EASY SCIENCE

Spinning in space...

October 4 - 10 has been declared World Space Week by the United Nations. This event, celebrated in more than 50 countries, highlights how space technology has improved people's lives. Find more information on www.spaceweek.org

In an ongoing campaign to highlight South Africa's world-class research and scientific contributions, the Department of Science and Technology (DST) declared October 2005 Astronomy Month.

The focus of this month's *EasyScience* is therefore on looking down from space to Earth and looking up from Earth to space.

FASCINATING FACTS ABOUT SATELLITES

A satellite is any smaller object travelling around a larger object. The Moon is a satellite of the Earth and the Earth is a satellite of the Sun. They are called natural satellites.

The Earth's satellite, the Moon, is about four times smaller, and orbits (or travels around another object in a single path) about 384 400 km from the Earth. A whole lot of movement is involved:

- The Moon spins (or rotates) on its axis
- The Earth spins on its axis;
- The Moon revolves (or orbits) around the Earth;
- The Earth and Moon revolve around the Sun.

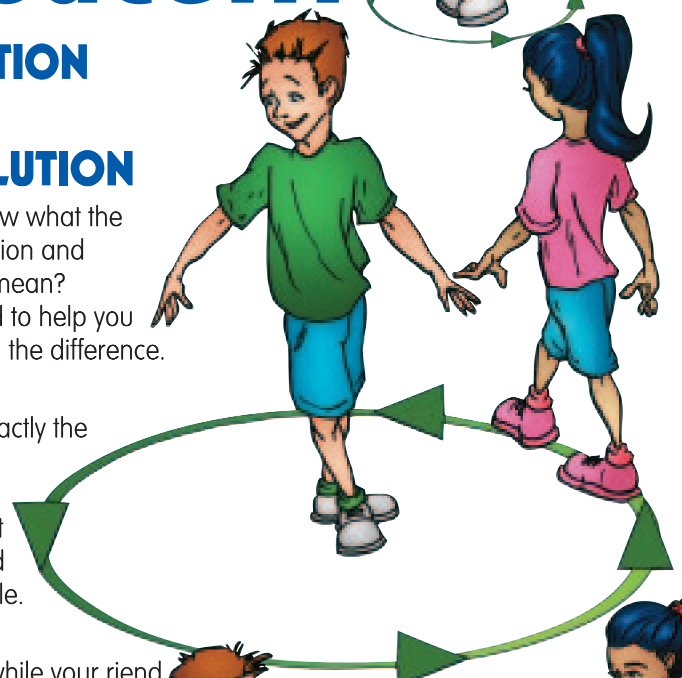
Since the Moon revolves around its own axis at the same rate at which it orbits the Earth, we always see one side of the Moon, called the near-side.

ROTATION AND REVOLUTION

Do you know what the words rotation and revolution mean? Get a friend to help you understand the difference.

Rotation:

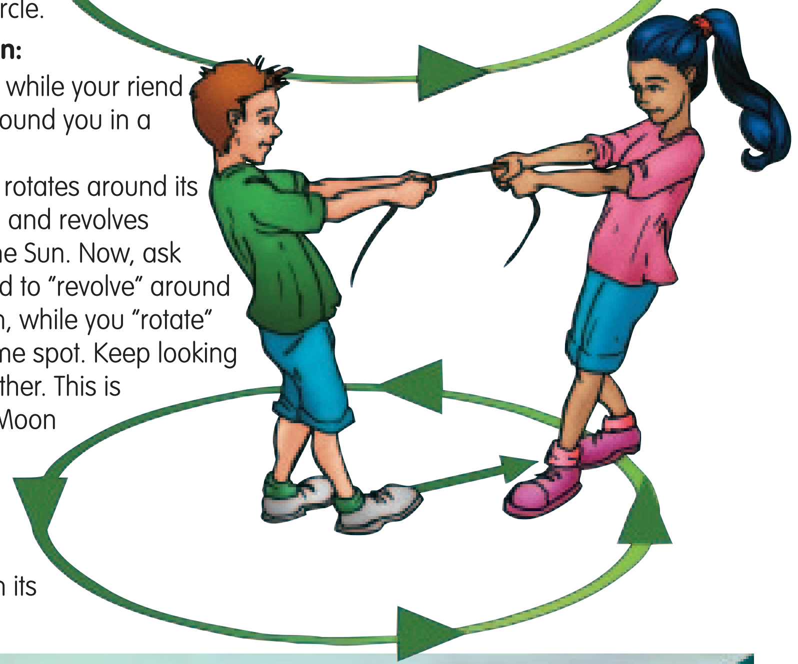
Stand in exactly the same spot on the ground, but turn around in a full circle.



Revolution:

Stand still while your riend moves around you in a circle.

The Earth rotates around its own axis, and revolves around the Sun. Now, ask your friend to "revolve" around you again, while you "rotate" in the same spot. Keep looking at each other. This is how the Moon revolves around the Earth, while it rotates on its own axis.



EASY SCIENCE

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.

One of the CSIR SAC antennae at Hartebeesthoek. It tracks the paths of many satellites that orbit the Earth

Man-made satellites

When we talk about satellites, we normally refer to man-made spacecraft placed in space for a specific reason. They are very useful for communicating information to the Earth. Satellites have different designs, depending on the type of information they need to communicate.

A satellite is put into an orbit around the Earth by blasting it off the Earth with a rocket. It needs to travel at a certain, very high speed (7.8 kilometres per second or 28 000km/h) before it will start orbiting the Earth.

Satellites orbit the Earth and don't go off into space along a straight line because the Earth's force of gravity pulls them back. The satellite's momentum and the Earth's force of gravity need to be balanced for the satellite to orbit.

Uses of satellites

Satellites are launched into space to do a specific job. Every satellite is designed specifically to fulfil its role.

- **A remote sensing satellite** carries a camera that, as it travels in its orbit, takes pictures of the Earth. Mapmakers can use these pictures to make more accurate maps. Images of the Earth can tell us about changes in crops, water supplies, urban development, and many other things.
- **Weather satellites** take pictures to help experts predict weather patterns and which way a weather pattern (like a hurricane) is moving.
- **Navigation satellites** carry special transmitters to help people determine exactly where they are on the Earth.
- **Communication satellites** send telephone calls from one side of the world to the other. If you decide to phone a friend in Alaska your call can be sent up in space to a satellite, then relayed to a ground station in North America, and sent from there to your friend's telephone. The satellite transmits, or sends information or data.
- **Space exploration satellites** have telescopes that look outward and teach us about the rest of the Universe.
- **Space tourism satellites** transport, transfer and care for people who want to holiday in space. This is a relatively new idea and only affordable to the super rich.
- **Military satellites** collect information about a country's enemies.
- **Scientific satellites** gather research information on, for example, the Earth's atmosphere.

Looking up into space

At the CSIR Satellite Applications Centre (SAC) scientists track the paths of many satellites that orbit the Earth. They use very large dish-like antennas at Hartebeesthoek to receive signals from satellites. International companies "book" CSIR SAC to keep track of the satellites as they are launched, or as they orbit.

Looking down from space

One of the main uses of satellites is to obtain detailed images of the Earth. This is of great value to people like farmers, those who take care of forests, drill for oil, dig for valuable minerals, build cities, and those who have to manage disasters. They can all do their jobs better if they have accurate images of the area they work in.

The best way to get these images is from satellites in space. More and more countries are cooperating to send technological "eyes" into space. This can help us to plan to take better care of planet Earth.

CSIR SAC buys images from other countries and organisations that are transmitted by their satellites as they pass over our part of the world. The data is then processed and sent to local organisations that want to buy copies, or they are analysed by CSIR SAC experts for their clients.

Some local examples of the uses of Earth Observation Imagery

Monitoring and managing disasters

Images from satellites can help to show the extent of disasters like floods, oil spills and fires. The images can help people to make decision on how to manage disasters better, and help to plan ahead in case such a disaster should ever happen again.

Agriculture

Farmers can subscribe to satellite data, which they receive on the Internet. This helps them to see how their crops are going and whether certain sections need more water, for example.

Urban planning

Cities seem to be growing fast in an uncontrolled way. By using satellite images, town planners can help prevent problems like traffic congestion, illegal building and too few recreational sites.

Global climatic systems

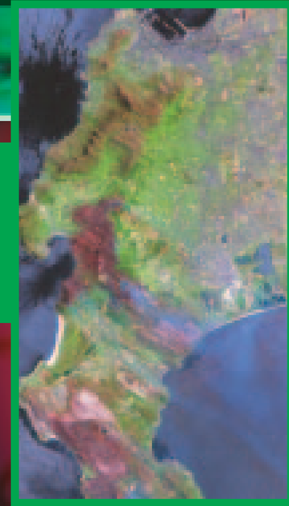
Satellites are monitoring almost all aspects of the world's climate system. This includes measuring the temperature of the sea and land, clouds and rainfall, winds, sea level, ice cover, vegetation cover and gases.

Mapping

Maps become outdated very quickly. Satellites take very precise photographs on a daily basis, which are used for making maps.

Military use

Accurate, up-to-date images of certain areas play a huge role in military success. They are used to analyse terrains, for spying, and planning missions.



The French SPOT satellite captured this image of the fires that swept through the Cape Peninsula in January 2000

Farmers can use satellite images to see how their crops are doing.

Capturing nature's tricks

Satellites can capture events like a total solar eclipse.

Information supplied by the CSIR Satellite Applications Centre at Hartebeesthoek. For more information or to organise a group visit, contact Johnny Rizos at: Telephone: 012 334-5000; email: jrizos@csir.co.za

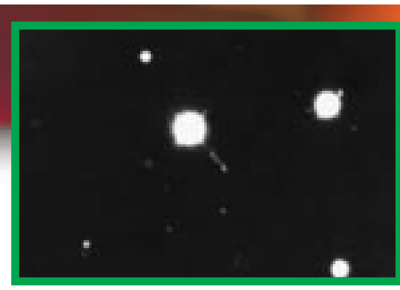
QUASARS ARE QUITE COOL

Many people make use of quasars every day, often without knowing what they are. These people include pilots, surveyors, hikers, geologists, soldiers and sailors.

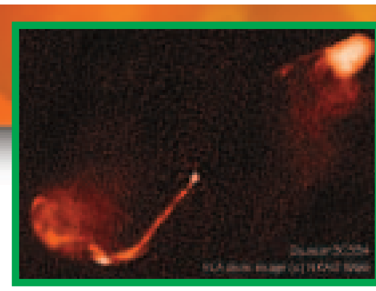
What are quasars?

Faint, peculiar stars that showed up in their pictures had astronomers really puzzled back in 1963. Maarten Schmidt at the Mount Palomar Observatory in California, USA then realised that these star-like ("quasi" stellar) objects, were not stars at all, but unusual galaxies lying at very great distances. A galaxy is a giant collection of gas, dust and millions or billions of stars.

Schmidt also discovered that quasars were the source of powerful radio signals being picked up by radio telescopes. A quasar's strong radio signal, he discovered, is produced by a jet of very hot gas that is blasted out from around a massive black hole in the heart of the galaxy. A black hole is an invisible object in space with such a strong pull of gravity that not even light can escape from it.



A star-like galaxy with a feint streak coming out of it. This is a jet of very hot gas being blasted out from around a massive lack hole in the heart of the galaxy.
Image: Kitt Peak National Observatory

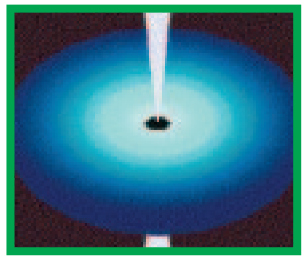


This shows how an array of radio telescopes "sees" another quasar. In this case it is face on to us, and we can see there are really two jets shooting out in oppoosite directions
Image: NRAO/AUI

Of what use is this knowledge to us?

The movement of continents

In some galaxies, these jets of hot gas are aimed straight towards Earth. To a radio telescope such gas jets seem like a tiny but powerful radio transmitters fixed in space. This makes them ideal "radio beacons" for finding the positions of radio telescopes on Earth. This is done with a bit of basic geometry, as surveyors with theodolites do when using the beacons on top of hills as targets to measure a position.



This diagram shows what we think a quasar looks like: a galaxy of billions of stars (in blue) with the black hole in the centre and jets (white) spitting out.

A network of radio telescopes across the Earth (including the one at Hartebeesthoek near Krugersdorp and telescopes in Australia, Chile, China, Italy, Germany, and the USA) look at one quasar after another in a set of 212 quasars across the sky. This set of quasars is called the International Celestial Reference Frame.

The quasar signals let us measure very accurately the positions on Earth for each of the radio telescopes. Done week after week, this shows that the position of each telescope is actually changing with time. Geologists studying the Earth's rocks have long known that this is happening over millions of years, but now we can use quasars to measure it happening in real time!

Experiments have also shown that during the course of each day, the Hartebeesthoek telescope moves up and down by up to about 20 centimetres, thanks to the tides in the solid Earth caused by the Sun and the Moon.

In the foreground is the small Global Positioning System (GPS) basestation antenna at HartRAO. Further back (right) is the Satellite Laser Ranger that measures the paths of satellites, and the big dish of the 26m radio telescope.

On longer timescales, the quasar measurements show that the Hartebeesthoek telescope is moving northeast at 2,5 centimetres per year – about the rate at which your fingernails grow. The Australian plate is moving north-east at almost three times this speed – 'breakneck' seven centimetres per year. This is actually pretty quick – in a person's lifetime Australia will move 50 metres.

The Australian plate is in fact colliding with the Asian plate. This on-going collision was the cause of the tsunami that resulted in such devastation in that area on 26 December 2004.

Earth's exact orientation in space

Another purpose of the radio telescope network is to measure the orientation of Earth in space. Earth seems pretty stable to us, but with the extraordinary accuracy that the quasars give us, we find it wobbles as it spins and speeds up and slows down.

Quasars help with surveying

As the Hartebeesthoek radio telescope is the most accurately measured position in Africa, in 1999 it was made the local reference point for the survey system. This reference point is called the Hartebeesthoek94 Datum. All surveying in South Africa can now be tied back through this to the distant quasars, with great accuracy.

All this is very exciting for scientists, but where do the hikers, surveyors, soldiers and navigators come in?

Global Positioning Systems

Some twenty years ago, the US military developed a position measurement system using signals transmitted by satellites. This is called the Global Positioning System, or GPS. Anyone can now buy a basic hand-held GPS receiver for less than R1 400. This can tell you your position to within a few metres.

The Harebeeshoek laser at night, with (inset) operator Sam Tshefu in action tracking a satellite

These receivers are what hikers, navigators and sailors use. Fancier versions will give you a position accurate to centimetres. One of these is located at Hartebeesthoek (HartRAO), where it operates as a fixed base-station.

For this system to work, the GPS satellites need to know where they are at any instant. To achieve this, their orbits are measured by firing pulses of laser light at them from Earth. The satellites are fitted with reflectors that send the light back in the direction from which it came. By measuring how long the laser pulse takes to get to the satellite and back, we can calculate its distance, knowing the speed of light. Thus we can measure the orbits of satellites very accurately. This technique is called Satellite Laser Ranging (SLR). An SLR is operated by Hartebeesthoek for the United States of America's National Aeronautics and Space Agency (NASA).

Global warming

Apart from positioning system satellites, some other types of satellite also carry these reflectors. Some satellites measure the Earth's gravity field, and others measure the rise in sea level caused by global warming. To compare these satellite results with "ground truth", HartRAO has installed GPS base-stations alongside tide gauges at Richards Bay in KwaZulu-Natal and at Simon's Town in the Western Cape Province.

The Richard's Bay GPS antenna on its mast

Splitting continents and erupting volcanoes

While South Africa is geologically relatively quiet right now, this is not the case further north in Africa. For example, the eruption of the Nyiragongo volcano in the Congo destroyed half of the city of Goma three years ago. HartRAO is establishing GPS base stations in countries to the north of us so that they can benefit both scientifically and practically from modern precise position measurements. For example, one is installed on the roof of the Surveyor General in Lusaka, Zambia, and another is located in the Okavango in Botswana.

Information supplied by Dr Mike Gaylard, Hartebeesthoek Radio Astronomy Observatory (HartRAO). For more information, visit www.hartrao.ac.za. Schools, groups and the public can visit HartRAO (about 50 km west 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.