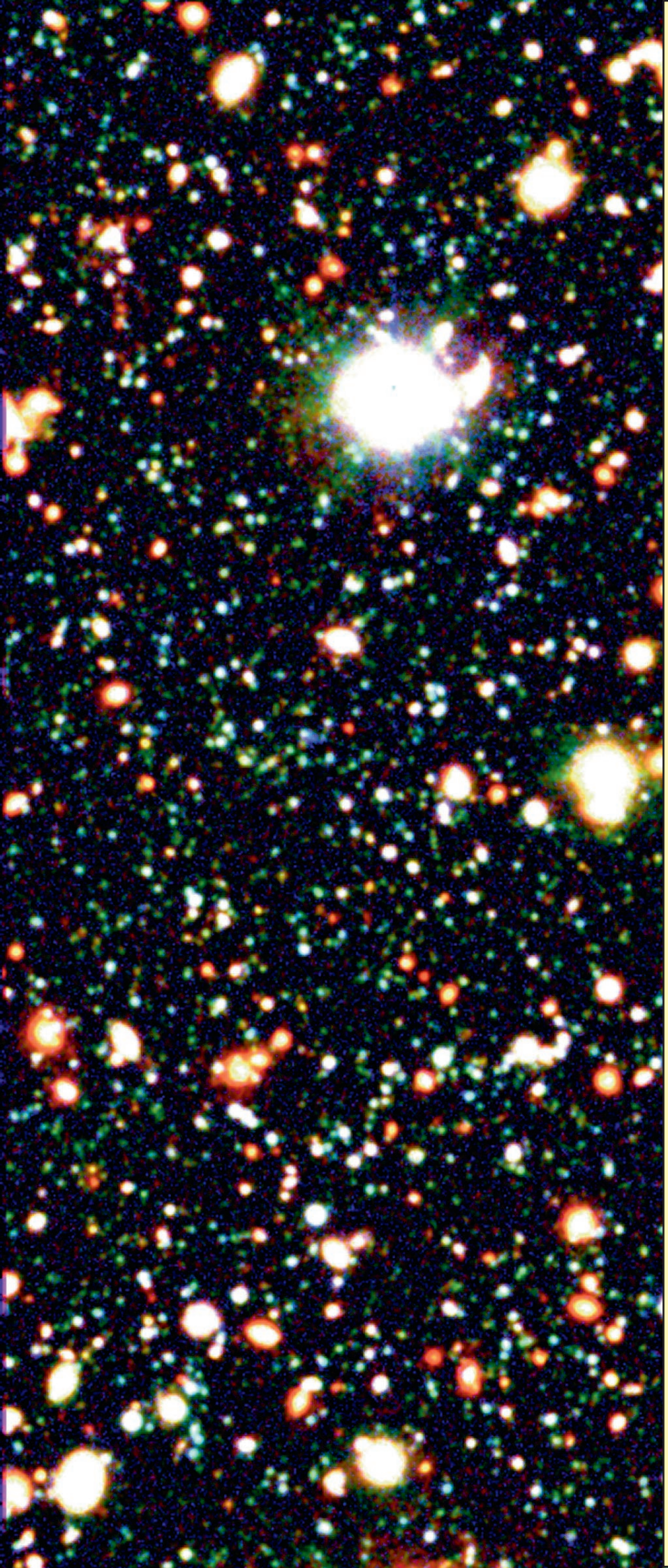
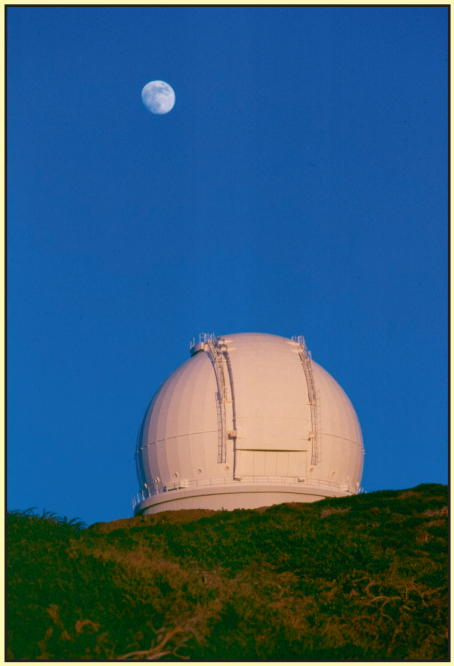


Isaac Newton Group of Telescopes



ROQUE DE LOS MUCHACHOS OBSERVATORY

AT A SPECTACULAR location on the remote island of La Palma, to the west of Tenerife in the Canary Islands, is to be found the Roque de Los Muchachos Observatory, of the Instituto de Astrofísica de Canarias. This international collection of telescopes is situated over 2,400 m above sea-level, near the highest of the peaks surrounding the Caldera de Taburiente – an extinct volcano that is now a national park. The observatory is dedicated to astronomical observations, and the Isaac Newton Group of Telescopes (ING) is the largest organisation working at the site.

The observatory covers an area of about 2 sq km and is reached by a winding 40 km of mountain road from the town of Santa Cruz de La Palma. The site was chosen after an extensive search for a location with clear, dark skies all the year round. All tests proved that the Roque is one of the best astronomical sites in the world. The remoteness of the island and its lack of urban development ensure that the night sky at the observatory is free from artificial light pollution. The continued quality of the night sky is protected by law. The mountain-top site has a remarkably stable atmosphere, owing to the local topography. The mountain has a smooth convex contour facing the prevailing northerly wind and the airflow is comparatively undisturbed, allowing sharp and stable images of the night sky. The site is clear of cloud for 90 per cent of the time in the summer months.

The observatory was established under a series of international agreements in 1979, and was inaugurated in 1985. The observatory is operated under the auspices of the local astronomical organisation, the Instituto de Astrofísica de Canarias, which also runs the observatory on Mount Teide on Tenerife.

The Roque de los Muchachos Observatory is the principal European northern hemisphere observatory. The impressive collection of telescopes at the observatory include:

- The Isaac Newton Group of Telescopes, comprising:
  - The 4.2m William Herschel Telescope
  - The 2.5m Isaac Newton Telescope
  - The 1m Jacobus Kapteyn Telescope
- The 3.6m Italian Galileo National Telescope
- The 2.5m Nordic Optical Telescope
- The German-Spanish La Palma Cosmic Ray Observatory HEGRA
- The Carlsberg Automatic Meridian Circle
- The Swedish Solar Telescope
- The Dutch Open Tower Telescope

Below: View of the observatory site.

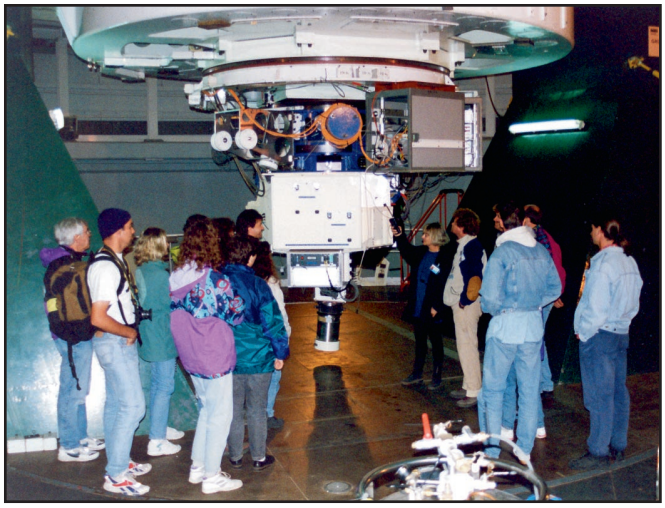
Juan Manuel Castro

How the ING is Run

THE SITE OF the Roque de los Muchachos Observatory belongs to the Instituto de Astrofísica de Canarias (IAC), as does the Teide Observatory on Tenerife. The operation of the site is overseen by an international scientific committee.

The construction, operation and development of the ING telescopes is the result of a collaboration between the UK, Netherlands and Eire. The site is provided by Spain, and in return Spanish astronomers receive 20 per cent of the observing time on the telescopes. A further 75 per cent of observing time is shared by the UK, Netherlands and Eire. The allocation of telescope time is determined by scientific merit. The remaining 5 per cent is reserved for large scientific projects to promote international collaborations.

Many of the state-of-the-art telescope and instrument components are custom-built. New instruments are designed and built by technology groups in the UK and the Netherlands, with which the ING maintains close links. Of particular importance is the historical link with the Royal Greenwich Observatory, originally responsible for the creation of the ING.



Above: Visitors at the WHT. The observatory excites a lot of local interest, and the ING values its strong links with the community on La Palma. There are a number of Open Days every year when the public can visit the telescopes. These always attract a lot of people, with up to 1,000 visitors on each occasion.

La Palma

La Palma is situated at the north-west of the Canarian archipelago, which is an autonomous region of Spain, a few hundred kilometres from the coast of north-west Africa. Shaped like a stone-age axe, La Palma is one of the smaller Canary Islands, with a surface area of 706 sq km and a population of 80,000. It is unusually steep in relation to its size, rising sharply out of the sea. A ridge runs down the centre of the island from north to south, and the entire mountain range exceeds 2,000 m in altitude. The highest point on the island is the Roque de los Muchachos (2,426 m), the location of the observatory.

The island's climate is sunny, but with moderate temperatures all the year round at sea-level. The cool north-easterly Canary current and trade-winds keep the island cooler than one might expect given the latitude. On the mountain top, however, there is greater seasonal variation of temperature, from 18°C in summer to 3°C in winter. Despite occasional extreme conditions in winter, the telescopes are operational throughout the year.

Juan Manuel Castro

Left: The north coast of La Palma, showing the cliffs rising steeply out of the sea.

TELESCOPES OF THE ISAAC NEWTON GROUP

THERE ARE THREE telescopes in the Isaac Newton Group:

4.2 m William Herschel Telescope (WHT)
2.5 m Isaac Newton Telescope (INT)
1 m Jacobus Kapteyn Telescope (JKT).

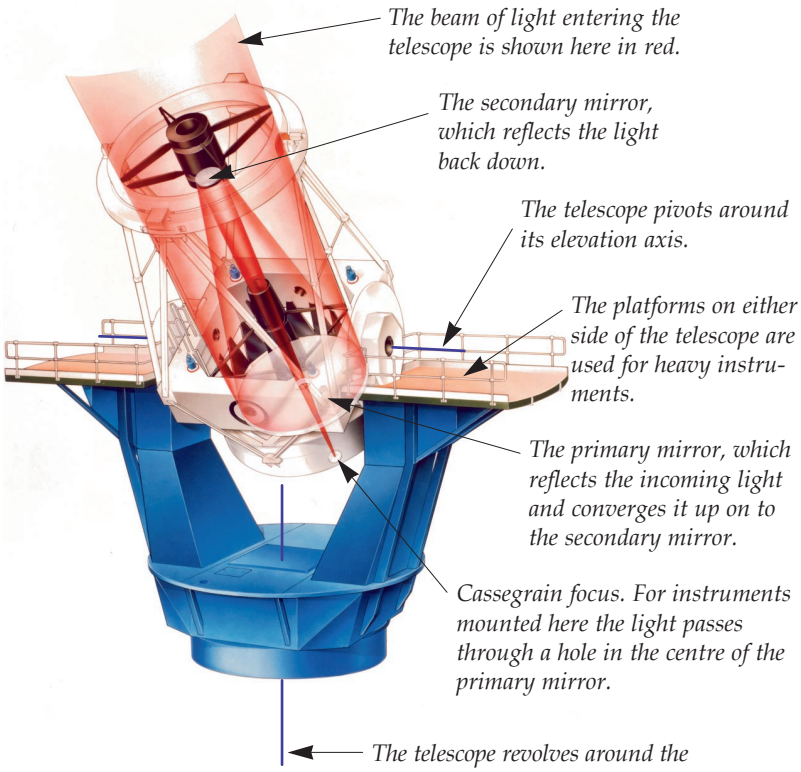
All three are reflecting telescopes, collecting and focusing the light from stars and galaxies by means of mirrors whose reflecting surfaces have been figured to within a fraction of the wavelength of light. Each telescope is housed in its own dome, which is opened at night to allow an unobstructed view of the sky. The observatory offers a wide range of instruments, allowing the light from distant objects to be analysed in different ways. These instruments are continually being upgraded and enhanced to keep the telescopes scientifically competitive.

The three telescopes have complementary roles:

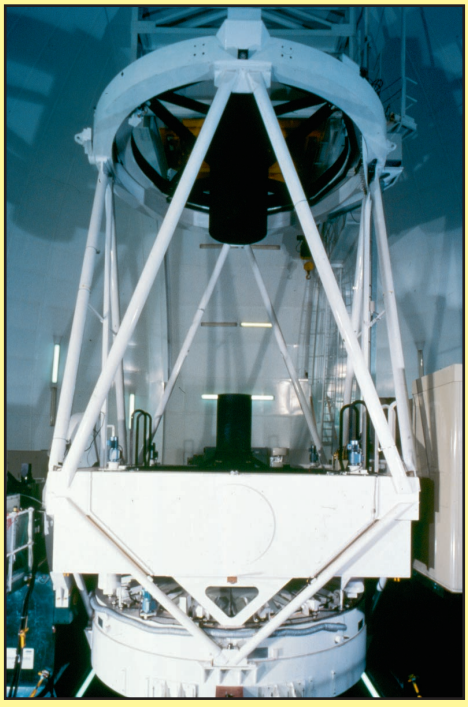
• The WHT, with its 4.2 m diameter primary mirror, is the largest telescope in Western Europe. It was first operational in August 1987. It is a general purpose telescope equipped with instruments for a wide range of astronomical observations.

• The INT was originally used at Herstmonceux in the UK, but was moved to La Palma and has been rebuilt with a new mirror and new instrumentation. It has a 2.5 m diameter primary mirror and is mostly used for wide-field imaging and spectroscopy.

• The JKT has a primary mirror of 1 m diameter. It is mainly used for observing relatively bright objects. It was first operational in May 1984.



Above: Diagram of the WHT, showing the light path for the Cassegrain focus.



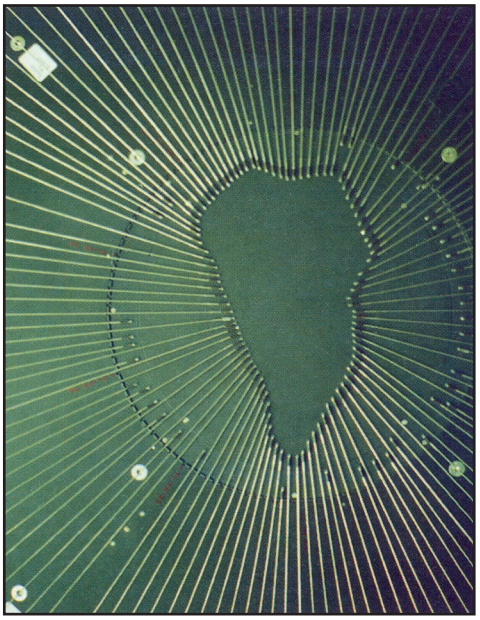
M. Briganti (IAC)

Left: The WHT. Its overall height from base is 18.1 m. Right: The INT, which was transferred from the UK, became operational on La Palma in May 1984.

Considering the weight of the instruments, the telescopes move with astounding precision. The WHT, for example, weighs 190 tonnes and has a pointing accuracy of 1 – 1.5 arcseconds, which compares to the diameter of a coin seen at a distance of 2 km. It can track the stars with an accuracy even ten times better!

INSTRUMENTS AND DETECTORS

THE TELESCOPES possess a wide range of instruments to cater for the requirements of the scientists. The ING has a strong instrument development programme to keep abreast of the latest technological developments. Observations can be performed not only in visible light but also in ultra-violet and infra-red, and astronomers can select which part of the spectrum they want to use to take images of the sky. The light from stars, galaxies or any other night-time celestial object can be analysed by spectrographs – instruments that separate the light according to wavelength. Until recently astronomers could only study the spectrum of one object at a time, but developments in optical fibre technology have made it possible to pick up the light of many objects at the same time.

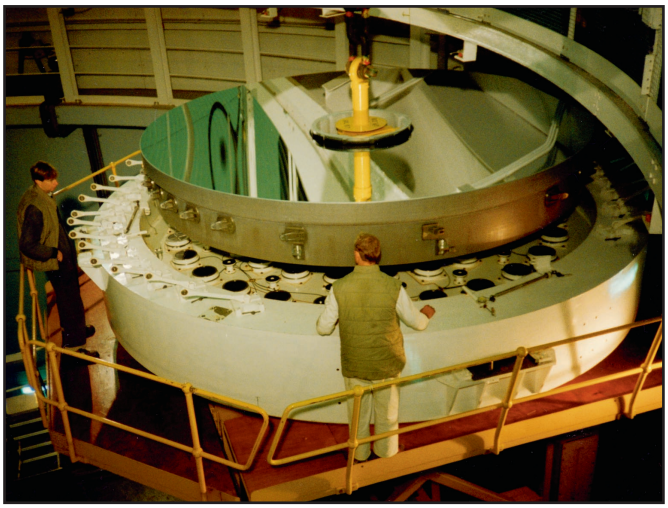


Fred Watson

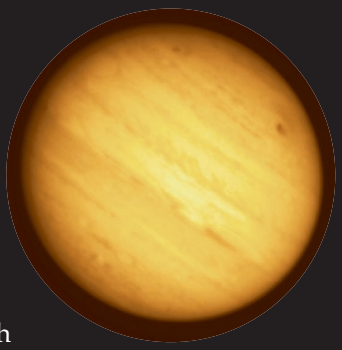
Above: The collection of optical fibres that make up Autofib. Using this instrument on the WHT, astronomers can obtain spectra of more than one hundred objects over a large field of view. The fibres can be positioned to an accuracy of half the thickness of a human hair. Here they trace an outline of La Palma.

All instruments are fitted with state-of-the-art detectors, which record the spectra or images received. Current CCD (Charge Coupled Device) detector technology provides nearly perfect solid-state, digital detectors that are now widely used in astronomy and have replaced other light sensitive devices such as photographic plates.

Despite the excellent climatic conditions on La Palma, the starlight is still distorted by the earth's atmosphere. Because of this, the full potential of the telescope optics cannot normally be achieved. However new optical methods have recently been developed that allow these atmospheric distortions to be corrected. The application of these techniques, adaptive optics, is the major development on the WHT over the next few years. This will allow astronomers to study objects in unprecedented detail.



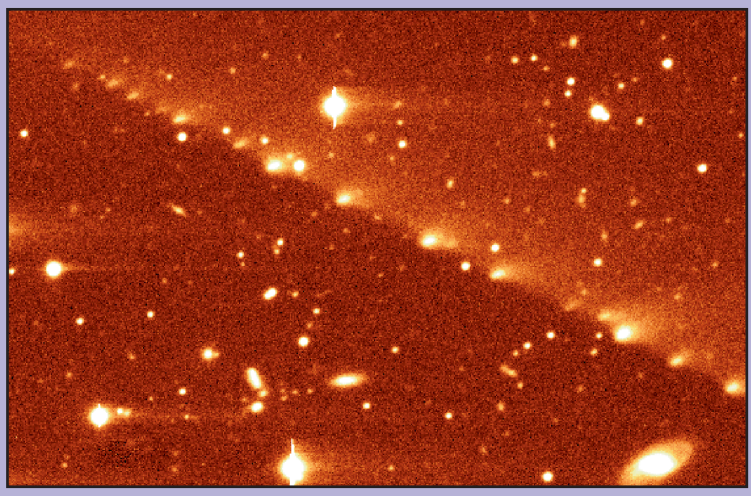
Above: The primary mirror of the WHT being replaced after aluminizing. The mirror is made out of a glass which is not affected by temperature changes. It is coated with aluminium to give a reflectivity of 90-95 per cent. The mirror is recoated each autumn. As the telescope moves across the sky, a mirror support system continuously measures the forces on the mirror and corrects for them, in order that the shape of the mirror remains constant.

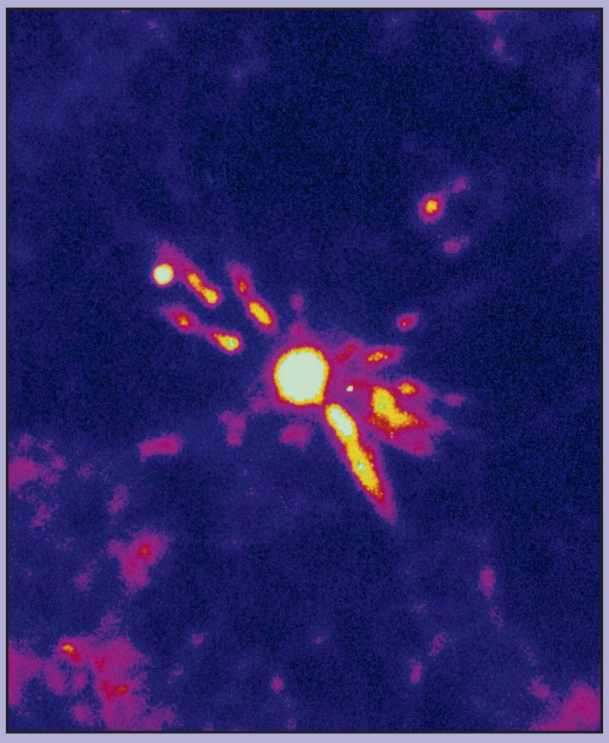


Except for occasional photography, nearly all astronomers' work is done electronically, and the astronomers rarely, if ever, look directly through the telescope. Telescopes, instruments and detectors are controlled by local microprocessors and control systems, with overall control from various system computers. Images such as this one of Jupiter, taken by the WHT at the time when the comet Shoemaker-Levy collided with this giant planet, are generated electronically and viewed on computer screens.

ASTRONOMY

ING TELESCOPES are used to study a wide range of astrophysical phenomena, including planets and comets in our own solar system, stars and star clusters, distant galaxies and quasars and cosmology. Some examples of work being done with the telescopes are illustrated on these pages.





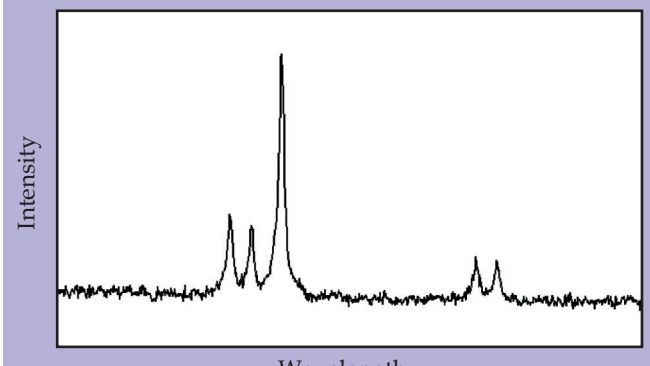
Stellar systems
Observations of other stellar systems tell us how stars like our sun are born, live and die. Newly-formed stars ionize the surrounding interstellar medium.

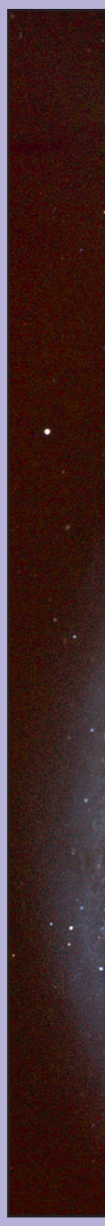
The evolution of stars can be modelled by statistical studies of the 100 billion stars in our galaxy, the Milky Way. At the end of their life stars often shed matter back into interstellar space, either through winds, as in the planetary nebula Abell 78 above, or in extreme cases through supernova explosions.

Other galaxies
Many astronomers visiting the ING use the telescopes to study galaxies outside the Milky Way. By taking images and spectra it is possible to determine how stars are distributed within other galaxies, and model how the galaxies rotate.

A WHT image of Messier 51, also known as the Whirlpool galaxy, is shown to the right. This is a bright spiral galaxy, at the relatively close distance of 25 million light years from our own galaxy. The companion galaxy to the north is being disrupted by the gravitational force of the main galaxy.

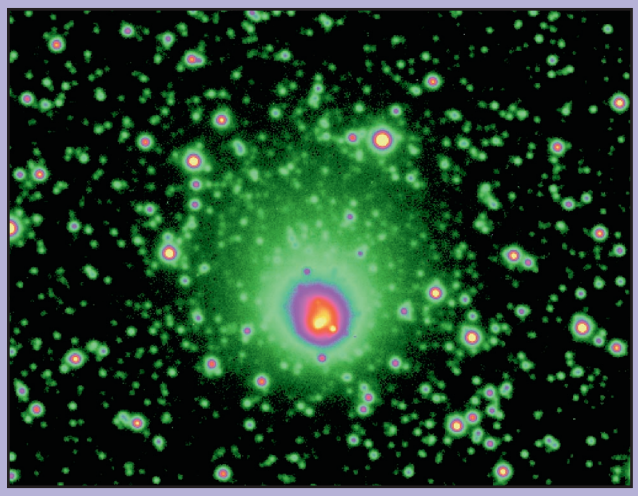
Where matter is attracted by the strong gravitational forces associated with black holes, large amounts of energy are released which can be seen and measured as intensely bright light sources or explosions. Such activity has been found in the cores of distant galaxies as well as around stars in our own galaxy. The spectrum below shows emission lines from the high-excitation plasma in the nucleus of Messier 51.





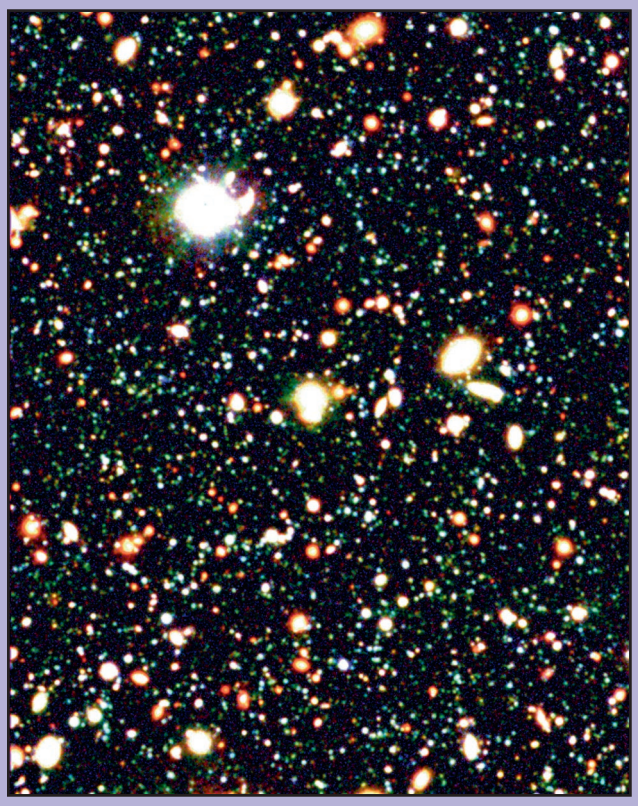
Our solar system
Our solar system contains not just the sun and planets, but also a wide variety of other bodies. Of particular interest are comets, historically seen as harbingers of doom; more recently it has been suggested that the dinosaurs might have been wiped out as a result of a comet colliding with the Earth. Understanding the origin and nature of comets may be important for understanding the history of life on Earth.

On the left are the fragments of comet Shoemaker-Levy, which made the news in 1994 when they collided with the planet Jupiter. On the right is comet Hale-Bopp, dominant in the night skies in early 1997. Both pictures were taken with the Jacobus Kapteyn Telescope.

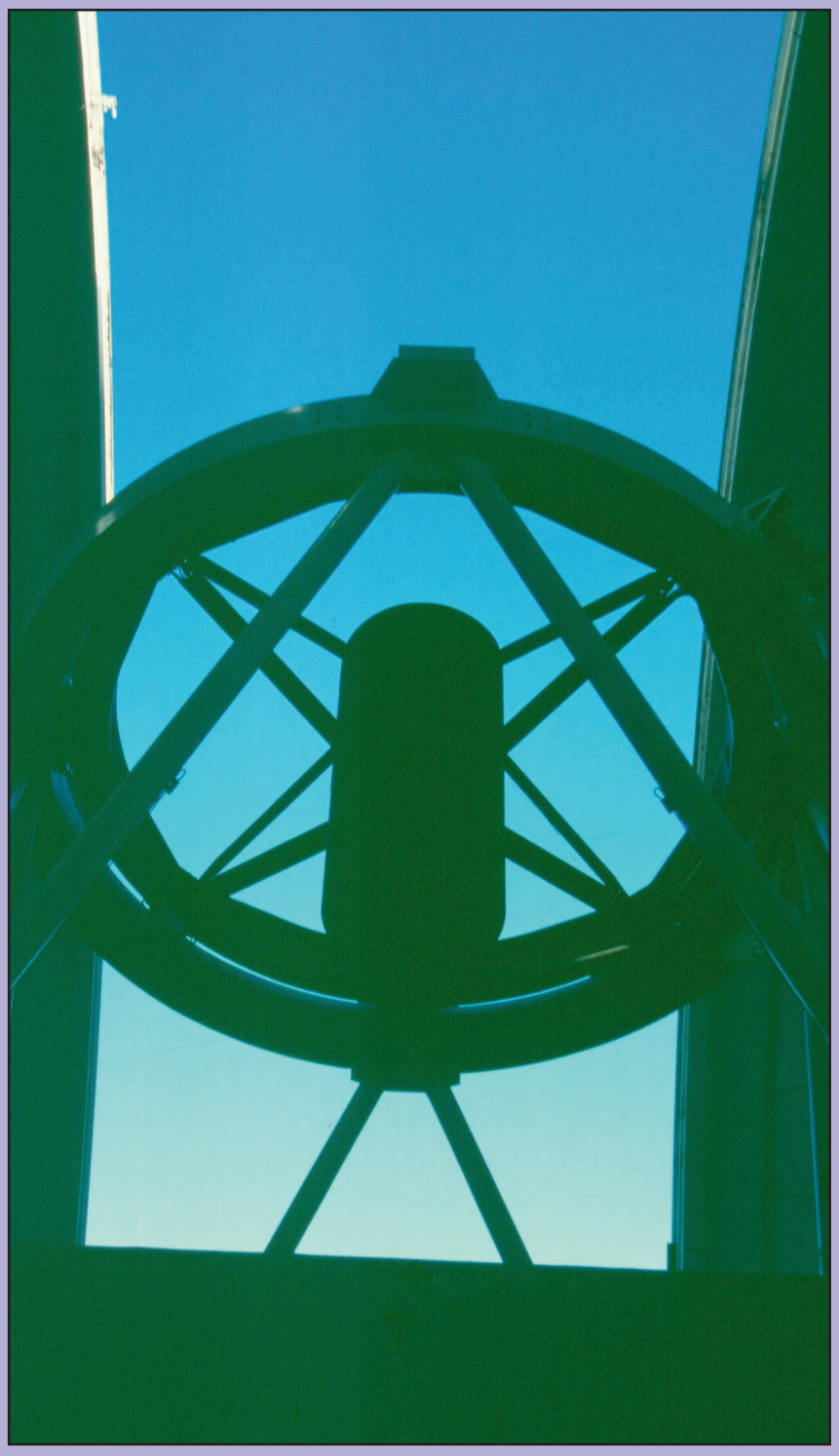


Cosmology
Images taken with long exposures at the WHT reveal galaxies so distant that their light has taken thousands of millions of years to reach us. By studying such galaxies, astronomers are able to look back in time to observe the Universe soon after its creation.

In the image shown here, the faint blue fuzzy spots are galaxies at the edge of the observable universe. These young galaxies, only recently created, are undergoing intense bursts of star-formation. The density of galaxies is found to be much higher in the early universe than it is now.



Tom Shanks



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