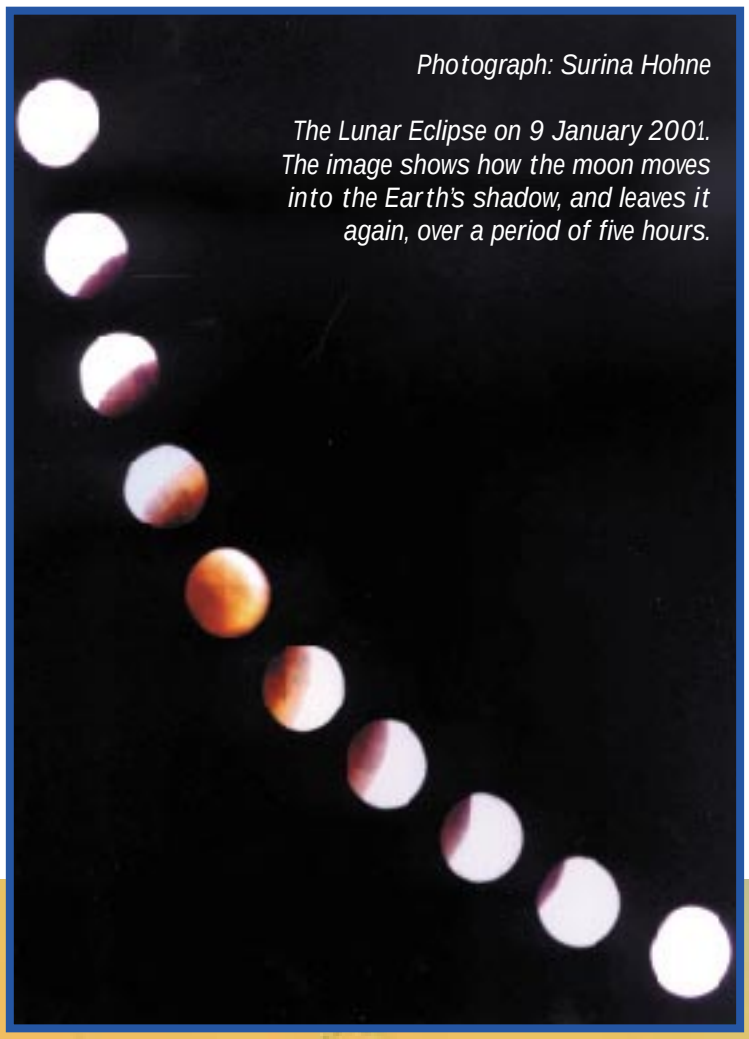
The Earth's shadow

The fact that the Earth is round is best proven by the shape of the shadow of the Earth (thrown on to the Moon by the Sun) during a lunar eclipse.

A lunar eclipse happens when the Moon enters the shadow of the Earth (that is when the Earth comes between the Sun and the Moon). If you ever have the chance to watch this (the next total lunar eclipse is on 28 October this year – (see **http://sunearth.gsfc.nasa.gov/eclipse/OH/OH2004.htm**), you will see that the edge of the Earth's shadow is curved. This can only be because the Earth is round.

Some other proofs

- In some countries it is day time, while in others it is night. If the Earth were flat, it would be day time in all countries at the same time.
- Until about 500 years ago, people feared that if a ship sailed too far to the east or west, it would fall over the Earth's edge. The navigators found that they could travel all the way around the Earth in the same direction without reaching any edges
- These days, aircraft and satellites travel round the Earth. Photographs taken from space show that the Earth is roughly shaped like a ball.



Photograph: Surina Hohne

The Lunar Eclipse on 9 January 2001. The image shows how the moon moves into the Earth's shadow, and leaves it again, over a period of five hours.

This material was prepared with the help of staff of the Hartebeesthoek Radio Astronomy Observatory (HartRAO). Schools, groups and the public can visit HartRAO (about 50 km from Johannesburg and Pretoria) to learn more about the Sun and planets, stars and galaxies, and about radio astronomy. Booking is essential. Enquiries and bookings: Telephone 012 326-0742. For more information visit the website: www.hartrao.ac.za.

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