The bigges

The 4.2-metre William Herschel Telescope is the largest telescope sited within Europe and twenty years ago this month it started observing the sky. **Chris Kitchin** investigates the telescope – its design, its construction and its scientific achievements.

On 1 June 1987, the William Herschel Telescope (WHT) obtained its first image using its TAURUS camera, which captures images at many differing wavelengths simultaneously. By September of this year it is expected to acquire its millionth image. Those simple statistics summarise the outstanding success of one of the most powerful telescopes ever built. Indeed, until 1993 the WHT was regarded as the most powerful telescope in the world – not the largest by any means, but the combination of cutting-edge technology within the telescope and its instrumentation and superb sky quality in the Canary Isles enabled it to out-perform even the five-metre Mount Palomar and the six-metre Russian telescopes. It only lost its premier position with the opening of the first of the ten-metre Keck telescopes fourteen years ago.

The concept of the WHT originated during the 1960s when the 3.9-metre Anglo–Australian Telescope (AAT) was being designed. A comparable telescope was needed in the Northern Hemisphere to complement the AAT's observations and a 4.2-metre mirror blank made of the low-expansion material Cervit by Owens–Illinois was already available. The blank was shaped into a mirror by the UK firm Grubb–Parsons who produced one of the best mirrors ever made, concentrating 85 percent of the light that it picks up into a spot just 0.3 arcseconds across.

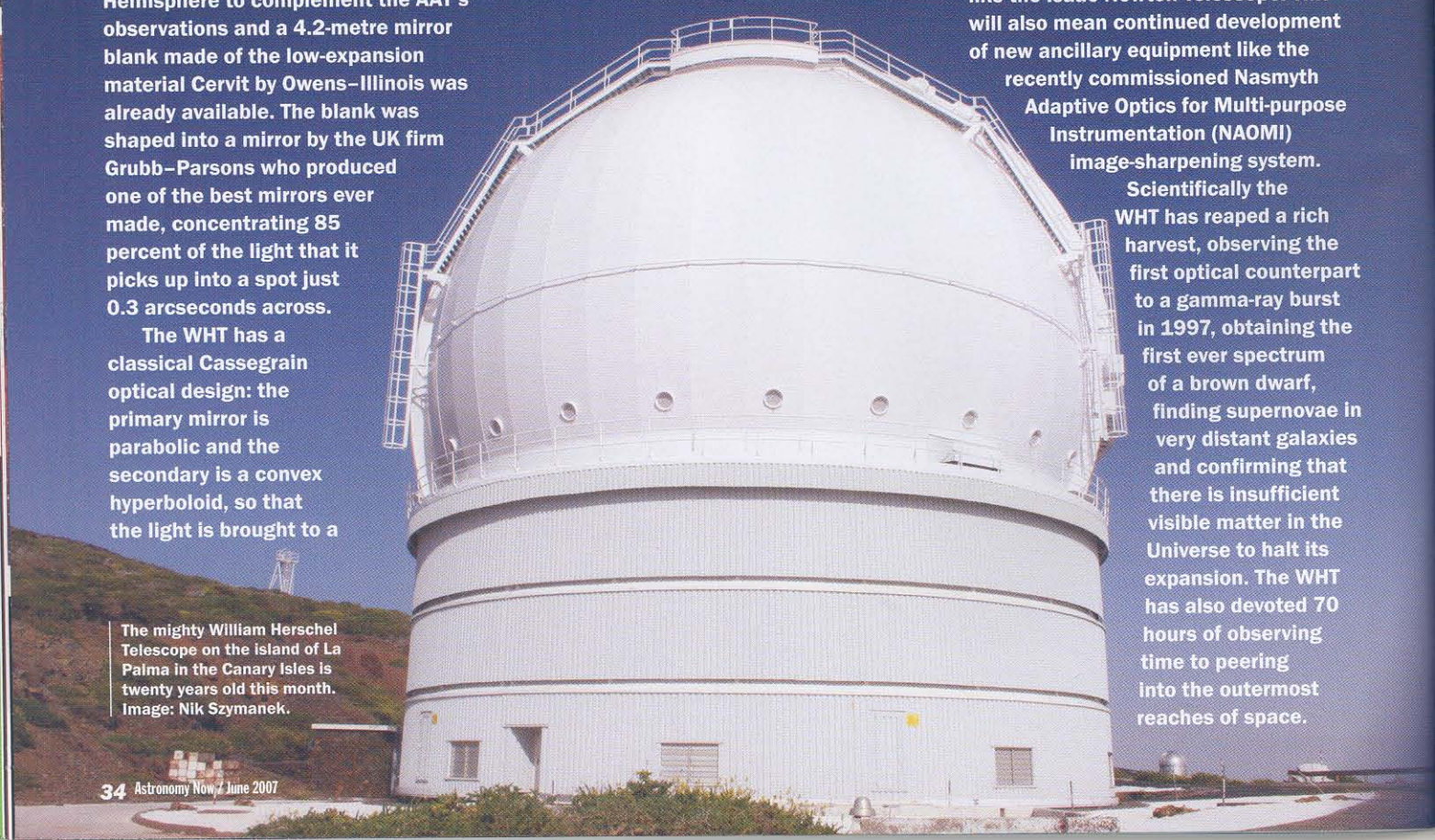
The WHT has a classical Cassegrain optical design: the primary mirror is parabolic and the secondary is a convex hyperboloid, so that the light is brought to a focus behind the primary mirror having passed through the latter's central hole. The primary mirror is about half a metre thick and it weighs some 16.5 tonnes. Unlike many recently built large telescopes, the WHT's primary mirror retains its shape through its own rigidity and does not need the active supports required for thin and multi-mirror telescopes. The telescope is often used without the secondary mirror, i.e. at prime focus, when, with a correcting lens, it provides a field of view two thirds of a degree across – comfortably larger than the full moon.

The telescope has an alt-azimuth mounting so that it rotates around horizontal and vertical axes and by using a third mirror the light can be reflected through holes within the altitude bearings to two further (Nasmyth) foci at the sides of the telescope. With an alt-azimuth mounting the field of view of the telescope rotates as the telescope tracks across the sky and so further optical systems called image de-rotators have to be used to counteract this effect. Small and lightweight equipment such as cameras, simple spectroscopes and photometers can be mounted at the Cassegrain and prime foci of the telescope; larger, heavy equipment such as high resolution spectroscopes is placed onto platforms on top of the mounting at the Nasmyth foci.

Scientific highlights

The WHT is sited on the Roque de los Muchachos in La Palma in the Canary Islands at a height of 2,330 metres (7,650 feet) along with several other observatories including the 2.5-metre Isaac Newton Telescope. Its original cost was £10 million and its running costs are now shared between the UK, the Netherlands and Spain. The telescope is available to UK astronomers for about half the available observing time. Funded by the Science and Technology Facilities Council (formerly PPARC), the WHT seems likely to continue to be a priority for their support even if it means reducing the backing given to smaller telescopes like the Isaac Newton Telescope. This will also mean continued development of new ancillary equipment like the recently commissioned Nasmyth Adaptive Optics for Multi-purpose Instrumentation (NAOMI) image-sharpening system.

Scientifically the WHT has reaped a rich harvest, observing the first optical counterpart to a gamma-ray burst in 1997, obtaining the first ever spectrum of a brown dwarf, finding supernovae in very distant galaxies and confirming that there is insufficient visible matter in the Universe to halt its expansion. The WHT has also devoted 70 hours of observing time to peering into the outermost reaches of space.



The mighty William Herschel Telescope on the island of La Palma in the Canary Isles is twenty years old this month. Image: Nik Szymanek.

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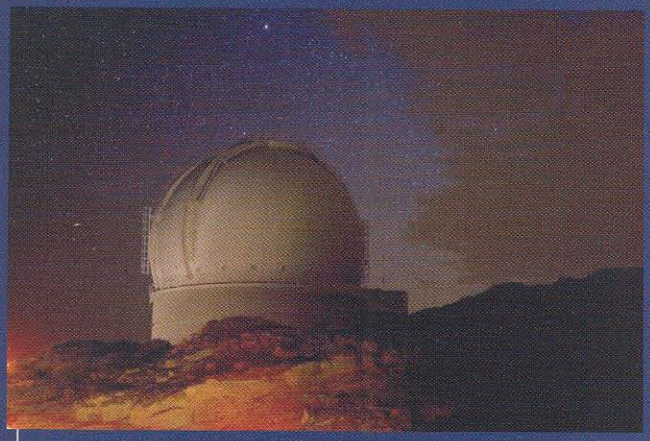


The WHT at night. Image: Nik Szymanek.

The Herschel Deep Field penetrates almost as far as the better-known Hubble Deep Field, but covers ten times the latter's area of sky.

Professor Jim Hough of the University of Hertfordshire, who has designed and built the revolutionary PLANETPOL instrument that finds extra-solar planets via observations using polarized light, has used the WHT many times and is extremely enthusiastic about it. "It is a very productive telescope and still doing front-line astronomy," says Hough. "Most importantly it is one of the few major telescopes where visiting instruments – like PLANETPOL – are welcomed."

By 2005, the number of papers published in refereed research journals as a result of data from the WHT had reached nearly 1,500 – a truly remarkable triumph for a truly remarkable telescope.

Chris Kitchin is Emeritus Professor of Astronomy at the University of Hertfordshire and the author of over two-dozen books.

Showing off the tremendous abilities of the WHT's 4.2-metre mirror is this image of the ringed spiral galaxy NGC 7217 in Pegasus, taken with the telescope's Prime Focus Imaging Camera. Image: Isaac Newton Group of Telescopes, La Palma/Mischa Schirmer (ING) and Gilles Bergond (IAA, Granada).

Timeline of discovery

1989 – The WHT makes the first ever images of surface features on a star other than the Sun, a hot spot on the red giant Betelgeuse.

1989 – The first ever detection of gravitational microlensing, in this case where the light from a distant quasar is gravitationally lensed by a nearby bright galaxy, and massive, unseen objects in the galaxy cause variations in the brightness of the lensed images.

1993 – The WHT observes supernova 1993J in the galaxy M81, the closest supernova since supernova 1987A.

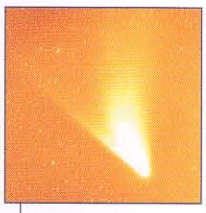
1994 – Improved observations point firmly to the presence of supermassive black holes at the centre of galaxies such as M31, NGC 3115 and NGC 4594 to explain their rotation velocities as measured by the Intermediate dispersion and Spectrograph and Imaging System (ISIS) on the WHT.

1994 – The WHT discovers what is at that time the most distant galaxy known with a redshift of 4.255, which corresponds to over 12 billion light years away.

1995 – The WHT produces the first definitive evidence of the existence of brown dwarfs from observations of these cool sub-stellar objects in the Pleiades.

1995 – The WHT is single-handedly making the Universe a bigger place, beating its own distance record with the discovery of a galaxy at a redshift of 4.41, around 12.5 billion light years, or 650 billion trillion kilometres, away.

1996 – The WHT'S ISIS instrument takes part in the discovery of an odd galaxy, NGC 7331, where the disc rotates in the opposite direction to its bulge.

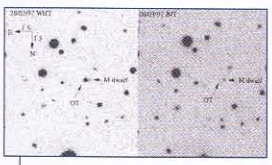


The straight line is Hale–Bopp's neutral gas tail. Image: European Comet Hale–Bopp team

1997 – As Comet Hale–Bopp streaks through our night sky, the WHT (amongst other telescopes) produces the first ever observations of a comet's neutral sodium gas tail.

1997 – In a landmark observation, the WHT makes the first ever detection of the optical counterpart to a gamma-ray burst.

1998 – Cosmology is turned on its head with the discovery of dark energy via the effects it has on the light of distant supernovae imaged during a survey involving many observatories across the world, including the WHT.



The first observed optical afterglow of a GRB. Image: J van Paradijs (University of Amsterdam).

2000 – The 'Herschel Deep Field' is a look into the farthest reaches of the Universe that goes almost as deep as the Hubble Deep Field and covers ten times the area on the sky. A huge success for ground-based imaging.

2001 – The WHT discovers a black hole in the galactic halo, the first to be found there.

2004 – The remaining mystery of the Type Ia supernova seen by Tycho Brahe in 1572 is solved by the WHT. It identifies the G-class (Sun-like) companion star that the white dwarf was stealing large amounts of gas from before it exploded.

The Herschel Deep Field. Image: Nigel Metcalfe and Tom Shanks (University of Durham).