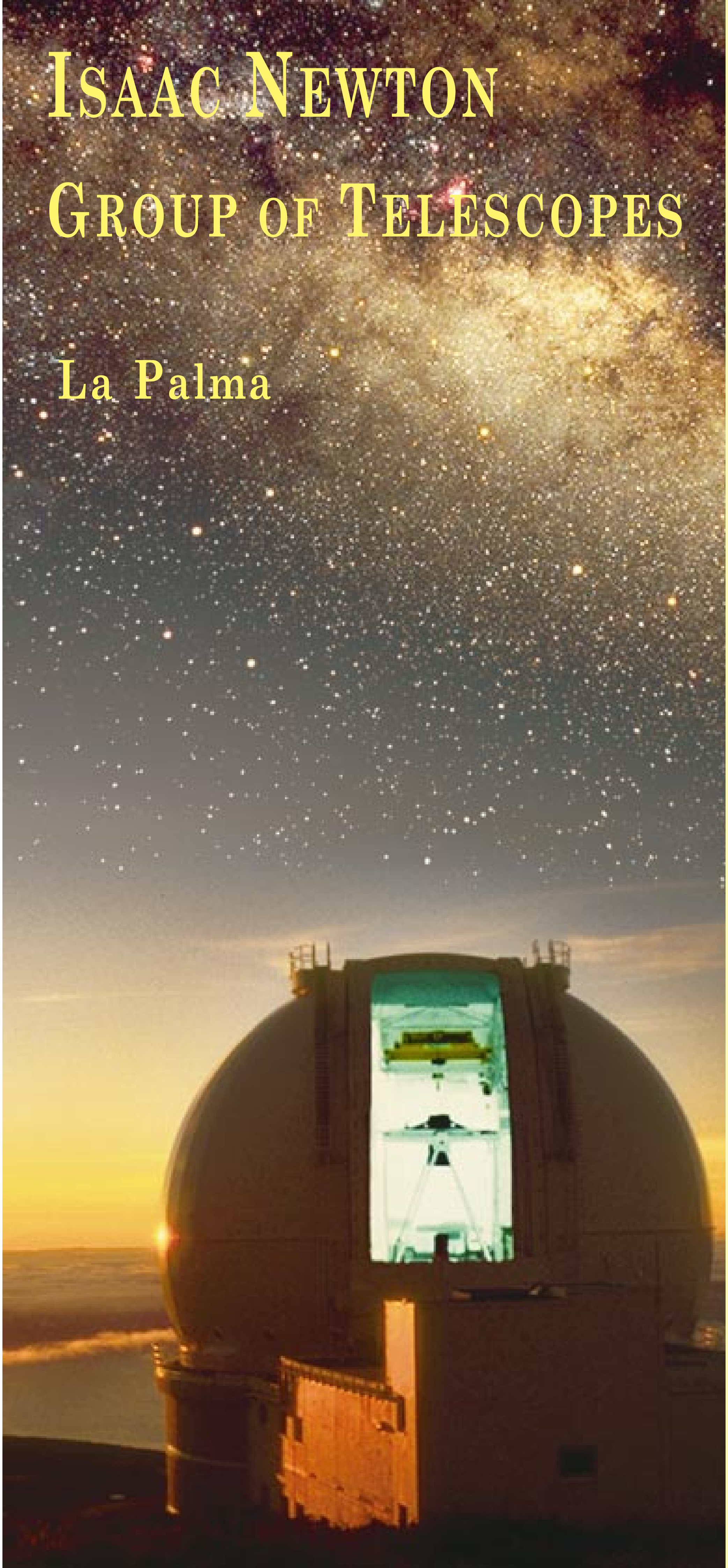
Isaac Newton Group of Telescopes

La Palma



Annual Report

1997

Published in Spain
by the Isaac Newton Group of telescopes (ING)
Legal License:

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Printing: Gráficas Sabater. Tel: +34 922 623555

Front Cover: Photo-composition made by Nik Szymanek (of the amateur UK Deep Sky CCD imaging team of Nik Szymanek and Ian King) in summer 1997. The telescope shown here is the William Herschel Telescope.

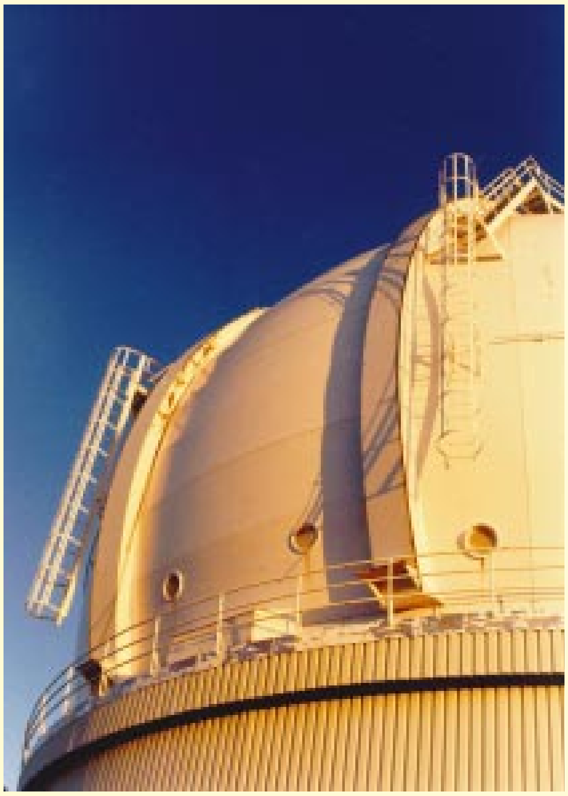
ISAAC NEWTON
GROUP OF TELESCOPES

Annual Report

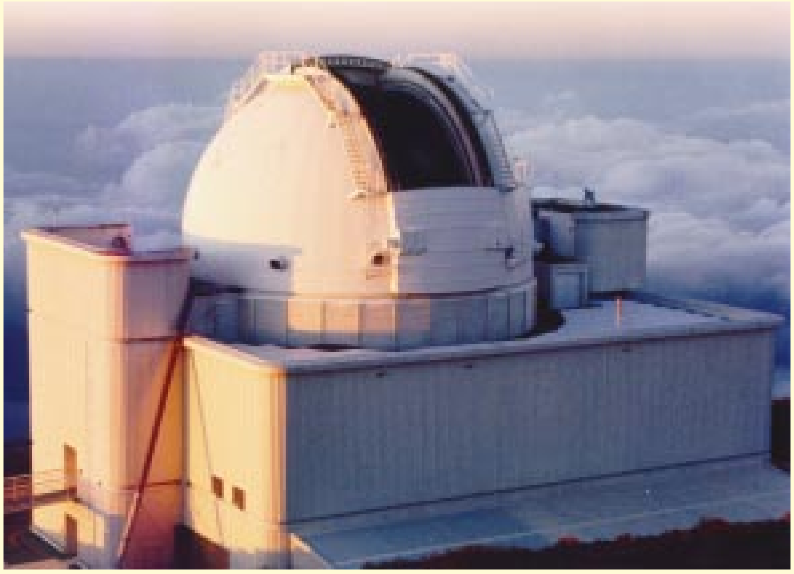
of the
PPARC-NWO Joint
Steering Committee

1997

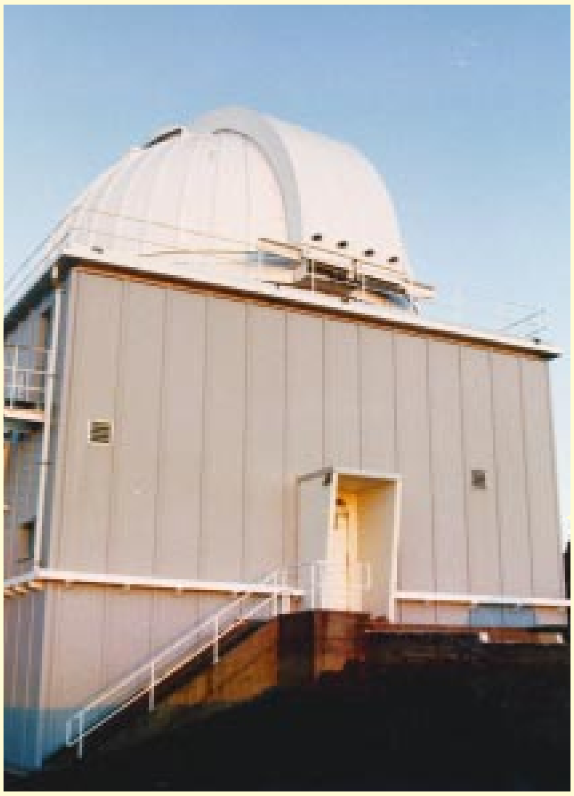
Isaac Newton Group



William Herschel Telescope



Isaac Newton Telescope



Jacobus Kapteyn Telescope

# of Telescopes

The Isaac Newton Group of telescopes (ING) consists of the 4.2m William Herschel Telescope (WHT), the 2.5m Isaac Newton Telescope (INT) and the 1.0m Jacobus Kapteyn Telescope (JKT), and is located 2350m above sea level at the Roque de Los Muchachos Observatory (ORM) on the island of La Palma, Canary Islands. The WHT is the largest telescope in Western Europe.

The construction, operation, and development of the ING telescopes is the result of a collaboration between the United Kingdom, 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. The operation of the site is overseen by an International Scientific Committee, or Comité Científico Internacional (CCI).

A further 75 per cent of the observing time is shared by United Kingdom and Netherlands. 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 between institutions of the CCI member countries.

The ING operates the telescopes on behalf of the United Kingdom's Particle Physics and Astronomy Research Council (PPARC) and the Netherlands' Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO).

The Roque de Los Muchachos Observatory, which is the principal European northern hemisphere observatory, is operated on behalf of Spain by the Spanish Instituto de Astrofísica de Canarias (IAC), as does the Teide Observatory on Tenerife.

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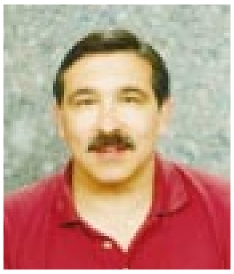
F O R E W O R D

I am delighted to write the foreword to the 1997 Annual Report of the Issac Newton Group of telescopes, on behalf of the Joint Steering Committee. It gives the JSC great satisfaction to see that the steady increase in the scientific productivity of the telescopes has continued unabated during 1997. This year was marked by several exciting discoveries, including a major breakthrough in a subject with a 25-year old history of enigma and controversy.



Dr Carlos Frenk

Chairman of the Joint Steering Committee

The breakthrough to which I am referring is, of course, the first optical identification of a gamma-ray burst. This was accomplished by means of multicolour images taken at the WHT and the INT of a small area of sky where only a few hours previously the BeppoSAX satellite had detected a burst and imaged it in X-rays. The discovery of the optical "afterglow" at the ING paved the way for HST follow-up which revealed extended emission at the location of the burst, most certainly the burst's host galaxy at a redshift approaching one. Shortly afterwards, a similar burst was detected and this time spectroscopy with the 10m Keck telescope in Hawaii revealed the presence of absorption lines in the optical transient at redshift 0.835. Thus, the extragalactic origin of the bursts was finally established, providing strong support for theoretical models in which the huge energy of the burst is released in a relativistic blast wave, most probably triggered by collisions and mergers of neutron stars or black holes.

Gamma-ray bursts experienced strong competition for the headlines from the opposite end of the astronomical domain. The Hale-Bopp comet made its spectacular appearance at about the same time as the gamma-ray burst was being detected. Just as investigation of the burst called for the largest telescopes, some of the most striking pictures of the comet were taken with one of the smallest, the 35mm lens of the CoCAM camera built by ING staff. Hale-Bopp was, of course, also observed with the WHT and this led to the discovery of a new type of cometary tail, made of sodium and having different kinematics to the well-known ion and dust tails. Other scientific highlights may be found in the body of the report.

I would like to take this opportunity to pay tribute to Steve Unger who departed at the end of 1997 after five years as Director of the ING (first as Acting Director and later as Director.) Steve presided over some of the most difficult, but also some of the most exciting years in the history of the ING. His legacy is a mature and highly efficient operation which is generally regarded as one of the prime astronomical facilities in the world. Steve was a Director of unflinching commitment and I am sure that the entire astronomical communities of the UK and the Netherlands will wish to join the JSC in thanking him for his stewardship and in wishing him well in his new career in industry.

Steve was replaced by René Rutten, formerly Head of Astronomy. Just like Steve before him, he started off as Acting Director but, I am very pleased to report, he was subsequently persuaded to take on the Directorship on a substantive basis. In the few months since taking office, René has already shown an imaginative style of leadership which augurs well for the future of the ING. The JSC looks forward to working alongside him in ensuring that the ING continues to prosper as an institution of astronomical excellence.

It is a fact of life that forewords to Annual Reports are written well after the reporting period has elapsed and a new set of issues has come to prominence. Although I do not wish to abuse such extemporal privilege, I cannot resist mentioning briefly the outcome of the review by the International Visiting Panel chaired by Russell Cannon (as an extenuating circumstance, the panel was actually set up in 1997.) The report concludes that the ING is a world class facility, efficiently run and well managed. It makes a number of important recommendations aimed at preserving and enhancing the scientific productivity of the ING into the new millenium. Not least of these is the recommendation of a stable budget and a search for imaginative ways to prepare the ING for the arrival on La Palma of the 10m Gran Telescopio de Canarias in the early years of the next decade. Further details of the Cannon report will no doubt feature in the 1998 Annual Report but, in the interim, they may be obtained from the JSC or from the funding agencies.

The scientific achievements of the ING, only a minuscule fraction of which are highlighted in this Annual Report, are the tangible outcome of the work of many people. In my visits to the ING over the years I have been deeply impressed by the competence, enthusiasm and commitment of the observatory's personnel. It is their talent and effort that underpins the success of the ING. I am confident that the ING's staff, under the directorship of René Rutten, is well equipped to meet the challenges that are an integral part of life at a leading scientific facility.

INTRODUCTION

The year 1997 has been a very busy and exciting year at the observatory, with various important discoveries, and enhancements of the instrument suit. This annual report presents an overview of the most important aspects.

Dr René Rutten

Director of ING

The productivity of the telescopes in terms of publication counts has again been very high, totalling 225 papers in refereed journals. The commitment of staff and very high quality of research projects carried out at the telescopes has led to many exciting discoveries. A small selection of scientific highlights are presented in this report, but I would like to mention one specifically, which is the discovery of the first optical counterpart of a gamma-ray burster, which was based on data obtained on the William Herschel Telescope and the Isaac Newton Telescope. This discovery is an exquisite example of how motivation and dedication of researchers, and coordination of various ground based and space facilities may lead to exciting new results.

In November the former Director, Dr Steve Unger left the Isaac Newton Group of Telescopes, and continued his career in the commercial sector in the United Kingdom. Dr Unger guided the ING through very difficult years where the observatory faced a severe reduction in funding while at the same time the service to the community and productivity of the telescopes had to be improved. The Particle Physics and Astronomy Research Council itself was facing important changes as well, and the Royal Observatories were being restructured. In spite of these unfavourable external factors Dr Unger was highly successful in building up ING as a strong and effective observatory, delivering a first-class service to the astronomical community. As the new Director I am fortunate in being able to build upon the foundations that Steve laid down.

Another important highlight was the signing of the agreement under which the University of Porto in Portugal became a full member of the international partnership of the Isaac Newton Group. I welcome our new partner, and look forward to a strong and productive collaboration.

Last but not least, this annual report pays tribute to all those active researchers who visited the observatory and exploited ING's facilities to further our knowledge of the universe, and to the staff at the ING on who's continuing efforts and enthusiasm the observatory flourishes.

Chapter 1

SCIENTIFIC HIGHLIGHTS

IN THE LIMITED SPACE AVAILABLE, IT IS IMPOSSIBLE TO MAKE A comprehensive survey of the science being carried out by the ING telescopes. The following is therefore necessarily only a selection of highlights, intended to be representative of the scientific quality and range of research being undertaken.

FIRST DETECTION OF THE OPTICAL COUNTERPART OF A GAMMA-RAY BURST

WHT+Prime Focus, INT+Prime Focus

Since their discovery Gamma-Ray Bursts (GRBs) have been one of astronomy's great mysteries. The distribution and properties of the bursts are explained naturally if they lie at cosmological distances, but there is an opposing view that they are relatively local objects, perhaps distributed in a very large halo around our Galaxy. For a long time it was expected that the detection of a counterpart at other wavelengths would provide the key to understanding the GRB phenomenon. However, such counterparts were not found, in spite of much effort during the last 25 years. The main problem was the lack of fast and accurate GRB positions. With the launch of the Wide Field Cameras (WFCs) on board the Italian-Dutch X-ray satellite BeppoSAX this has changed. For the first time GRB positions can be determined with accuracies of a few arcminutes within a few hours after the burst, unprecedented in GRB astronomy.

Finally the situation changed dramatically on February 28, 1997 when a team of astronomers led by Jan van Paradijs of the University of Amsterdam and the University of Alabama in Huntsville pointed the William Herschel Telescope to the part of the sky where shortly before a new GRB had been detected (GRB

970228) by the Gamma-Ray Burst Monitor onboard BeppoSAX satellite.

On February 28, UT 23 h 48 m, 20.8 hours after the GRB occurred, the astronomers obtained a V-band and an I-band image (exposure times 300 s each) of the WFC error box with the Prime Focus camera of the William Herschel Telescope. The 1024 × 1024 pixel CCD frames cover a 7.2' × 7.2' field, well matched to the size of the GRB error box. The limiting magnitudes of the images were V=23.7, and I=21.4. They obtained a second I-band image on March 8, UT 21 h 12 m with the same instrument on the WHT (exposure time 900 s), and a second V-band image on March 8, UT 20 h 42 m with the Isaac Newton Telescope (exposure time 2500 s).

A comparison of the two image pairs immediately revealed one object with a large brightness variation: it was clearly detected in both the V- and I-band images taken on 28 February, but not in the second pair of images taken on 8 March. The position of this object was coincident with all the known error-boxes of GRB 970228. This led the discovery team to conclude that they had identified the first example of optical afterglow of a GRB.

Following this first detection, other optical counterparts of GRBs have been discovered and followed up photometrically and spectroscopically. In most of these subsequent detections the ING telescopes have played an important role.

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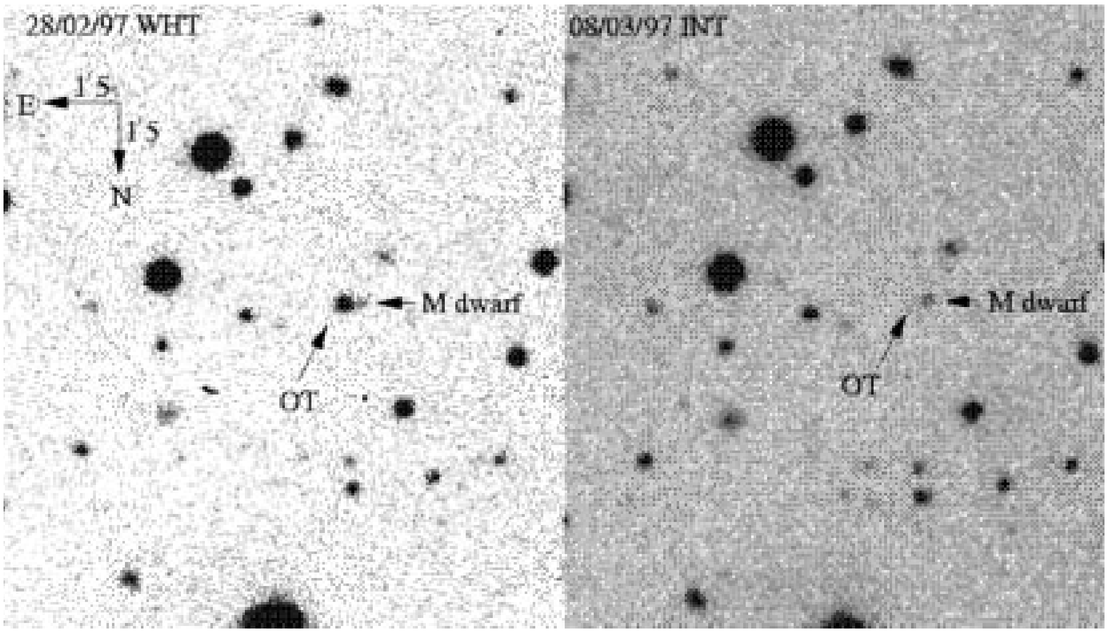

Discovery image of the optical counterpart of a Gamma-Ray Burst (GRB). OT: Optical Transient. The left panel shows the part of the sky where the GRB occurred as seen by the William Herschel Telescope. The right panel shows the same part of the sky only a few days later with the Isaac Newton Telescope, when the source had already become much fainter. After more than two decades of intensive searches for signs in the visible light of these extremely energetic events in the Universe, these two images show that GRBs can be spotted with optical telescopes from the ground. This discovery is helping scientists to unreveal the true nature of the cataclysmic events known as Gamma-Ray Bursts.

COMET HALE-BOPP: FIRST EVER IMAGES OF A NEUTRAL GAS TAIL

CoCAM, WHT+UES

The 1997 International Time Project on comet Hale-Bopp was a great success and several major discoveries were made, including the first detection of a neutral gas tail, the observation of "cyanogen shells" and the detailed study of the rotation of the nucleus. Members of the Comet Hale-Bopp European Team participated in this project. This team was formed in early 1996 to co-ordinate European observing efforts because comet Hale-Bopp provided an extraordinary opportunity for scientists to observe a bright comet in great detail with the most advanced instrumentation, including the last generation of digital detectors.

Observations carried out to study the distribution of sodium atoms in comet C/1995 O1 Hale-Bopp led to the discovery of a new type of comet tail. Sodium atoms had previously been seen near the center of other comets, but these observations revealed for the first time a straight tail of sodium 6 degrees long.

The discovery images were taken with the CoCAM wide-field CCD camera, built and operated by staff at the Isaac Newton Group, set up next to the INT. CoCAM consists of a 35-mm camera zoom lens working at f/3.5 and imaging onto a 2220×1180 pixel EEV CCD chip, whose pixel size of 22.5µ square corresponds to 26", thereby achieving on the sky a total field of 17°×9°.

On 16 April members of the European Comet Hale-Bopp Team made several exposures of the comet through a narrow filter that isolates emission from sodium atoms, and to their great surprise they found that these atoms were distributed over an enormous region in and around the comet. Contrary to earlier observations of bright comets near the Sun, the sodium was present not only in the region next to the cometary nucleus, but there were also large amounts in the region of the cometary tails.

Following a careful analysis of the observed distribution of these atoms, the astronomers concluded that comet Hale-Bopp displayed a third type of tail never seen before and consisting of sodium atoms.

Whereas the well-known ion and dust tails so prominently displayed by Hale-Bopp show a large amount of structure, the new sodium tail had a completely different appearance. It takes the form of a long tail approximately 600,000 km wide and 50 million km long, in a direction close but slightly different to that of the ion tail. While the electrically charged particles in the ion tail are accelerated to large velocities by the solar wind (very fast atomic particles emitted by the Sun), the sodium atoms are released from dust grains and then accelerated in the antisolar direction by simple fluorescence. These latter conclusions were achieved thanks to observations with the William Herschel Telescope.

Other interesting features reported by the European Comet Hale-Bopp Team include the spiral-jet and arc structures observed with the Jacobus Kapteyn Telescope in the inner coma of the comet. The astronomers made use of a CN and a blue continuum filter, obtaining an expansion velocity for CN of 1.3 km/s.

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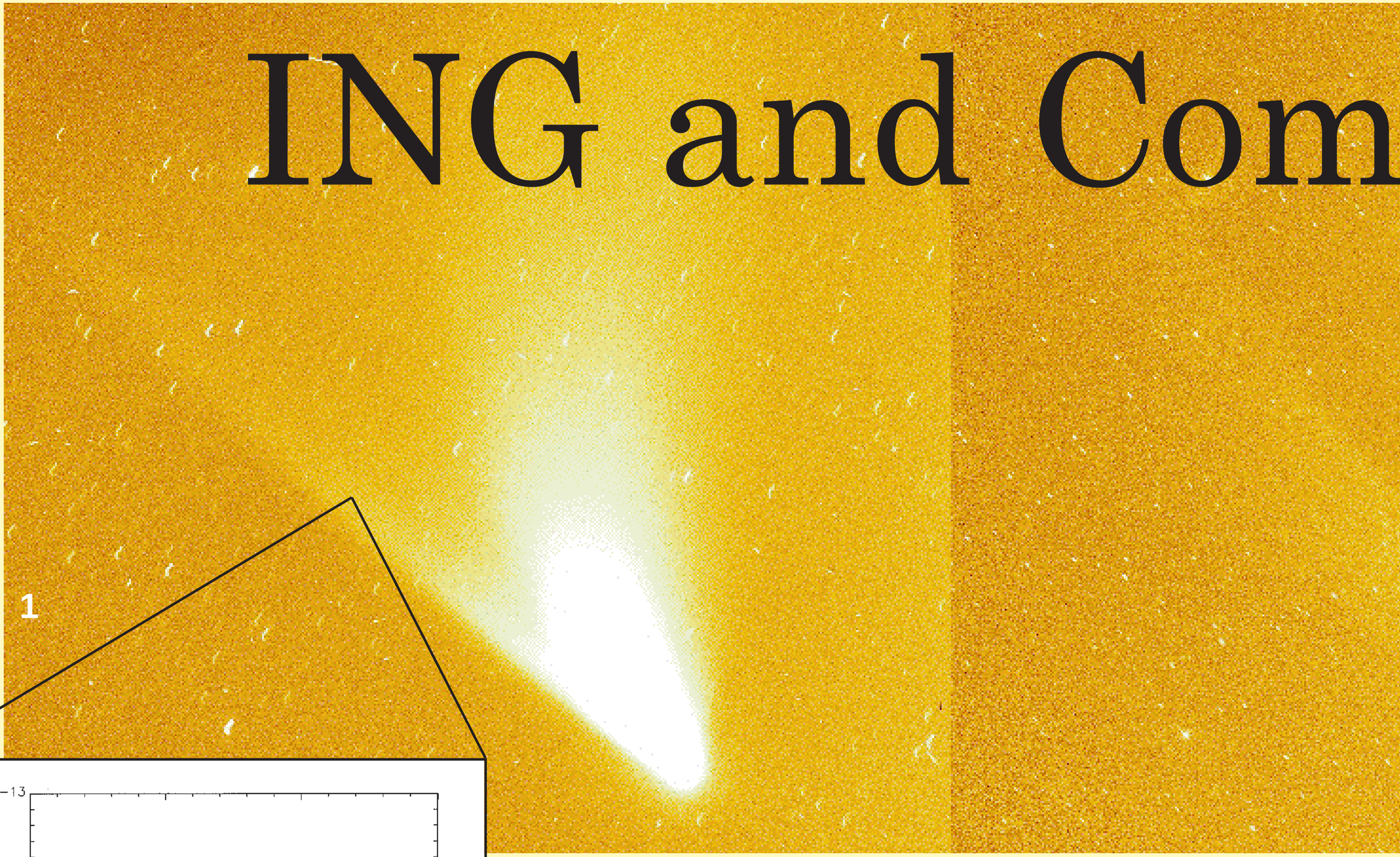
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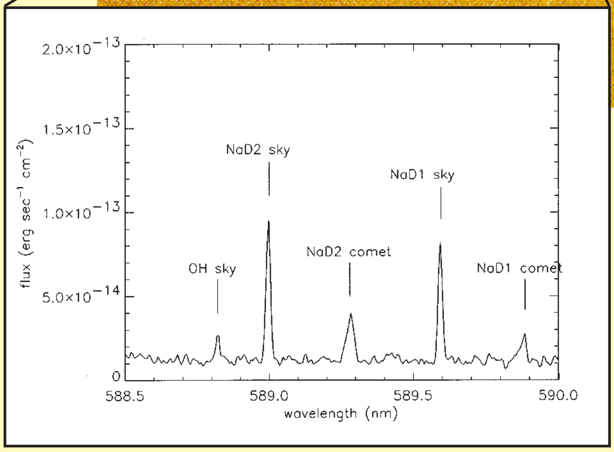
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flux (erg sec⁻¹ cm⁻²)
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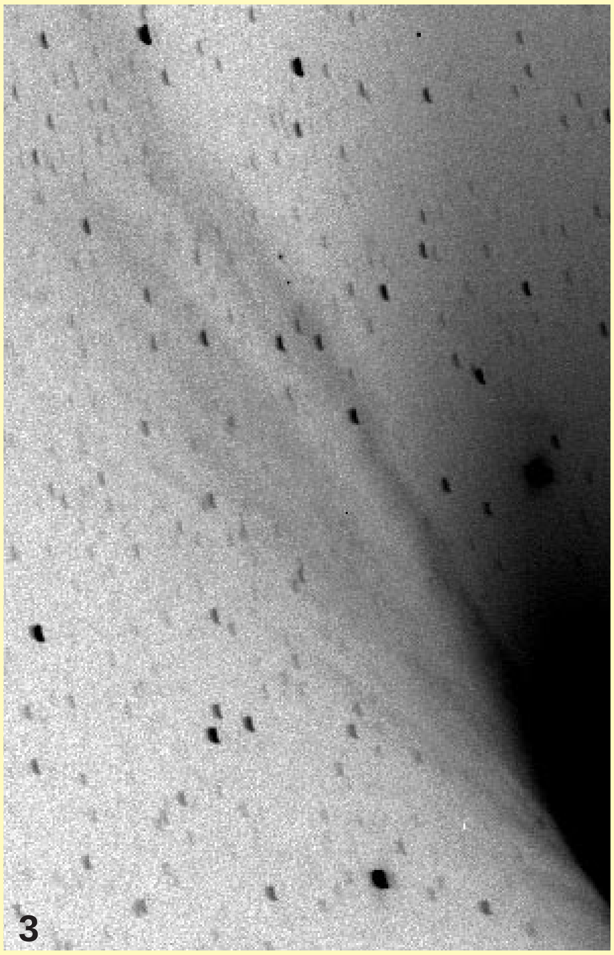
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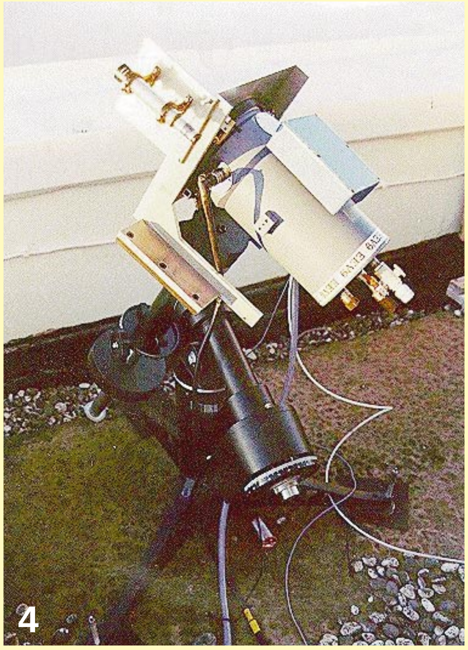
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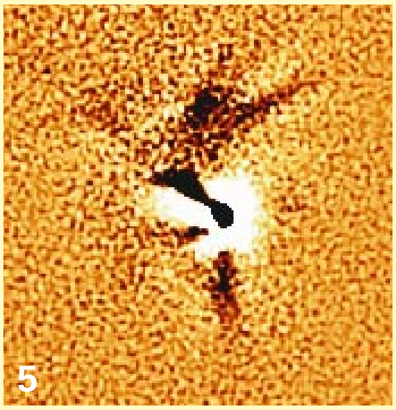
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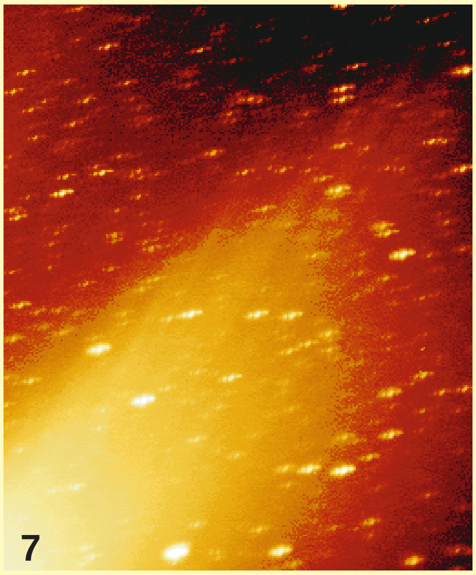
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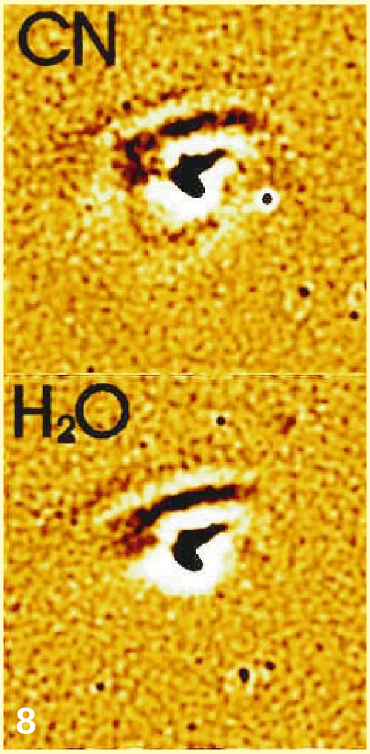
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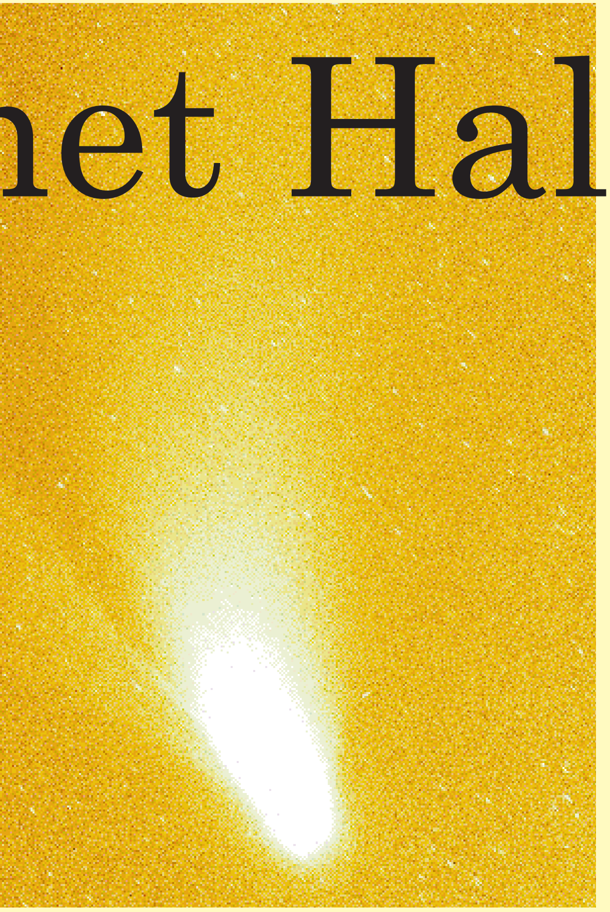
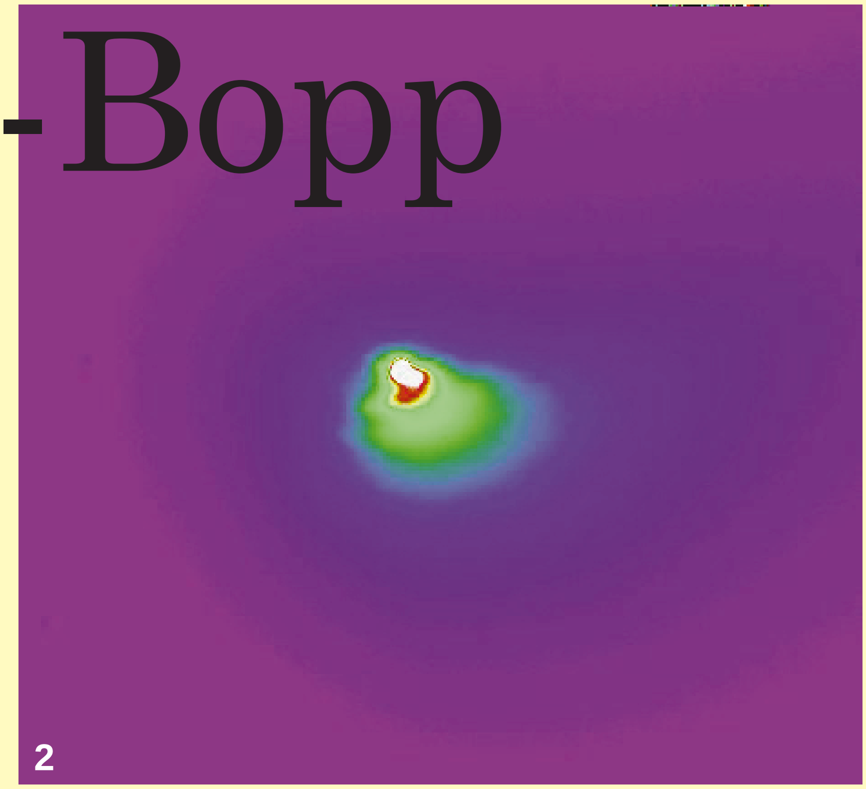
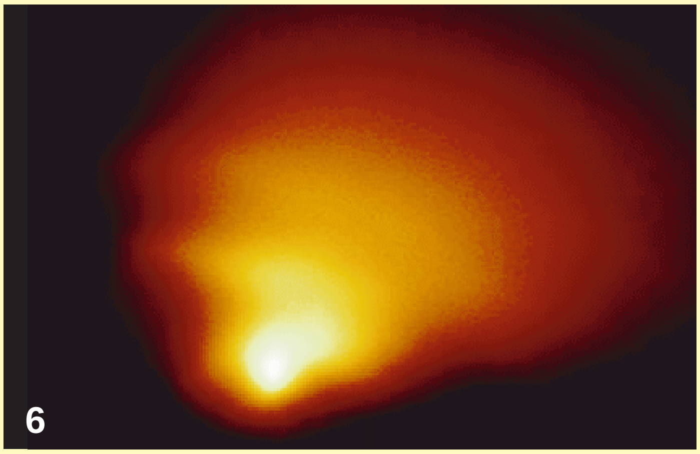
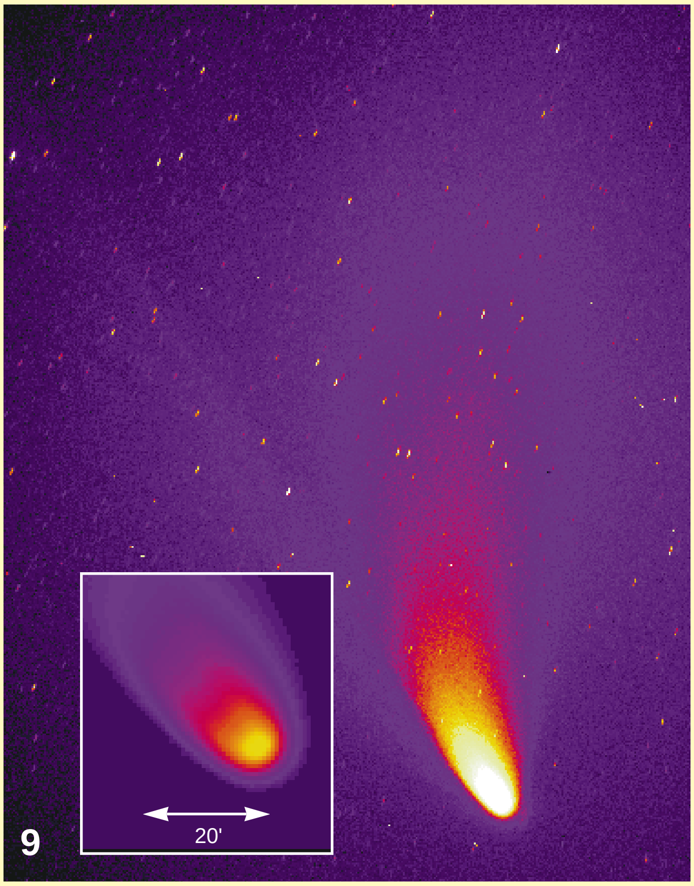








1.- The picture on the left is the discovery image of the sodium tail in Comet Hale-Bopp taken on 16 April. The tail appears as a very straight narrow feature extending from the head of the comet to the upper left. The spectrum corresponds to the sodium tail 3.1° from the nucleus, obtained with the WHT plus the Utrecht Echelle Spectrograph (UES) on April 23.9 UT. Sky lines due to OH and Na are labelled. The cometary NaD lines are clearly observable due to an apparent Doppler shift of 144 km/s from the terrestrial emission (Cremonese et al, 1997, Astrophys J, ***490****, L200). The picture on the right is an image of Comet Hale-Bopp showing the usual ion and dust tails of the comet, taken a few minutes before the discovery of the sodium tail. The dust tail is the broad tail pointing straight upwards, while the ion tail is the filamentary structure to the left.Comparison of the two images shows how the sodium tail has a completely different appearance to the other tails of the comet.*

2.- The 28th February saw first images of Hale-Bopp obtained at the INT Prime Focus camera. This image was taken through an RGO-B filter.

3.- Filamentary ion tail of comet Hale-Bopp on 9 April. This is a 300s exposure taken with CoCAM using a narrow band filter centered at 618.5 nanometers to isolate H_2O^+ emission.

4.- CoCAM camera.

5.- This image was taken by the IAC Hale-Bopp Team at the Auxiliary Port of the WHT on 4 February. A broad-band R filter was used for the observation and an exposure time of just two seconds. A complex series of twisted and spiral jets can be seen in the processed image, with many jets splitting into two, three, or even more parts.

6.- This Z filter image was taken on 1 March with the WHT. Two dusty shells are visible.

7.- Sum of four 10 s, three 20 s and five 5 s CoCAM exposures with no filters taken on 19 March. The filaments visible in the dust tail are synchronic bands of material, i.e., ejected at the same time from the nucleus.

8.- Observations obtained by the European Comet Hale-Bopp Team with the JKT on 5 March revealed both spiral-jet and arc structures. These images were taken through a CN (cyanogen) and a H_2O filter with Laplacian filtering applied to the reduced images. The CN image shows a faint arc below the nucleus due to the expansion of a shell of cyanogen-emitting dust.

9.- 300 s CoCAM image of comet Hale-Bopp taken on 13 April through a H_2O^+ filter and a 3 s exposure of the inner coma using no filters (inset). These images show the extraordinary possibilities of the wide field imaging device COCAM.

DETECTION OF SPIRAL WAVES IN A STELLAR ACCRETION DISC

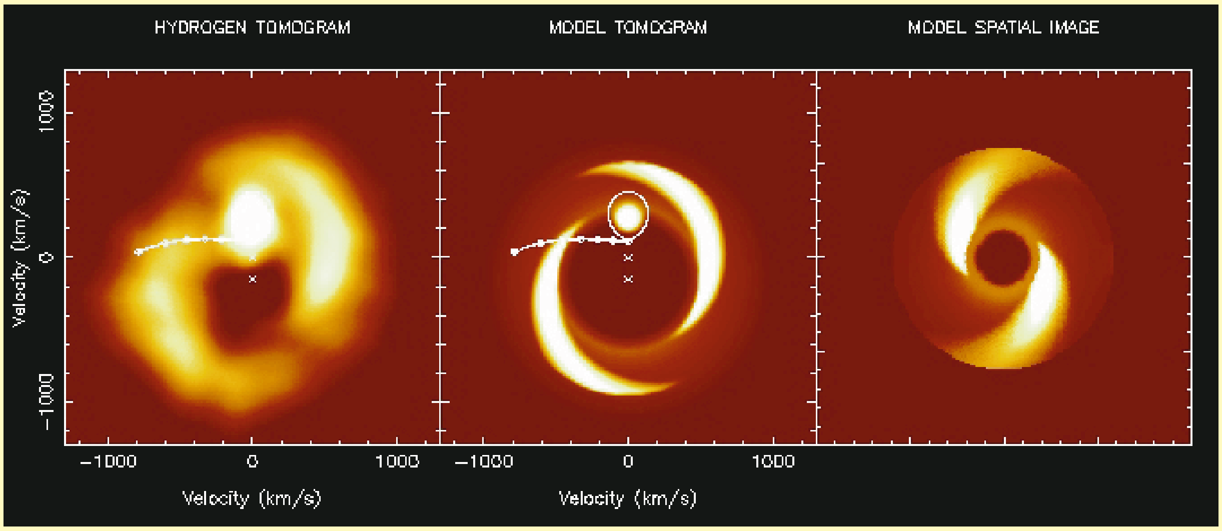
INT+IDS

For the first time, astronomers detected spiral structure in the disc of gas that surrounds one of the stars in an interacting binary star system. The observed system is known as IP Pegasi. IP Pegasi is an eclipsing dwarf nova, a subclass of cataclysmic variables, consisting of a K5 secondary star of 0.5 solar masses losing mass to a white dwarf of 1.0 solar masses in a 3.8-hour orbit. At semi-regular intervals of about three months the system brightens by 2 magnitudes as the mass transfer through the accretion disc suddenly increases.

The disc is smaller than the radius of the Sun, so it is not possible to resolve it directly in any telescope. The technique used involved measuring the velocity of the gas by looking at the Doppler shift in its spectrum. As the stars revolve around each other in their 3.8-hour orbit, the observers got successively different views of the disc. By using a technique called “tomography”, they were able to reconstruct a picture of the flow pattern of the gas.

The results showed a two-armed trailing spiral in the outer part of the disc. Such spirals are thought to be created by tidal forces due to the gravitational pull of the normal star. The formation of such spirals had been predicted, but this is the first positive detection.

This discovery was made thanks to observations carried out at the INT using Service time. The Service programme at the ING telescopes is well suited for undertaking a quick look at new cataclysmic variables or providing complementary emission-line information on old ones. But the programme's main advantage is that it offers the observers the opportunity of some flexibility over the predetermined schedule to cover unexpected events such as nova outbursts. Indeed the astronomers observed IP Pegasi while it was on the rise to outburst with the Intermediate Dispersion Spectrograph (IDS) on the INT, which resulted in the discovery of spiral structure in the binary's accretion disc.



A hot disk of gas surrounding a compact white dwarf star in the constellation of Pegasus has recently been revealed to be imprinted with this dramatic pattern. The white dwarf is part of the interacting binary star system IP Pegasi and the disk of gas is an accretion disk formed of material lost from a companion star and falling toward the white dwarf. The disk itself is smaller than the Sun's diameter, so the spiral pattern can not be imaged directly by telescopes. Instead, the spiralling disk of gas is mapped over a series of observations using a spectroscopic technique known as Doppler “tomography”. The left panel above shows a tomogram, the directly measured gas velocity map for the system. The relative brightness corresponds to the intensity of light emitted by Hydrogen gas moving at the indicated velocity. The position at the center of this panel represents the velocity of the binary system's center of mass. In the middle panel, a simple model velocity field consistent with the measurements is shown. At the right, the calculated position map of the IP Pegasi accretion disk reveals a striking two armed trailing spiral pattern.

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THE FIRST L-TYPE BROWN DWARF

WHT+ISIS, INT+Prime Focus

Since the discovery of the first brown dwarf in 1995 by the WHT, it has been proved that objects with masses between those of stars and planets can be formed in nature and several observations of brown dwarfs have been reported.

To directly detect single brown dwarfs of known age, distance and metallicity, the ideal place to search is within young open clusters. Many brown dwarf surveys have been conducted in the Pleiades open cluster. This is because the Pleiades cluster in near enough that the lower main sequence is not beyond the limits of detection, but far enough away that the area of sky covered is not too large. The cluster is young enough so that any brown dwarfs will be relatively bright. The discovery of the first brown dwarfs in a small survey of the Pleiades suggests that a large number of very low mass objects may populate this cluster.

With the aim of searching for new Pleiades brown dwarfs, a deep ITP CCD I,Z survey was performed covering 1 deg^2 within the central region of the cluster. Over 50 faint (I ≥ 17.5), very red (I–Z ≥ 0.5) objects were detected down to I~22. Their location in the I–Z color diagram suggested cluster membership. According to current evolutionary models, they should have masses in the interval 30 – 80 M_{Jup} (1 M_{Jup} ~ 10^{-3} solar masses).

The most secure Pleiades brown dwarfs are those with kinematic information that supports cluster membership and lithium detection that confirm their substellar status. After spectroscopic observations, several candidates were confirmed as brown dwarfs, among them, Roque 4 (45 M_{Jup}, I=19.75, M9 V) and Roque 25 (35 M_{Jup}, I=21.17, early L), the coolest and faintest brown dwarfs ever observed. Roque 25 is a benchmark brown dwarf in the Pleiades because it is the first known one that belongs to the L-type class. The optical spectrum of Roque 25 is characterised by the following features: (1) the lack of strong molecular absorption band heads in the range 640–760 nm, in particular, the strong TiO bands starting at 705.0 nm are absent or extremely weak in Roque 25; (2) the molecular systems of CaH, CrH, and FeH become as strong or stronger than the systems of TiO and VO; (3) the atomic lines of KI and CsI that are very strong in L-type objects are weaker in Roque 25.

Roque 25 provides evidence that the initial mass function extends down to about 0.035 solar masses and serves as a guide for future deep searches for even less massive young brown dwarfs.

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M R Zapatero Osorio, R Rebolo, and E L Martín, 1997, “Brown Dwarfs in the Pleiades cluster: a CCD-based R, I survey”, *Astron Astrophys*, **317**, 164.

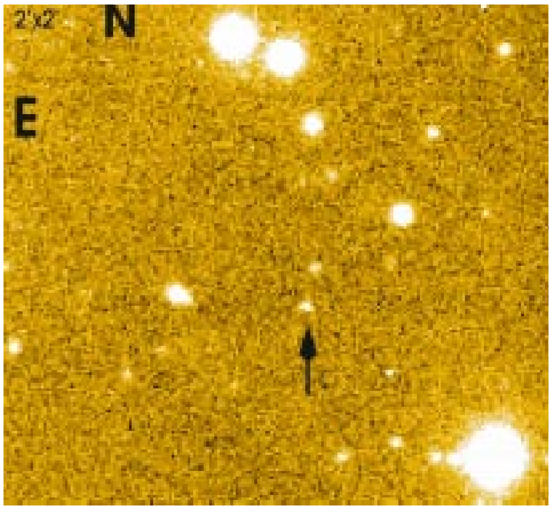
M R Zapatero Osorio, E L Martín, and R Rebolo, 1997, “Brown Dwarfs in the Pleiades cluster. II. J, H and K photometry”, *Astron Astrophys*, **323**, 105.

M R Zapatero Osorio et al, 1997, “New Brown Dwarfs in the Pleiades Cluster”, *Astrophys J*, **491**, L81.

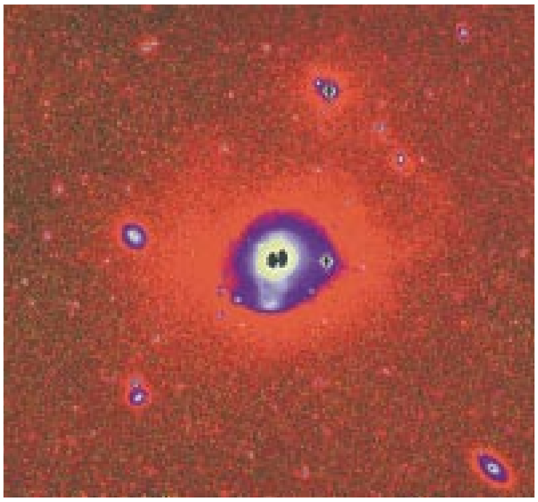
OBSERVATIONAL EVIDENCE THAT ELLIPTICAL GALAXIES ARE PRODUCED BY FUSION

INT+Prime Focus

It has been known since the 80’s that hidden behind the apparent simplicity and uniformity of elliptical galaxies are some unusual properties. Almost half of the ellipticals which have been studied show faint luminous arcs which are called shells. The nucleus of between 20 and 30% of



INT image of Roque 25, the coolest (T_{eff} ~ 2050 K) and faintest (I=21.17) brown dwarf ever observed, and the first one belonging to the L-type class.



CCD image of the peculiar elliptical galaxy NGC 3656 (Arp 155) obtained in the R band with the INT. The first of the two tails emerges to the west (right) and then curves to the north (up). The three objects in line with the end of the tail are, from south to north, a dwarf galaxy and two stars, the northernmost of which hides a small galaxy in its halo. It is as yet unknown if the galaxies are physically associated with the tail. The second tail emerges from the east side of the galaxy and extends towards the north.

ellipticals rotate in the opposite or orthogonal direction from the rest of the galaxy. An undetermined number of ellipticals have rings or polar disks with stars, gas and dust. The existence of such structure can only be understood as a result of accretion or fusion processes between existing galaxies and not as a result of monolithic collapse during the formation stage. In fact the presence of two counter posed tidal tails is unequivocal evidence for the fusion of two disk galaxies. The fact that the tails are diluted with time until they become unobservable has made it difficult in the past to obtain fundamental proof of the origin of ellipticals from the fusion of spiral galaxies.

This proof has been obtained as a result of observations with the INT of the peculiar elliptical galaxy NGC 3656. This galaxy had been understood to be the result of a minor fusion (an elliptical galaxy swallowing a smaller galaxy) due to the presence of photometric shells and a nucleus which rotates orthogonally. The INT data, after being treated with a special equalising process for the detector's photometric response, have revealed an extensive luminous halo and two tidal tails. Such tails are incompatible with minor fusion and suggest that a major fusion has taken place between two galaxies with disks of similar size in direct orbit.

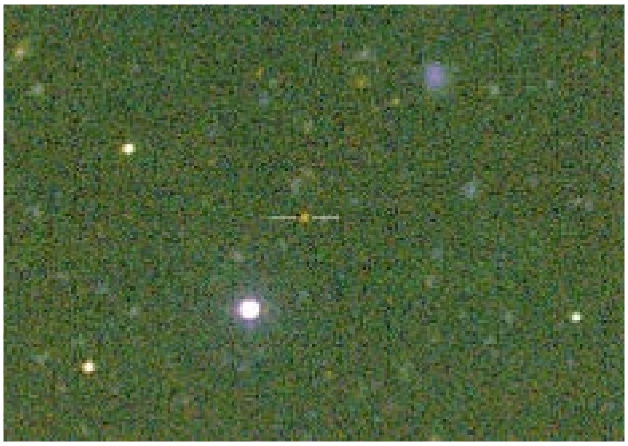
References:

M Balcells, 1997, "Two tails in NGC 3656 and the major merger origin of shell and minor-axis dust lane elliptical galaxies", *Astrophys J*, **486**, L87.

DISCOVERY OF THE THIRD MOST DISTANT QUASAR AND THE HIGHEST REDSHIFT RADIO AND X-RAY SOURCE

INT+Prime Focus, WHT+ISIS

During an imaging survey of the evolution of the space density of radio-loud quasars, a quasar at z=4.72 was discovered. This quasar, GB 1428+4217, is the third most distant quasar and the highest redshift radio and X-ray source currently known. It has a radio flux density at 5 GHz of 259 ± 31 mJy and an optical magnitude of R ~ 20.9. The rest frame absolute UV magnitude is M (1450 Å) = –26.7. Another radio-loud quasar was discovered during the same CCD imaging survey, GB 1713+2148, with z = 4.01. Combined with earlier survey results, these objects give a lower limit on the space density of quasars with radio power $P_{5\ GHz} > 5.8 \times 10^{26}$ W Hz^{-1} sr^{-1} between z = 4 and z = 5 of $1.4 \pm 0.9 \times 10^{-10}$ Mpc^{-3}.



B and R image of GB1428+4217 (the very red object in the center). GB1428+4217 is the third most distant quasar and the highest redshift radio and X-ray source currently known. This picture was taken using the Prime Focus camera at the INT.

References:

A C Fabian et al, 1997, "The extreme X-ray luminosity of the z=4.72 radio-loud quasar GB 1428+4217", *MNRAS*, **291**, L5.

I M Hook and R G McMahon, 1998, "Discovery of radio-loud quasars with z=4.72 and z=4.01", *MNRAS*, **294**, L7.

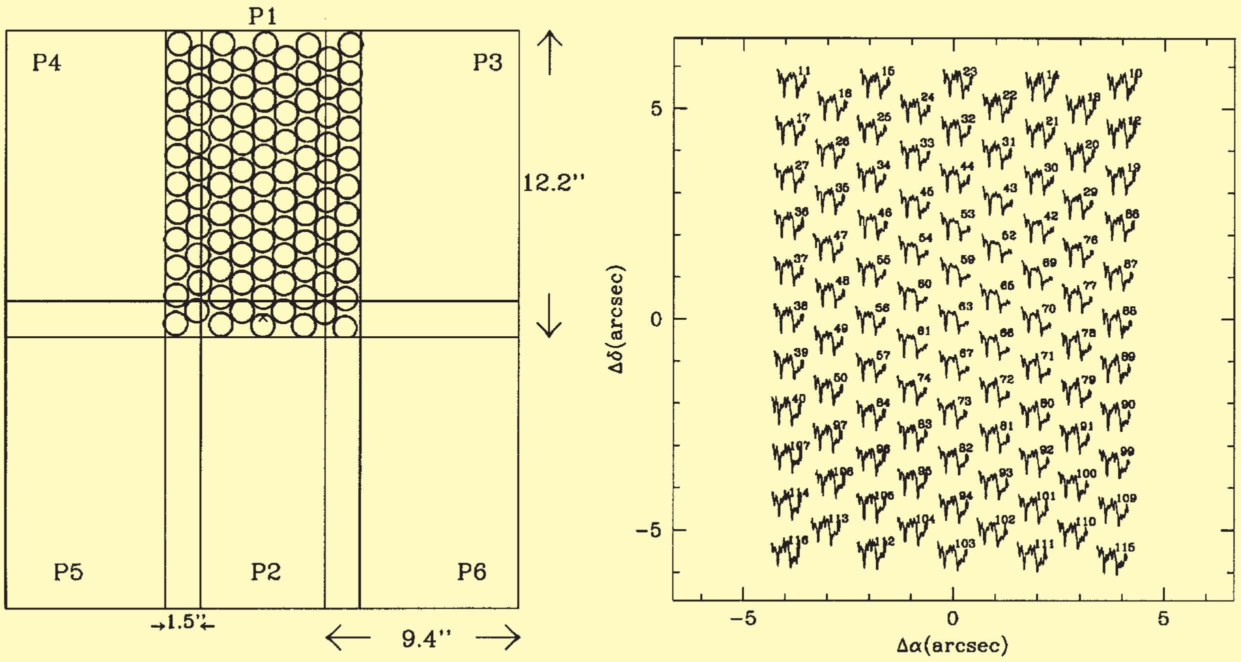
EVIDENCE OF TWO KINEMATICALLY DIFFERENT STELLAR SYSTEMS IN NGC 1068

WHT+ISIS 2D-FIS

NGC 1068 is a nearby (~ 22.7 Mpc), luminous and well-studied active galaxy. Despite of being the Seyfert 2 prototype galaxy, it shows broad permitted lines in polarised light. The current interpretation of this result is that NGC 1068 has a Seyfert 1 nucleus obscured from our direct view. The existence of a large concentration of molecular gas and dust in the nucleus of NGC 1068 supports this hypothesis.

The kinematic off-centering between the inner and the outer regions of NGC 1068 observed in the gas velocity fields could indicate the presence of a non-symmetric contribution to the gravitational potential. Both regions exhibit kinematic minor axes aligned and could have similar systemic velocities. However, their kinematic centers are displaced by ~ 2.5", and this can be interpreted as two kinematically different stellar systems rotating around parallel but with shifted axes.

The almost discontinuous transition between the inner and outer regions rather suggests a strong decoupling between both zones, as if they corresponded to two distinct stellar systems. This leads to the interesting possibility of considering NGC 1068 as a merger remnant: a satellite galaxy could have been captured by the primary galaxy, a



*The 2D-FIS system consists of a bundle containing 125 optical fibers distributed in the focal plane of the WHT. It can be used in combination with ISIS. Left: The circles at position P1 represent the distribution of the fibers in the focal plane of the WHT. The cross indicates the location of NGC 1068 optical nucleus. Right: Spectra from the observed region of NGC 1068 in the range 8503-8748 Å (extracted from B García-Lorenzo et al, Astrophys J, **483**, L99).*

merged core being situated close to the disk center of the primary.

References:

B García-Lorenzo et al, 1997, "Evidence of two kinematically different stellar systems in NGC 1068", *Astrophys J*, **483**, L99.

OTHER HIGHLIGHTS

A new slitless spectroscopy technique was developed to simultaneously detect and measure the kinematics of planetary nebulae in external galaxies, and first experiments with ISIS spectrograph on the WHT proved successful. Plans now exists to build a dedicated instrument. Construction would take place in Groningen and at ASTRON.

An international team led by astronomers of the University of Wyoming announced the discovery of a new type of star. In many binary systems, the initially more massive star ends its life and becomes a white dwarf, while the initially less massive star tries to evolve normally, but all the while loses mass to the white dwarf. Eventually, all that remains of the less massive star is an exposed stellar core with a size near that of the planet Jupiter and a mass of only 5/100th or so of its original value. Having used up or lost essentially all its hydrogen, this very small star has no remaining energy generation. It cannot ever become one of the usual stellar end-products. Therefore, it has a structure unlike any other kind of known star. This discovery was made thanks to observations with the WHT.

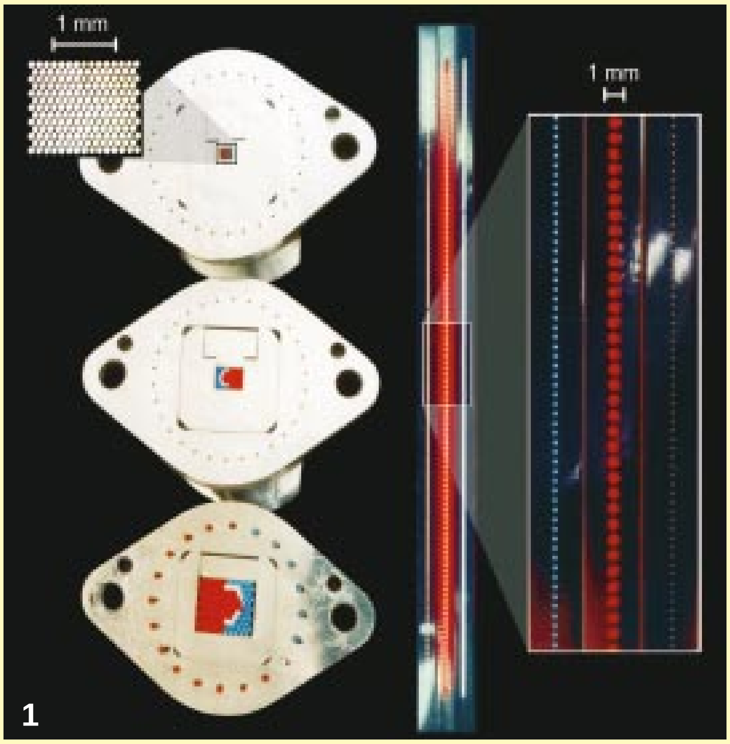
Chapter 2

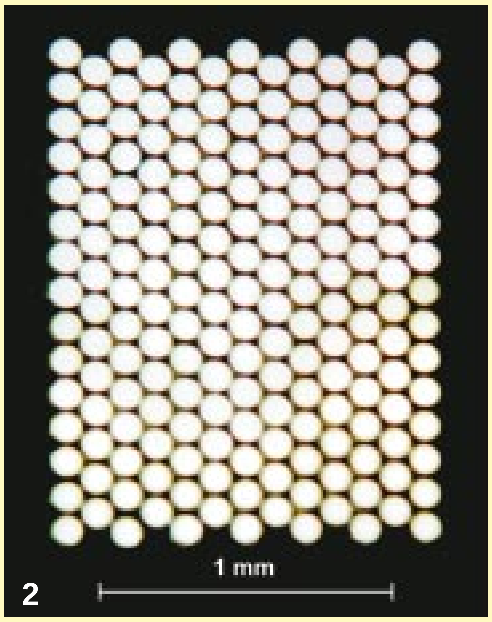
NEW INSTRUMENTATION AND ENHANCEMENTS

WILLIAM HERSCHEL TELESCOPE

Good data continued to be obtained with the prime focus AUTOFIB multi-fibre positioning unit feeding light into the WYFFOS fibre spectrograph. Spectra from thousands of galaxies, hundreds of globular clusters and tens of planetary nebulae in M51 had been gathered in only a few nights on the WHT. However, the operational reliability of the AUTOFIB fibre positioner continued to be problematic. These problems led to a detailed analysis of the faults which resulted in a re-design of the fibre griper mechanism and parts of the fibre support assembly. The new system was put through its paces in December 1997 and was shown to perform very satisfactory. The accuracy of fibre positioning is now good enough to proceed with the manufacturing of a fibre unit with 1.6 arcsec diameter fibres with confidence.

An integral-field spectroscopic facility, INTEGRAL, was deployed at the Nasmyth focus of the WHT. This collaborative development between teams from the Instituto de Astrofísica de Canarias and the Royal Greenwich Observatory picks up and dissects light from extended objects, and channels the light into the WYFFOS fibre spectrograph. Three fibre bundles are available with field sizes ranging from 10 to 40 arcseconds and different fibre core sizes, which allow observers to make the most efficient use of the prevailing seeing conditions. This instrument is particularly useful for kinematic studies of galaxies.





1.- The focal plane end of the standard INTEGRAL fibre bundles. The insert (top left) shows a close up of the bundle with the smallest aperture fibres. The inset on the right is a close up of the slit assemble showing the 'pseudo-slit' arrangement of fibres.

2.- Back illuminated fibres from the 0.45" bundle.

3.- INTEGRAL mounted on the GHRIL rotator. The fibre bundles can be seen exiting the instrument on the coupled ring at the back of the instrument. The insert is a close up of the fibre complex, showing plate and also the autoguiding bundles.

4.- INTEGRAL fibre bundles mounted in a WYFFOS slit unit.

A new UES derotator was commissioned in December 1997. The new derotator has high UV throughput, but a small field of view. The old derotator remains available for long-slit work.

Work progressed on INGRID (the ING Red Imaging Device), the new near-infrared camera for the WHT. Unlike WHIRCAM, this camera will be optimised for a wide field of view at relatively short wavelengths, with good performance expected out to about 2.2 microns. The detector will be a Rockwell 1024×1024 HgCdTl array. This camera will be deployed at the Cassegrain focus of the WHT for direct imaging, where it will provide a pixel scale of 0.25 arcseconds/pixel, and it will be the principal detector for the NAOMI Adaptive Optics system, where it will provide a pixel scale of 0.04 arcseconds/pixel. Most of the detailed design of the instrument was finished, and the detector readout electronics were tested using the engineering array in a test camera.

The main instrument development project for the William Herschel Telescope is the NAOMI natural guide star adaptive optics system. A number of milestones were successfully passed. The wavefront sensor and opto-mechanical chassis design phases were completed. The first deployment of the ELECTRA segmented mirror, which will be a key part of NAOMI, suffered some delay, but in June the loop between the (preliminary) Shack-Hartmann wavefront sensor and the 78-element segmented mirror was closed for the first time on a star. This was a key milestone for the project. The next important phase will be to achieve closed loop full strain gauge control over the mirror segments with virtually zero hysteresis, which will allow very accurate wavefront correction.

Other instrumentation developments include LIRIS, a cooled near-infrared (0.9-2.5 microns) intermediate-resolution spectrograph for the Cassegrain focus of the WHT. This instrument is being planned by the Instituto de Astrofísica de Canarias. LIRIS will also use a Rockwell 1024×1024 HgCdTl array to cover a large spectral range and a wide spatial field of view.

ISAAC NEWTON TELESCOPE

The new prime focus Wide Field Camera was commissioned in May. This system is based on a mosaic of four thinned 2048×2048 pixel CCDs. Its scientific performance was unfortunately limited by the relatively poor performance of the CCDs, which led to the decision to look for alternative CCDs to replace the existing set. New and larger thinned detectors were acquired from EEV and the upgrade of the camera was planned to take place early in 1998.

Important progress was made on the initiative to modernise the instrument and telescope control infrastructure. The new infrastructure is based around a DEC-Alpha workstation for the telescope control, and Unix based instrument control and data acquisition systems. This upgrade allowed decommissioning of the very old control computers which became difficult to support and did not comply with the more demanding tasks and much higher data rates.

The upgrades programme has been carried out through various stages, gradually replacing old equipment. This approach caused that observers had to cope with many changes, but on the other hand the telescope did not have to be taken out of service for any substantial length of time.

Towards the end of the year the Cambridge Institute of Astronomy's CIRSI wide field infrared camera was commissioned at the INT as a private instrument. This panoramic wide field camera is based on a mosaic of 4 Rockwell HgCdTl 1024×1024 arrays. The absence of cold fore optics limits it use in the thermal infrared, but its collecting area makes it a highly competitive instrument in the near infrared. It will be particularly well-suited for surveys of star-forming regions, low mass stars, distant galaxies, clusters and quasars.

JACOBUS KAPTEYN TELESCOPE

Parallel to the upgrades of the computing infrastructure on the INT, a similar development took place on the JKT. A Unix based data acquisition system was commissioned in 1997, and full completion of the upgrades programme, which includes a DEC-Alpha based telescope control system and a Unix based instrument control system will take place in 1998.

The INT Wide Field Camera (WFC) consists of a 4 chip mosaic assembly. A fifth CCD, a Lesser thinned Loral device, is co-mounted with the science array in the cryostat to provide autoguiding functions (see picture on the left). The picture in the middle corresponds to the first commissioning on the telescope in May 1997. Finally, the picture on the right is a true-colour image of M51 galaxy using BVR imaging on the WFC.

DETECTOR ENHANCEMENTS

Progress on the contract to procure 2k×2k pixel thinned Loral CCD continued to be problematic and has not yielded the quality of devices that was aimed for. Also progress on the procurement of thinned 4k×2k pixel CCD from EEV was slow, but in the fall of 1997 one EEV detector was delivered which did perform satisfactory and quickly became the detector of choice for most observers. The large size of the chip, in combination with the small pixels, the good quantum efficiency, and intrinsically good point spread function, makes this a highly attractive tool for astronomy.

In order to accommodate the strong need for large format thinned devices two 2048×2048 pixel thinned devices from SITe were purchased in the beginning of the year and successfully put into operation.

Chapter 3

TELESCOPE OPERATION

TELESCOPES

The quality control programme continued to be enhanced, in order to ensure that not just the quantity, but also the quality of data obtained by visiting observers is maximised. The programme includes regular checks of the telescope image quality, of the primary mirror reflectivity, of key optical performance indicators of the main spectrographs, and of detector performance.

Trials of queue scheduled observations were carried out with the INT prime focus CCD mosaic imaging camera. The observations were carried out by staff astronomers using the priority order established by the time allocation committee. The aim was to gain experience with queue observing, in particular in the area of pre-observing information, on-line assessment of data quality, dissemination of data, and to assess the cost. No major problems were encountered, and user feedback was generally positive. Results from a questionnaire that was sent out to the user community suggests that many observers see a worthwhile benefit in service and queue observing, in particular where these observing modes use the valuable observing time more effectively, and allow greater flexibility in the observing schedule. It is the intention to explore these observing modes further.

The Richardson Brealey Spectrograph had its last observing run on the JKT in November 1997. From then on the JKT has effectively become a single-instrument imaging telescope, which reduced overall operational cost of this telescope.

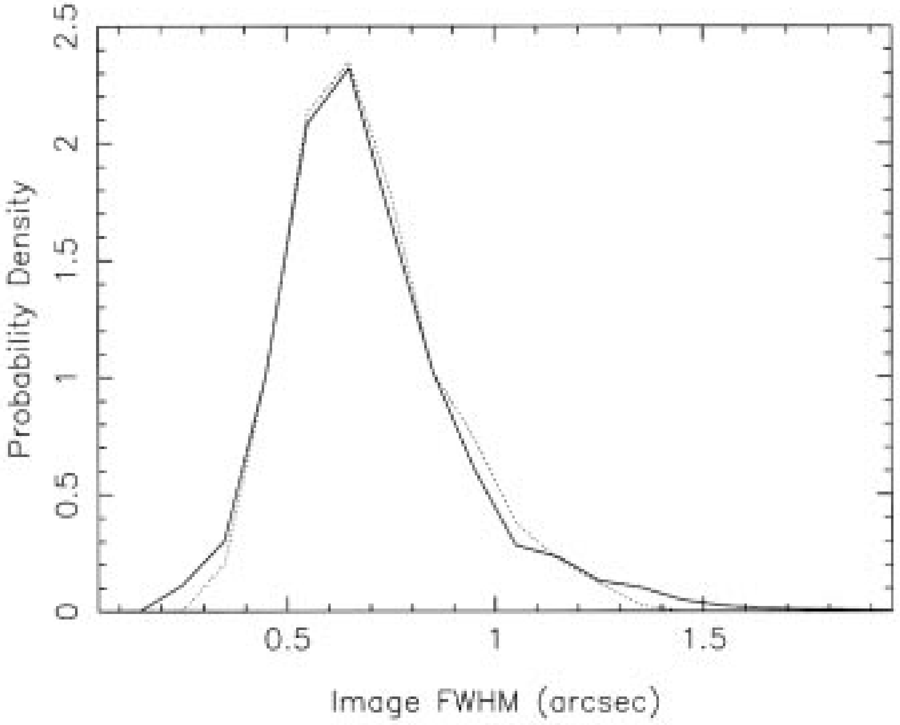
Good progress was made on the programme to modernise and improve the control systems of the telescopes and instruments. The ultimately aim is to have common control systems on all three telescope based on modern equipment and using industry standards where possible. These measures will improve reliability and reduce the total operational cost of the telescopes.

The Telescope Control System (TCS) as well as the Instrument Control System (ICS) on the INT were renewed. Also the Data Acquisition System (DAS) on both the INT and the JKT were replaced by a Unix based system which resulted in an important reduction in time loss due to acquisition overheads.

The year 1997 also saw an upgrade of the ING data archive which is based in Cambridge. This new archive is based on the system developed by the Canadian Astronomy Data Centre, using the Sybase commercial database, and has also been adopted by a number of other observatories (e.g. HST, ESO, UKIRT). There is an easy to use user interface, accessible via the World Wide Web (http://archive.ast.cam.ac.uk/ingarch/), and the archive provides links to other major archives. The preferred method of disseminating requested archive data is now via ftp transfer, although the data can be sent on DAT tape if requested. Usage of the archive doubled shortly after introduction of the new system, and continued to rise.

During the period Feb - March 1997 the European Comet Hale-Bopp team used the ING telescopes during their extensive observing campaign. In order to further the scientific use of the data obtained, a Hale-Bopp archive was set-up, containing all of the data obtained at the ING telescopes, plus that from the other telescopes on La Palma and Tenerife. This archive is hosted in Cambridge as part of ING's science archive.

The continuing investigation of the quality of the seeing at the observatory has now resulted in a large dataset from the Differential Image Motion Monitor (DIMM), as well as from Shack-Hartmann



Histogram for JOSE (dotted line) and DIMM (solid) contemporaneous data from all nights in 1996-98. The JOSE experiment measures seeing from the telescope, and DIMM from outside the dome. So this plot clearly shows that WHT dome seeing is negligible (extracted from R W Wilson et al, MNRAS, in press).

wavefront sensor experiments at the Nasmyth focus of the WHT (JOSE). The results can be summarised as follows. The median value of the intrinsic site seeing is 0.70 arcseconds. There is no significant variation between different areas of the site, as the seeing values deduced by simultaneous measurements taken at various telescope sites are essentially the same to within approximately 0.05 arcsec. There is a substantial seasonal variation, with a peak-to-peak amplitude of about 0.35 arcsec.

The median value of the image quality measured through the telescope using a Shack-Hartmann wavefront sensor (hence including contributions from dome as well as site seeing) is about 0.75 arcsec. The small difference between free atmosphere seeing and the seeing measured through the telescope indicates that the William Herschel Telescope does not substantially degrade the natural seeing. Further improvements are expected from better focussing procedures, and improved focus-tracking models.

An international agreement between PPARC, NWO and the University of Porto was signed in October 1997. Under this agreement the University of Porto obtains 28 nights of observing time on the JKT and access to the INT and WHT under open competition with other astronomers through the normal peer review process. In return, the University of Porto will station one person at ING in support of the operation. This agreement takes effect from February 1998.

OBSERVATORY INFRASTRUCTURE

The facilities for staff working in the new sea-level offices as well as on the mountain top were further improved. A detector clean room has been constructed which allows repairs and testing of CCD systems under clean and controlled conditions. A detector workshop providing an area for tests and maintenance work on detectors is under construction in the WHT building.

The instrument test focal station on the ground floor of the WHT building has been extended and now allows maintenance work to be carried out on two or three instruments at the same time, and it allows for easy connection to the observatories computing infrastructure. Full system tests can now be carried out as if the instrument were on the telescope.

The mechanical workshop in the INT building has undergone a major reorganisation to provide a better and more safe work environment.

New cars were acquired for visiting and support astronomers' use on site.

Chapter 4

TELESCOPE PERFORMANCE

USE OF TELESCOPE TIME

The available observing time on the ING telescopes is allocated between British, Dutch and Spanish time allocation committees, the CCI International Time Programmes (ITP), service and discretionary nights, and scheduled stand-down/commissioning time.

The PPARC-NWO Joint Steering Committee has delegated the task of time allocation to British and Dutch astronomers to the PPARC Panel for the Allocation of Telescope Time (PATT). On the other hand it is the responsibility of the IAC to allocate the Spanish time via the Comité para la Asignación de Tiempos (CAT). The ratio of UK PATT:CAT:NL PATT:ITP is nominally 60:20:15:5. This ratio is monitored and small differences in these proportions in any one year are corrected over a number of observing seasons.

Service nights listed in the following table belong to UK PATT and NL PATT (ratio 5:1). CAT also provides service time out of their quota. The aim of the ING service programme is to provide astronomers with a way to obtain small sets of observations, which would not justify a whole night or more of telescope time. For each telescope and instrument several nights per month are set aside especially for this purpose. During those nights, ING support astronomers perform observations for several service requests per nights.

Discretionary nights are used partly for minor enhancements, calibration and quality control tests, etc., and partly for astronomy, for example, as compensation for breakdowns or for observations of targets of opportunity. They are scheduled together with service nights for greater flexibility, but a careful record of service observations with nationality is kept.

Allocation of time for semesters 97A+97B

	WHT		INT		JKT	
	Nights	%	Nights	%	Nights	%
UK PATT	162	44.4	169	46.3	189	51.8
CAT	60	16.4	63	17.3	65	17.8
NL PATT	42	11.5	43	11.8	51	14.0
ITP	16	4.4	16	4.4	16	4.4
Service	26	7.1	21	5.7	10	2.7
Discretionary	22	6.0	10	2.7	11	3.0
Stand-down/ commissioning	37	10.2	43	11.8	23	6.3
Total	365	100.0	365	100.0	365	100.0

Stand-down and commissioning time is used for basic maintenance, quality control, and upgrades to the telescope and instrument systems.

The way the available observing time on the ING telescopes has been shared in semesters 97A and 97B is summarised in the table above.

USE OF INSTRUMENTATION

The following tables show for each telescope the number of nights in semesters 97A and 97B for which the different instruments were used. Stand-down (but not commissioning) periods are excluded. The abbreviations are explained in Appendix B and J.

ISIS comprises three modes of operation: ISIS, ISIS+Aux, and ISIS+fibers. In semesters 97A and 97B GHRIL was used for own instruments and JOSE. Finally “Other” includes instrumentation which is not common-user, like CIRSI, INTEGRAL or ELECTRA on the WHT, CIRSI on the INT, or Triffid, Durham Polarimeter and Texas Photometer on the JKT.

Again ISIS and UES are the most used WHT instruments, but with the improved large CCD detectors available, prime focus imaging is becoming very popular. On the INT, dark time periods are becoming almost exclusively used for CCD imaging with the Wide Field Camera and the JKT is rapidly becoming a single instrument telescope for CCD imaging.

TELESCOPE RELIABILITY

Telescope downtime due to technical problems averaged 2.3, 3.8, and 3.1% on the WHT, the INT, and the JKT respectively in 1997. The continuing low figures are particularly creditable in view of the range of new systems, both instruments and infrastructure, that were commissioned during the period, and the substantial reductions in night time technical and astronomy support. These continuing low downtime figures should also be assessed against the remarkable increase in observing efficiency that has been accomplished on the INT and the JKT through the re-engineering programme.

Use of instrumentation for semesters 97A+97B

WHT

	ISIS	LDSS	TAURUS	UES	PF	FOS	WYFFOS+Fib	GHRIL	WHIRCAM	Other	Total
Nights	159	27	22	45	40	2	22	14	12	16	359
%	44.3	7.5	6.1	12.5	11.2	0.6	6.1	3.9	3.3	4.5	100.0

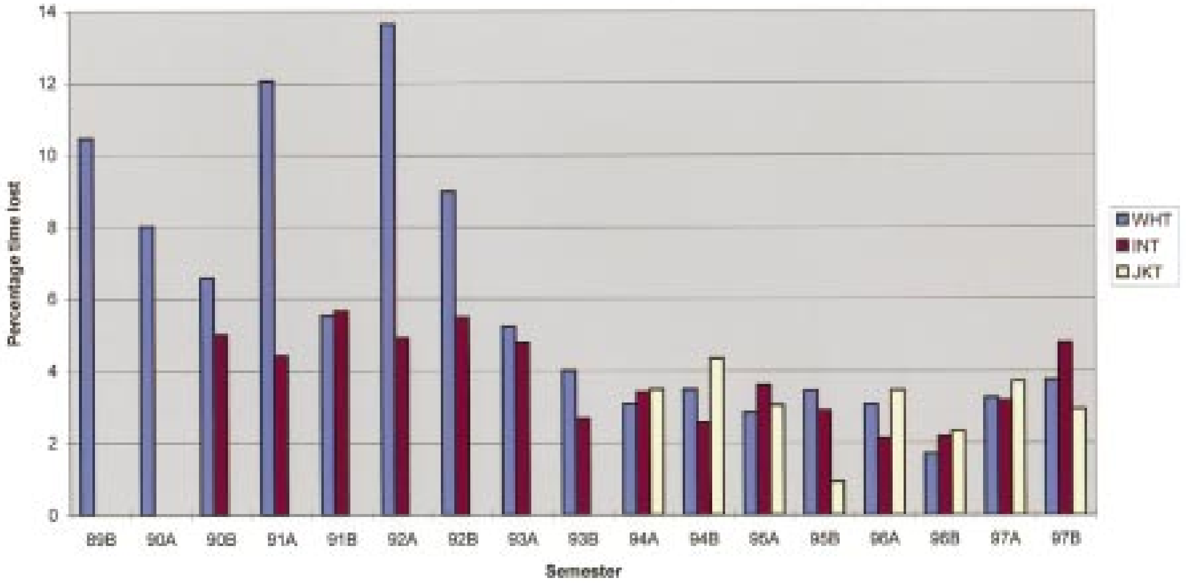
INT

	PFC/WFC	IDS	Musicos	Other	Total
Nights	137	169	29	6	341
%	40.2	49.5	8.5	1.8	100.0

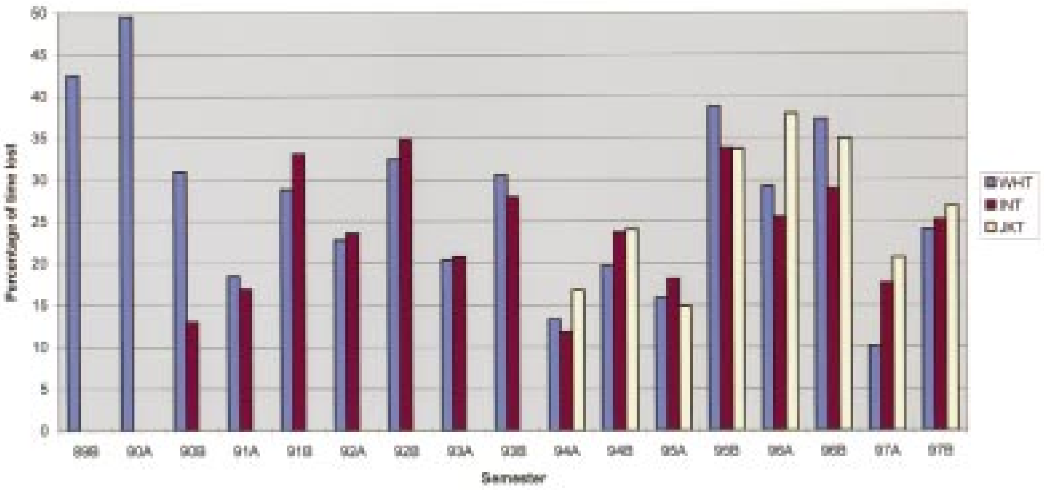
JKT

	CCD	RBS	Other	Total
Nights	263	53	28	344
%	76.5	15.4	8.1	100.0

Engineering down time



Weather down time



Percentage of weather and technical down time by semester

Semester	WHT weather	WHT technical	INT weather	INT technical	JKT weather	JKT technical
89B	42.5	10.5				
90A	49.6	8.0				
90B	30.9	6.6	13.0	5.0		
91A	18.4	12.1	16.9	4.4		
91B	28.8	5.5	33.0	5.7		
92A	22.8	13.6	23.6	4.9		
92B	32.4	9.0	34.8	5.5		
93A	20.4	5.2	20.7	4.8		
93B	30.5	4.0	27.9	2.7		
94A	13.3	3.1	11.8	3.4	16.7	3.5
94B	19.7	3.5	23.7	2.5	24.1	4.3
95A	15.8	2.8	18.1	3.6	14.8	3.1
95B	38.8	3.4	33.8	2.9	33.7	0.9
96A	29.2	3.1	25.5	2.1	37.9	3.5
96B	37.2	1.7	28.9	2.2	34.9	2.3
97A	10.1	3.3	17.6	3.2	20.7	3.7
97B	24.0	3.7	25.2	4.8	26.9	2.9

Chapter 5

PUBLIC RELATIONS

THE MOST AUSPICIOUS PUBLIC EVENT THIS YEAR WAS THE VISIT TO the observatory of His Royal Highness Crown Prins Willem Alexander of the Netherlands on 30 and 31 October for the First Light Celebration of the Dutch Open Telescope. During his visit the Prins of Orange, accompanied by the Dutch Minister for science and education J Ritzen, visited the WHT to experience night-time observing. The following day they returned to the WHT to view the telescope and ancillary installations.

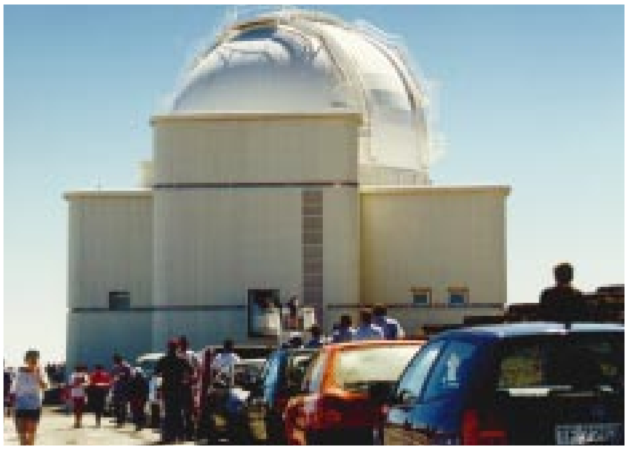
During 1997 the observatory had one hundred and fifty visits from schools, universities, astronomical associations, congresses, local institutions, etc, giving a grand total of 2700 visitors of different nationalities. At the same time we attended a large number of requests for information, amongst them over 50 from communication media, including press, radio and TV. Of particular interest were the contacts made by the BBC, CNN, *Nature* and the *Financial Times*.

1997's public open days were very successful. During the three days for the general public, and the one open day specially for the people from the observatory hosting district of Garafía, a total of over 3200 visitors visited the observatory. One hundred tours were organised to view the WHT and the INT. Approximately half of the visitors were Spanish nationals, and one out of four visitors came from La Palma.

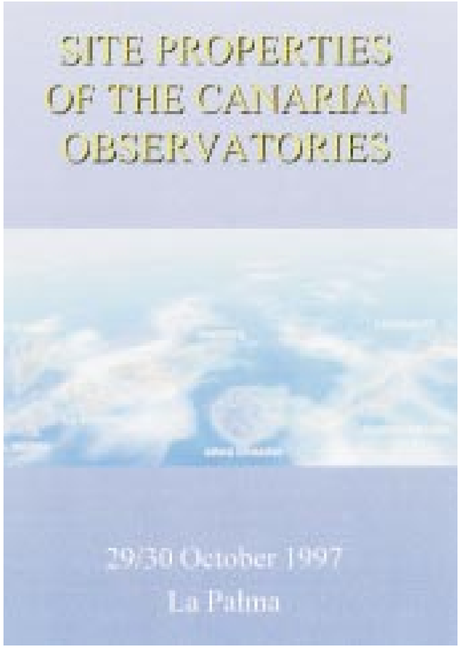
A total of nine ING press releases covering scientific highlights achieved with our telescopes and other astronomical events were sent out. A series of full-page articles describing research carried out at ING for the general public was published in the local newspapers.

As we were well aware that the arrival of the comet Hale-Bopp was going to be the event of the year, ING organised a series of activities orientated towards the public in general. Of particular interest were the CCD images obtained from the CoCAM camera that were offered daily on the Internet.

On 29-30 October 1997 the "Site Properties of the Canarian Observatories" workshop took place in Los Cancajos, near Santa Cruz de La Palma. This collaborative effort between the Instituto de Astrofísica de Canarias, the ING, and the Nordic Optical Telescope, under the auspices of the Site Characterisation Sub-committee to the CCI, proved to be a success. There was a total of 70 registered delegates at the workshop, and a wide variety of topics was covered, including many results from ING. The proceedings were published in *New Astronomy Reviews*, **42**, 395.



Over 1000 people visited the observatory on each open day, being able to visit both the William Herschel and the Isaac Newton telescopes, guided by ING staff. For this activity we also received collaboration from the amateur astronomers of La Palma.



A workshop on "Site Properties of the Canarian Observatories" was held at La Palma on 29-30 October. A press conference took place during the workshop to supply information to journalists.

His Royal Highness Crown Prins Willem Alexander (on the left) during the First Light Celebration of the Dutch Open Telescope.

Appendix A

The Isaac Newton Group of Telescopes

THE ISAAC NEWTON GROUP OF TELESCOPES (ING) CONSISTS OF THE WILLIAM HERSCHEL Telescope (WHT), the Isaac Newton Telescope (INT) and the Jacobus Kapteyn Telescope (JKT). The three telescopes have complementary roles. The WHT, with its 4.2m diameter primary mirror, is the largest 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 in 1979 and rebuilt with a new mirror and new instrumentation. It has a 2.5m diameter primary mirror and is mostly used for wide-field imaging and spectroscopy. The JKT has a primary mirror of 1m diameter. It is mainly used for observing relatively bright objects. Both INT and JKT were first operational in May 1984.

The ING is located at the Observatorio del Roque de Los Muchachos (ORM), on the island of La Palma. The observatory also includes the Carlsberg Meridian Circle, the 3.6m Italian Galileo National Telescope, the 2.5m Nordic Optical Telescope, the 60cm telescope of the Swedish Royal Academy of Sciences, the 50cm Swedish Solar Telescope, the 45cm Dutch Open Solar Telescope, and the German High Energy Gamma-Ray Array (HEGRA).

The Isaac Newton Group is operated on behalf of the British Particle Physics and Astronomy Research Council (PPARC) and the Nederlandse Organisatie voor Wetenschappelijk Onderzoek (NWO).

The observatory occupies an area of 1.89 square kilometres approximately 2350m above sea level on the highest peak of the Caldera de Taburiente National Park, in the Palmeran district of Garafía. La Palma is one of the westerly islands of the Canary Archipiélago and the Canary Islands are an autonomous region of Spain.

The site was chosen after an extensive search for a location with clear, dark skies all the year around. All tests proved that the Roque de Los Muchachos 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 air-flow 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 following table shows each telescope's location:

	Latitude	Longitude	Ground Floor Height
WHT	28° 45′ 38.3″ N	17° 52′ 53.9″ W	2332 m
INT	28° 45′ 43.4″ N	17° 52′ 39.5″ W	2336 m
JKT	28° 45′ 40.1″ N	17° 52′ 41.2″ W	2364 m

The Roque de Los Muchachos Observatory, which is the principal European northern hemisphere observatory, is operated on behalf of Spain by 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 (CCI). Financial and operational matters of common interest are dealt with by appropriate subcommittees.

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 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 between institutions of the CCI member countries.

Many of the state-of-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 (RGO), originally responsible for the creation of the ING.

THE INTERNATIONAL AGREEMENTS

The international agreements by which the Roque de Los Muchachos and Teide Observatories were brought into existence were signed on La Palma on 26 May 1979 (B.O.E., **161**, 6 July 1979). The participant nations at that time were Spain, The United Kingdom, Sweden and Denmark. Other European countries later also signed the agreements. Infrastructural services including roads, communications, power supplies and meals and accommodation facilities have been provided by the Spanish side. In return for the use of the observatory and its facilities all foreign user institutions make 20 per cent of time on their telescopes available to Spanish observers. Representatives of the participant institutions meet together as the International Scientific Committee, or Comité Científico Internacional (CCI).

The inauguration of the Canary Islands observatories took place on 29 June 1985 in the presence of the monarchs and members of the Royal Families of five European countries, and the Presidents of another two.

THE PPARC-NWO JOINT STEERING COMMITTEE

The PPARC and the NWO have entered into collaborative agreements for the operation of and the sharing of observing time on the ING telescopes. The Joint Steering Committee (JSC) has been set up to oversee the operation of this agreement, to foster and develop collaboration between astronomers of the UK and the Netherlands and to ensure that the telescope installations are maintained in the forefront of world astronomy. In particular, the JSC oversees the construction programme of the telescopes and instrumentation, determines the programme of operation, maintenance and development of the installations, approves annual budgets and forward estimates and determines the arrangements for the allocation of observing time.

TELESCOPE TIME AND DATA OWNERSHIP

Spain has at its disposal 20 per cent of the observing time on each of the three telescopes. It is the responsibility of the IAC to make this time available to Spanish institutions and others, via the Comité para la Asignación de Tiempos (CAT).

A further 5 per cent of the observing time is for international collaborative programmes between institutions of the CCI member countries. It is intended that this time be used for the study of one, or a few, broad topics each year by several telescopes. This time is allocated by the CCI.

The remaining 75 per cent of the time is distributed as follows. The PPARC and NWO share the time on all three telescopes in the proportions 80 per cent PPARC : 20 per cent NWO. The PPARC-NWO Joint Steering Committee has delegated the task of time allocation to astronomers to the PPARC Panel for the Allocation of Telescope Time (PATT), which has set up procedures for achieving the 80 : 20 ratio whilst respecting the separate priorities of the UK and Dutch communities. The PPARC has made 27 nights per year of its share on the JKT available to the National Board of Science and Technology of Ireland (NBST) and the Dublin Institute for Advanced Studies (DIAS). The Irish Advisory Committee for La Palma set up by the two Irish Institutions has decided that JKT proposals by Irish Astronomers should also be submitted to PATT. Irish astronomers are not however discouraged from applying for use of the other telescopes of the ING. PATT includes representatives from the Netherlands and the Republic of Ireland.

All the above agreements envisage that observing time shall be distributed equitably over the different seasons of the year and phases of the Moon.

Notwithstanding the above, any astronomer, irrespective of nationality or affiliation, may apply for observing time on the ING. Astronomers who are working at an institute in one of the partner countries should apply through the route appropriate to their nationality or the nationality of their institute.

PATT allocates time on all PPARC supported telescopes in two semesters, from 1 February to 31 July (semester A) and from 1 August to 31 January (semester B). The corresponding closing dates are the end of September and March respectively. Decisions on time allocations are made on the basis of scientific merit and technical feasibility of the proposed observations.

The PPARC-NWO JSC and the CCI have decided that ING policy is that data belongs exclusively to those who collected it for a period of one year, after which it is available in a common archive for all astronomers. It may be used at any time for engineering or instrumental investigations in approved programmes carried out to improve facilities provided at the observatory.

Service observations which are made by support astronomers at the request of others are similarly treated. However, calibration data may well be used for more than one observation and may therefore be available in common several groups. It may happen that identical or similar service observations are requested by two or more groups. Requests which are approved before the data are taken may be satisfied by requiring the data to be held in common by the several groups. It is up to them how they organise themselves to process it, analyse it, relate it to other work, and eventually publish it.

Requests for observations from programmes already executed on the telescopes should be referred to the original owners of the data, and/or to the data archive. This is the policy whether or not the data were obtained by PATT or CAT scheduled astronomers, or by service requests.

Appendix B

Telescope Instrumentation

THE INT AND JKT ARE EQUIPPED WITH A RESTRICTED SET OF INSTRUMENTS THAT MATCH the capabilities of the telescopes whilst satisfying the requirements of a large fraction of users. The number of instrument changes on these telescopes is kept to a minimum to reduce costs and increase reliability. The design of the WHT allows much greater flexibility, since it is straightforward to switch between the Cassegrain and the two Nasmyth focal stations, and a much greater variety of instruments may be left on the telescope. A broad functional division between the WHT, INT and JKT is as follows:

WHT	Spectroscopy and spectropolarimetry over a wide range of resolving powers
	Multi-object spectroscopy
	CCD imaging (faint objects, high spatial resolution)
	Infrared imaging
	High-resolution imaging and other projects in a laboratory environment
	Fabry-Perot imaging spectroscopy
INT	Intermediate- and low-dispersion spectroscopy
	CCD imaging
JKT	Spectroscopy of bright stars
	CCD imaging

The following table summarises the common-user instruments which were available during 1997.

Focus	Instrument	Detector
WHT		
Cassegrain	ISIS double spectrograph	Tektronix and EEV CCDs
	Faint Object Spectrograph (FOS-2)	Coated GEC CCD
	TAURUS-2 (imaging Fabry-Perot)	Tektronix and EEV CCDs
	Low Dispersion Survey Spectrograph (LDSS-2)	Tektronix and EEV CCDs
	CCD imaging (Acquisition and Guidance Unit Auxiliary Port)	Tektronix and EEV CCDs
	TAURUS CCD imaging (f/2 or f/4)	Tektronix and EEV CCDs
Nasmyth	Ground Based High Resolution Imaging Laboratory (GHRIL)	Tektronix and EEV CCDs
	William Herschel Infrared Camera (WHIRCAM)	InSb array
	Utrecht Echelle Spectrograph (UES)	Tektronix and EEV CCDs
Prime	CCD imaging	Tektronix and EEV CCDs
	Autofib Fibre Positioner (AUTOFIB-2)	Tektronix CCD (WYFFOS at GHRIL)
INT		
Cassegrain	Intermediate Dispersion Spectrograph (IDS)	Tektronix and EEV CCDs
	Faint Object Spectrograph (FOS-1)	Coated GEC CCD
Prime	CCD imaging	Tektronix and EEV CCDs
JKT		
Cassegrain	Richardson-Brealey Spectrograph (RBS)	Tektronix and EEV CCDs
	CCD imaging	Tektronix and EEV CCDs

Appendix C

Staff Organisation

THE YEAR 1997 SAW CONSIDERABLE TURNOVER IN THE STAFFING AT ING. PERHAPS THE most notable event in this respect was the departure of Dr Steve Unger who had come to La Palma in 1992, initially as Head of Astronomy, before being appointed as ING's Director. Following Dr Unger's departure on 1 November 1997, Dr R G M Rutten took over initially as Acting Director before his appointment was made substantive. As stated in the previous ING Annual Report, the post of Head of Engineering had been vacant since an unsuccessful exercise to fill it in 1994. However, during 1997 it was decided to re-run this exercise, which this time bore fruit, although the successful candidate would not take up the post until the beginning of 1998.

For 1997, the telescope manager of the WHT was Dr C R Benn and of the INT, Dr N A Walton. Mr P J Rudd, who had been telescope manager of the JKT for several years left ING during August 1997 and was succeeded by Dr J H Telting.

The total UK approved annual staff effort for La Palma operations for financial year 1997/98 was 36.6. This comprised 29.6 staff on-island and 7 staff at the RGO in Cambridge. Actual effort on-island was 1 staff year short of this target and was compensated for by a cash payment. The total approved staff effort for the Netherlands was 7.4 on-island and 1 in Cambridge.

Astronomical support for the ING provided by the RGO is the responsibility of the La Palma Support Group of the RGO's Astronomy Division. The Support Group, headed by Dr W Martin, supplements the work of the ING Astronomy Group.

The list of staff in post on La Palma during the calendar year 1997 is set out below.

MANAGEMENT

S W Unger, *Director* (to 31/10/97)
R G M Rutten, *Director* (from 1/11/97)
R L Miles, *Bilingual Secretary*

ADMINISTRATION

M Acosta
E Arzola (to 5/5/97)

E C Barreto
L I Edwins
A Felipe (from 11/12/97)
C J Felipe (to 17/2/97)
D Griffiths (from 1/9/97)
S S Hunter
M Lorenzo
J Martínez
E McCann (to 31/8/97)
N Pirotte

ASTRONOMY

M W Asif
M Azzaro
C R Benn
M Broxterman
J N González
C Martín
J Méndez
C Moreno
N O'Mahony
C Packham (from 1/3/97)
D L Pollacco
J C Rey
P J Rudd (to 31/8/97)
R G M Rutten (to 31/10/97)
S J Smartt (from 14/1/97)
P M Sorensen
D Sprayberry (to 20/11/97)
J H Telting
N A Walton

COMPUTING

Software

J M Burch (to 3/8/97)
S M Crosby
R J Edwards (to 21/11/97)
P M Fishwick
F J Gribbin
P C T Rees
S G Rees (from 15/9/97)

Computing Facilities

V Borraz
B M Hassan (to 17/10/97)
G F Mitchell
A G Povoas (to 2/12/97)
P G Symonds
P van de Velde

ELECTRONICS

S Barker (to 21/7/97)
C Benneker
S J Crump
T Gregory (from 14/7/97)
A Guillén
C W M Jackman
K W Kolle
R Martínez
E J Mills
P C Moore
R J Pit
A W Ridings
G Woodhouse (from 1/4/97)

MECHANICAL ENGINEERING

F Concepción
K M Dee
C Hankinson (to 1/12/97)
P S Morrall
S Rodríguez
J C Pérez
B van Venrooy

SITE SERVICES

C Alvarez
A K Chopping
J R Concepción
N Dean (to 25/4/97)
J M Díaz
D Gray
M V Hernández
A C Osborne
C Ramón
C Riverol
M A Simpson

Appendix D

Telescope Time Awards

THE PANEL FOR THE ALLOCATION OF TELESCOPE TIME (PATT) AND THE COMITÉ PARA LA Asignación de Tiempos (CAT) made time awards to the following ING proposals. Only the PATT or CAT reference, the principal applicant, his or her institute, and the title of the proposal are given in each case. Semester A is from February to July and semester B is from August to January.

BRITISH SUCCESSFUL PROPOSALS - SEMESTER 97A

William Herschel Telescope

W/97A/10	*Allington*	DURHAM	The environmental dependence of galaxy evolution
W/97A/11	*Mason*	MSSL	The origin of optical emission lines in narrow-line Seyfert 1 galaxies
W/97A/12	*Glazebrook*	AAO	The Hubble Deep Field - star-formation at z > 1 via the TAURUS Tunable Filter
W/97A/16	*Maxted*	SOUTHAMPTON	The remarkably useful eclipsing binary star CM Dra - determining the metallicity
W/97A/21	*Schild*	ZURICH	Scattering processes in symbiotic and CP binary systems
W/97A/24	*Edge*	IOA	Redshifts of giant arcs from a survey of luminous X-ray clusters
W/97A/30	*Merrifield*	SOUTHAMPTON	Mapping the stellar kinematics and gravitational potential of M87's halo
W/97A/31	*Merrifield*	SOUTHAMPTON	Dark halos and planetary nebula kinematics in S0 Galaxies
W/97A/33	*Dhillon*	RGO	An infrared-adaptive-optics search for cataclysmic variables in globular clusters
W/97A/35	*O'Brien*	LEICESTER	Evolution of the Broad Line Region ***Long Term***

W/97A/42	*Harlaftis*	St. Andrews	X-ray nova outbursts with WHT/XTE/HST ***Overriding and Long Term***
W/97A/48	*Still*	St. Andrews	Spectropolarimetry and Zeeman emission mapping of magnetic cataclysmic variables
W/97A/49	*Hanlon*	Dublin	IR observations of well localised Gamma-Ray Bursts
W/97A/50	*Tenorio-Tagle*	IoA	Kinematics of HII galaxies
W/97A/55	*Oudmaijer*	IC	A model atmosphere analysis of the Young Stellar Object MWC 297
W/97A/56	*Marcha*	Lisbon	Spectropolarimetry of newly discovered flat spectrum radio galaxies
W/97A/59	*Young*	Hatfield	Optical spectropolarimetry of type 1 Seyferts
W/97A/69	*Welsh*	Keele	Spectroscopy of Dwarf Nova Oscillations
W/97A/71	*Davies*	Durham	Galaxy Scaling Relations in clusters at intermediate redshift
W/97A/72	*Robinson*	Hatfield	Probing the structure of the BLR of radio-loud AGN
W/97A/74	*Dunlop*	Edinburgh	Optical spectroscopy of potential evolved elliptical galaxies in the highest redshift cluster
W/97A/76	*Serjeant*	IC	Narrow band imaging and spectroscopy of $0.75 < z < 0.85$ steep-spectrum radio-quasars and radio-galaxies
W/97A/79	*Baldwin*	MRAO	Combined synthesis imaging of cool stars with the WHT and COAST
W/97A/80	*Clark*	Sheffield	Kinematic imaging and ionisation structure of shocks in radio galaxies
W/97A/81	*Peacock*	ROE	Optical spectroscopy of distant blue mJy radio galaxies
W/97A/86	*McMahon*	IoA	Large spectroscopic survey for QSOs with $z > 5$
W/97A/87	*Ellis*	IoA	A UV-Selected Galaxy Redshift Survey: star formation history of galaxies
W/97A/88	*Tanvir*	IoA	PNLF distance to NGC4258: an acid test of the extragalactic distance scale
W/97A/89	*Charles*	Oxford	X1905+000: an ultra-short period X-ray binary
W/97A/10	*Dhillon*	RGO	Demystifying the SW Sex stars: optical spectroscopy of SW Sex and DW UMa

Isaac Newton Telescope

I/97A/2	*Bowen*	ROE	Identifying galaxies responsible for QSO absorption line systems
I/97A/3	*Pollacco*	ING	Sakurai's object: real-time evolution in a stellar thermal pulse
I/97A/7	*Marsh*	Southampton	The ages of cataclysmic variable stars
I/97A/11	*Irwin*	RGO	Imaging of Dwarf Galaxy candidates
I/97A/12	*Watson*	Leicester	Spectroscopy of the EUV transient, RE J1255+266
I/97A/14	*Cameron*	St. Andrews	Eclipse mapping and TiO band ratios as probes for polar star spots

I/97A/16	*Byrne*	Armagh	Tomography in a range of K and M dwarf stars and RS, CVn binaries
I/97A/18	*Jackson*	NRAL	Quasar NLR geometry from profiles of narrow lines
I/97A/19	*Hewett*	IoA	Quasars surrounding the Hubble Deep Field
I/97A/20	*Pollacco*	RGO	The period distribution of binary central stars of planetary nebula
I/97A/21	*Fitzsimmons*	QUB	The solar system beyond 50 AU
I/97A/23	*Irwin*	RGO	Faint high latitude carbon stars in the Galactic Halo
I/97A/24	*Jeffries*	Keele	The dependence of magnetic activity, rotation and lithium depletion on metallicity
I/97A/28	*Roche*	Sussex	Indirect mapping of the warped, precessing accretion disc about Hercules X-1
I/97A/31	*Eales*	Cardiff	A survey of activity in nearby radio galaxies
I/97A/33	*Johnstone*	IoA	Dust in the core of Abell 2199
I/97A/37	*Naylor*	Keele	Are hot sources efficient at irradiating Late Type Stars in close binaries?
I/97A/40	*Jeffery*	Armagh	What is the binary frequency among hot subdwarfs?
I/97A/46	*Lucey*	Durham	Accurate calibration of the Dn-sigma/Fundamental Plane zero-point
I/97A/51	*Williams*	IoA	Sub-critical gravitational lensing as a probe of high redshift galaxies
I/97A/52	*Tanvir*	IoA	Intergalactic PNe in the Virgo Cluster.
I/97A/53	*Eales*	Cardiff	The ultimate search for low-surface brightness galaxies and other projects

Jacobus Kapteyn Telescope

J/97A/1	*Maxted*	Southampton	The remarkably useful eclipsing binary star CM Dra - a modern light curve
J/97A/2	*Mathioudakis*	QUB	Resonant scattering in active regions
J/97A/3	*Schlegel*	Durham	Full-sky peculiar velocity mapping of IRAS galaxies
J/97A/4	*Scarrott*	Durham	The origin of optical polarisation in spiral galaxies - scattering or magnetic dichroism
J/97A/6	*Smith*	Cork	Rapid optical variability in radioquiet quasars with flat radio spectra
J/97A/7	*Shearer*	Galway	Stellar population of the inner regions of selected globular clusters
J/97A/8	*Crawford*	IoA	Optical monitoring of variability in narrow-line Seyfert 1 galaxies
J/97A/9	*Barstow*	Leicester	Observing stellar structure and evolution through a new class of pulsating subdwarfs
J/97A/10	*Fitzsimmons*	QUB	Dust and plasma in comet Hale-Bopp at perihelion ***Overriding***
J/97A/12	*Hodgkin*	Leicester	Defining and calibrating a cool star colour-temperature relation for CCDs

J/97A/13	*de Jong*	Durham	The radial distribution of star formation history and the morphology evolution in spiral galaxies
J/97A/18	*Bell*	RGO	Time resolved narrow-band photometry of planetary nebula central stars

SPANISH SUCCESSFUL PROPOSALS - SEMESTER 97A

William Herschel Telescope

CAT W4	*Manchado*	IAC	Planetary nebulae, luminosity function
CAT W5	*Oscoz*	IAC	Hubble constant from QSO 0957+561
CAT W6	*Piotto*	Padova	Distances with Cepheids
CAT W7	*Martínez*	IFCA	Protogalaxies in galaxy clusters
CAT W8	*Centurión*	IAC	Lyman alpha systems at high redshift ***Backup***
CAT W12	*Gutiérrez*	IAC	Galaxies near quasars
CAT W14	*Villar*	Sheffield	Models of unification
CAT W19	*Mas-Hesse*	Madrid	Mixing in starburst galaxies
CAT W22	*Mediavilla*	IAC	2D atlas of NGC4151 spectrum
CAT W25	*Battaner*	Granada	Properties of discs in spirals
CAT W26	*Arribas*	IAC	Nuclei of galaxies ***Backup***
CAT W38	*Méndez*	Munich	Planetary nebulae and the Virgo cluster
CAT W40	*Corradi*	IAC	Dynamics of symbiotics
CAT W41	*Manchado*	IAC	Light echoes of supernovae
CAT W45	*García*	IAC	Abundances of metal-poor stars
CAT W47	*G-Lario*	Leiden	Lithium abundances in O-rich AGB stars
CAT W51	*Martín*	IAC	Low mass visual binary systems

Isaac Newton Telescope

CAT I2	*R-Lapuente*	Barcelona	Supernovae at high redshift
CAT I11	*Zamorano*	Madrid	Mass function of galaxies
CAT I14	*Martínez*	IAC	Stellar formation in spheroidals
CAT I21	*Vassiliadis*	IAC	Planetary nebulae, mass loss
CAT I22	*Rosenberg*	IAC/Padua	Globular clusters CM diagrams
CAT I28	*G-López*	IAC	K and M stars for ROSAT
CAT I29	*Díaz*	Madrid	Stellar population synthesis
CAT I30	*de Winter*	Madrid	Monitoring Herbig stars

Jacobus Kapteyn Telescope

CAT J1	*G-Serrano*	Cantabria	UBVR of emission quasars

CAT J2	*Iglesias*	IAC	Compact groups of galaxies
CAT J3	*Campos*	IMAFF	Radial distribution of spiral galaxies
CAT J5	*Cepa*	IAC	Star formation in spiral discs
CAT J6	*Rosenberg*	IAC/Padua	CM diagrams of globular clusters
CAT J7	*Peletier*	Kapteyn	Calibration of CaII triplet
CAT J8	*Zapatero*	IAC	Photometry of metal-poor stars

DUTCH SUCCESSFUL PROPOSALS - SEMESTER 97A

William Herschel Telescope

W/97A/N1	*Best*	Leiden	Nature and evolution of radio galaxies at redshift one
W/97A/N2	*Bremer*	Leiden	Cluster environment of distant 3C quasars
W/97A/N5	*Schoenmakers*	Utrecht	Spectroscopy of a sample of high redshift Giant Radio Galaxies
W/97A/N6	*Peletier*	Groningen	Test the formation of galactic bulges
W/97A/N7	*Kuijken*	Groningen	Weak lensing from poor clusters
W/97A/N10	*Snellen*	Leiden	GPS galaxies as cosmological probes
W/97A/N11	*Barthel*	Groningen	Evolution of X-ray selected BL Lac objects
W/97A/N13	*Miley*	Leiden	Deep imaging of 1243+036 at z=3.6
W/97A/N15	*v Woerden*	Groningen	Distances and metallicity of HVC complex C

Isaac Newton Telescope

I/97A/N1	*Ehrenfreund*	Leiden	Diffuse interstellar Bands: Band correlations and DIB families
I/97A/N2	*Sprayberry*	ING	Stellar populations in Very Low Surface brightness galaxies
I/97A/N3	*Miley*	Leiden	An adaptive optics sample of quasars
I/97A/N4	*Briggs*	Groningen	CERES spectroscopy of CLASS high redshift radio quasars
I/97A/N6	*Schrijvers*	SIAP	Non-radial pulsations in early-type stars
I/97A/N7	*Zwaan*	Groningen	Optical imaging of an HI selected galaxy sample - part 4

Jacobus Kapteyn Telescope

J/97A/N1	*v Paradijs*	AIAP	Comparative study of disk and halo CVs
J/97A/N2	*Schoenmakers*	Utrecht	R-band imaging of a sample of high redshift Giant Radio candidates
J/97A/N4	*de Jong*	SIAP	The rotation of O stars
J/97A/N6	*Zwaan*	Kapteyn	Colours of HI selected galaxies

BRITISH SUCCESSFUL PROPOSALS - SEMESTER 97B

William Herschel Telescope

W/97B/2	*Ryan*	RGO	Galactic evolution of lithium
W/97B/3	*Naylor*	Keele	J0422+32 — the heaviest black hole of them all
W/97B/4	*Keenan*	QUB	Structure of the high velocity interstellar cloud towards the globular cluster M15
W/97B/13	*Bailey*	AAO	Spectro-astrometry of pre-main sequence stars
W/97B/14	*Harries*	St. Andrews	The wind geometry of dust-producing binary WR137
W/97B/15	*Dhillon*	RGO	A search for nova shells around cataclysmic variables
W/97B/18	*Kuntschner*	Durham	Do luminous ellipticals have young disks?
W/97B/22	*Wilson*	RGO	High resolution imaging polarimetry of alpha Ori and mu Cep
W/97B/28	*Marsh*	Southampton	Supersonic line broadening in accretion discs
W/97B/31	*Mobasher*	IC	Near-infrared luminosity function of field galaxies
W/97B/33	*Serjeant*	IC	Associated absorbers in a complete sample of z > 2 steep-spectrum radioquasars
W/97B/37	*Green*	Kent	Kuiper Belt Colour Survey
W/97B/40	*Sarre*	Nottingham	High-resolution spectroscopy of silicon-carbon molecules in cool dusty carbon stars
W/97B/41	*Storey*	UCL	Resolving the nebular abundances conflict deep optical spectroscopy of planetary nebulae
W/97B/44	*Tadhunter*	Sheffield	Starbursts and the origin of the activity in powerful radio galaxies
W/97B/49	*Hodgkin*	Leicester	Spectroscopy of the lowest mass brown dwarf candidate in the Pleiades
W/97B/50	*Charles*	Oxford	Nucleosynthesis of light elements around compact objects: Cyg X-2
W/97B/51	*Jeffery*	Armagh	Radial velocities of pulsating sdB stars
W/97B/52	*Olling*	Southampton	The mass-to-light ratio of stellar disks from HI and stellar kinematics
W/97B/56	*Tadhunter*	Sheffield	Deep OIII imaging of high-z radio galaxies: understanding the nature of the alignment effect
W/97B/60	*Ellis*	IoA	Gravitational convergence: absolute masses for distant clusters
W/97B/61	*Hughes*	RGO	IR Photometry of M31 Miras
W/97B/63	*Terlevich*	RGO	Spectroscopic search of variability in low-luminosity AGN
W/97B/64	*Fender*	Sussex	Simultaneous infrared: radio observations of the microquasar GRS 1915+105 ***Overriding***
W/97B/65	*Smartt*	ING	Quantitative spectroscopy of luminous blue supergiants in M31
W/97B/66	*Smartt*	ING	A survey of massive, luminous supergiants in M31

W/97B/71	*Wilkinson*	NRAL	Redshifts of a complete 25-50mJy flat-spectrum radio sample
W/97B/74	*Terlevich*	IoA	Spectrophotometric studies of high redshift HII galaxies
W/97B/75	*Veilleux*	Maryland	A Deep Multi-Line Imaging Survey of Edge-On Spiral Galaxies
W/97B/77	*Marsh*	Southampton	A search for binaries amongst low mass white dwarfs
W/97B/81	*Peacock*	ROE	The red envelope of galaxy evolution

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I/97B/2	*Naylor*	Keele	The mass of the white dwarf in the recurrent nova T CrB
I/97B/3	*Naylor*	Keele	J0422+32 — the heaviest black hole of them all
I/97B/4	*Naylor*	Keele	Is star formation in OB regions sequential?
I/97B/5	*Davies*	Cardiff	The colours of background galaxies around NGC 891
I/97B/6	*A-Salamanca*	IoA	Evolution of the Star Formation Rate density of the Universe
I/97B/11	*Alton*	Cardiff	The dust-to-gas ratio of the intergalactic gas in the M81 group
I/97B/13	*Davies*	Cardiff	Deep imaging of fields around the giant LSB galaxy Malin 1
I/97B/15	*A-Salamanca*	IoA	The Star Formation Rate density of the Universe at high redshift
I/97B/17	*Wood*	Keele	Are Hot Sources Efficient at Irradiating Late Type Stars in Close Binaries?
I/97B/18	*Crawford*	IoA	The stellar population of the haloes of central cluster galaxies
I/97B/23	*Irwin*	RGO	Confirmation spectroscopy of RBQS quasar candidates
I/97B/29	*Byrne*	Armagh	Tomography in a range of K and M dwarf stars and RS, CVn binaries
I/97B/30	*Jeffries*	Keele	Is there a Lithium abundance dispersion in the Pleiades?
I/97B/36	*Hodgkin*	Leicester	A CCD Survey of the Pleiades for Brown Dwarfs
I/97B/40	*Browne*	NRAL	An optically bright sample of flat spectrum radio sources for cosmology
I/97B/50	*Fitzsimmons*	QUB	The Solar System beyond 50 AU
I/97B/53	*Abraham*	RGO	Ultraviolet imaging of the cluster galaxy infall regime
I/97B/55	*Jackson*	NRAL	Quasar NLR geometry from profiles of narrow lines
I/97B/57	*Marsh*	Southampton	Determining the mass ratio of a detached double degenerate binary
I/97B/58	*O'Brien*	LJMU	The kinematics of mass ejection during nova outbursts ***Overriding and Long Term***

Jacobus Kapteyn Telescope

J/97B/1	*Keenan*	QUB	Four-colour photometry of stars from the Palomar-Green Survey

J/97B/3	*Reig*	SOUTHAMPTON	Emission from the circumstellar discs and neutron stars in HMXBs
J/97B/4	*Smalley*	KEELE	Convection in stellar atmospheres
J/97B/5	*Harper*	RGO	Astrometry of Saturn's satellites
J/97B/7	*Hewett*	IoA	Quasars at Redshifts z > 5
J/97B/9	*Wood*	KEELE	Are Hot Sources Efficient at Irradiating Late Type Stars in Close Binaries?
J/97B/10	*Edge*	IoA	Photometry of brightest cluster galaxies in a complete X-ray sample
J/97B/12	*Smith*	CORK	Rapid optical variability in radioquiet quasars with radio-loud properties
J/97B/13	*Roche*	SUSSEX	Optical identification of X-ray binaries in outburst ***Overriding***
J/97B/14	*Shanks*	DURHAM	Reddening towards Galactic Open Clusters Containing Cepheids
J/97B/15	*Burleigh*	LEICESTER	A photometric search for the faint optical counterparts of ROSAT EUV sources
J/97B/16	*de Jong*	DURHAM	The radial distribution of star formation history and the morphology evolution in spiral galaxies
J/97B/17	*Terlevich*	IoA	Improved determination of Luminosity - Linewidth relation for Giant Extragalactic HII Regions

SPANISH SUCCESSFUL PROPOSALS - SEMESTER 97B

William Herschel Telescope

CAT W1	*Campos*	MADRID	Herschel Deep Field galaxies
CAT W3	*Tijera*	BARCELONA	Normal galaxies at z > 2.5
CAT W8	*R-Lapuente*	BARCELONA	Supernovae at high redshift
CAT W9	*R-Lapuente*	BARCELONA	SNIa spectra
CAT W13	*Aretxaga*	GARCHING	Variability in low-luminosity AGNs
CAT W14	*P-Fournon*	IAC	Broad lines in LINERS
CAT W19	*Beckman*	IAC	Gaseous components in disc galaxies
CAT W20	*Rozas*	IAC	H alpha in spiral galaxies
CAT W22	*Vílchez*	IAC	HI in irregular galaxies
CAT W23	*Hidalgo*	IAC	Metallicity/luminosity for dwarf irregulars
CAT W25	*Trapero*	ANDALUCÍA	Gas in the Cygnus superbubble
CAT W28	*Abia*	GRANADA	Lithium in carbon stars
CAT W29	*Herrero*	IAC	Blue stars in M33
CAT W31	*Zapatero*	IAC	Brown dwarfs in the Pleiades

Isaac Newton Telescope

CAT I1	*Gaztanaga*	Barcelona	Gravitational lensing and faint galaxy clusters
CAT I3	*R-Lapuente*	Barcelona	Photometry of SNe at high z
CAT I4	*Vílchez*	IAC	Fate of matter in dwarf galaxies
CAT I5	*Gorgas*	UCM	Spiral galaxies velocity dispersion
CAT I6	*Díaz*	Madrid	Absorption lines for stellar population
CAT I7	*Peletier*	Durham	CaII triplet in M71
CAT I8	*Gutiérrez*	IAC	NGC 7331 and Stefan's quintet
CAT I9	*Deeg*	IAC	Search for young dwarf galaxies
CAT I12	*Casares*	IAC	Masses of X-ray binaries
CAT I14	*Sánchez*	Madrid	The protoplanetary OH231.8+4.2
CAT W31	*Zapatero*	IAC	Brown dwarfs in the Pleiades

Jacobus Kapteyn Telescope

CAT J1	*Kemp*	IAC	Colours of cD galaxy envelopes
CAT J2	*Iglesias*	IAC	Compact groups of galaxies
CAT J3	*Zamorano*	Madrid	Galaxy colours and stellar formation
CAT J4	*Fabregat*	Valencia	Photometry of young open clusters
CAT I5	*Gorgas*	UCM	Spiral galaxies velocity dispersion

DUTCH SUCCESSFUL PROPOSALS - SEMESTER 97B

William Herschel Telescope

W/97B/N3	*Jaffe*	Leiden	Extended H alpha emission from cooling flows
W/97B/N4	*v d Hulst*	Groningen	Density and ionisation structure of HII regions
W/97B/N5	*G-Lario*	Leiden	Lithium abundance and s-process elements enrichment in massive O-rich AGB stars
W/97B/N7	Galama	AIAP	Rapid imaging of GRB error boxes and spectroscopy of GRB-related optical transients ***Overriding***
W/97B/N8	*Lehnert*	Leiden	Clusters around z=1 AGN
W/97B/N9	*Lehnert*	Leiden	Clustering around the most distant quasars
W/97B/N11	*Kuijken*	Groningen	Weak lensing from poor clusters
W/97B/N14	*Prins*	SIAP	Spectroscopy of supernova remnant candidates in M31
W/97B/N16	*Koopmans*	Groningen	Shapes of spiral galaxy haloes and the Hubble parameter

Isaac Newton Telescope

I/97B/N1	*Katgert*	LEIDEN	Fundamental planes of ellipticals in 25 nearby, rich clusters
I/97B/N2	*Ehrenfreund*	LEIDEN	Environmental dependence of diffuse interstellar bands
I/97B/N3	*Beintema*	GRONINGEN	Accurate abundance determination of CNO in planetary nebulae
I/97B/N4	*Waters*	AIAP	Young Stellar Objects in transition
I/97B/N5	*Schrijvers*	AIAP	Non-radial pulsations in early type stars
I/97B/N6	*Sackett*	GRONINGEN	Mapping gravitational microlensing in M31's halo and bulge

Jacobus Kapteyn Telescope

J/97B/N1	*Zwaan*	GRONINGEN	Colours of HI selected galaxies
J/97B/N2	*Telting*	ING	Search for bow shocks around High-Mass X-ray binaries
J/97B/N3	*de Jong*	AIAP	The rotation periods of O stars

INTERNATIONAL TIME PROPOSALS FOR 1997

ITP1	*West*	ESO	Comet Hale-Bopp at perihelion
ITP2	*Corradi*	IAC	Distances to Planetary Nebula

Appendix E

ING Bibliography and Analysis

BELOW IS THE LIST OF RESEARCH PAPERS PUBLISHED IN 1997 THAT RESULTED FROM observations made at the telescopes of the Isaac Newton Group. Only papers appearing in refereed journals have been included, although many useful data have also appeared elsewhere, notably in workshop and conference proceedings. Papers marked (INT) or (JKT) at the end of the reference indicate those papers also include results from the INT or JKT.

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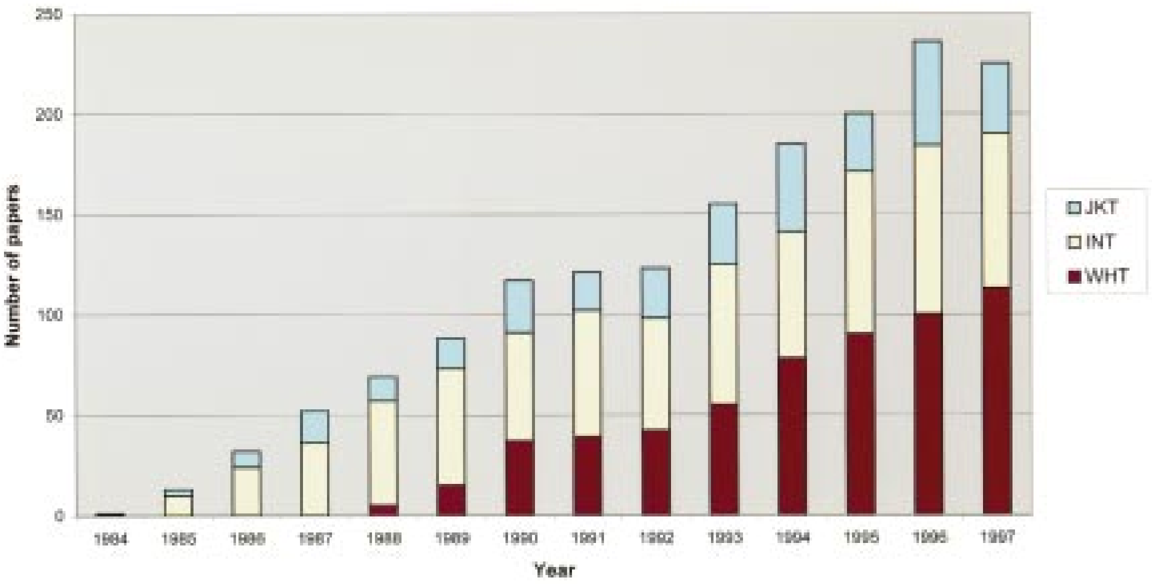
ANALYSIS

The above list contains 187 publications, some of which include results from more than one telescope. 113 papers contain results from the WHT, 77 contain results from the INT and 35 contain results from the JKT. The corresponding figures for 1996 were 100 from the WHT, 84 from the INT and 52 from the JKT. The combined publication rate is slightly less than in 1996, but by only 11 publications. The number of papers published from the WHT continues to increase and at 113, is the highest number to date. The contribution from the rest of the world authors has increased significantly as compared to the UK (only) contribution, which encourages us to believe that collaborative programmes are on the increase.

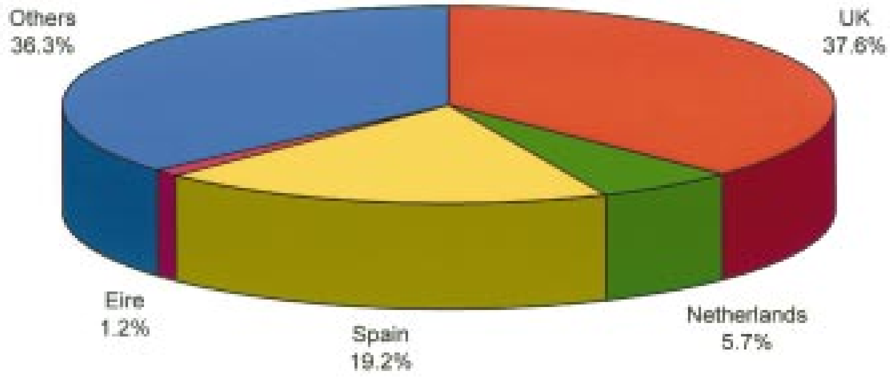
Number of publications 1984-1997

	WHT	INT	JKT	Total
1984	-	1	-	1
1985	-	10	3	13
1986	-	24	8	32
1987	-	36	16	52
1988	5	52	12	69
1989	15	58	15	88
1990	37	54	26	117
1991	39	63	19	121
1992	42	56	25	123
1993	55	70	30	155
1994	78	63	44	185
1995	90	81	29	200
1996	100	84	52	236
1997	113	77	35	225

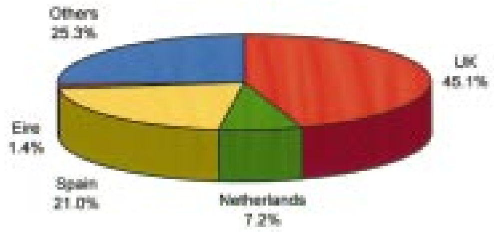
ING publications



Paper Authorship 1997



Paper Authorship 1984-1997



Appendix F

ING Staff Research Publications

THE FOLLOWING LIST INCLUDES RESEARCH PAPERS PUBLISHED BY ING STAFF IN REFEREED and unrefereed publications in 1997. It is organised by subjects and sorted in alphabetical order. ING authors appear in bold and italic.

SOLAR SYSTEM

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S J Smartt, W R J Rolleston, "The galactic oxygen abundance gradient", *Astrophys J*, **481**, L47.

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J van Paradijs, P J Groot, T Galama, C Kouveliotou, R G Strom, ***J H Telting***, ***R G M Rutten***, G J Fishman, C A Meegan, M Pettini, N Tanvir, J Bloom, H Pedersen, H U Nordgaard-Nielsen, Linden-Vornle, J Melnick, M Bremer, J In't Zand, E Costa, M Feroci, L Piro, F Frontera, G Zavattini, L Nicastro, E Palazzi, K Bennet, L Hanlon, A Parmar, “Transient optical emission from the error box of the gamma-ray burst of 28 February 1997”, *Nature*, **386**, 686.

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SITE CHARACTERIZATION

N O'Mahony, ***C Packham***, R Wilson, ***R G M Rutten***, "Optimisation of Seeing at ING Telescopes", Poster Paper, 23rd IAU General Assembly (Kyoto).

Appendix G

Financial Statement

ING OPERATIONS

Details of the allocations and expenditure for financial year 1996/97 for ING operations are set out below. The approved budgets for this financial year comprised £447.7k plus 343,000 kptas, a total of £2,222.2k at the exchange rate for the year of 193.2964 ptas/£. These figures included compensation for the shortfall in staff effort from the partner countries, receipts totalling 2,500 kptas for repayment work carried out on-island together with a carry-forward of £14.1k from the previous financial year. The main feature of expenditure during the year was an increase of operations expenditure by approximately £40k to compensate for an underspend on the enhancement programme. The additional expenditure on operations consisted of items brought forward from the following financial year, notably common services and capital equipment for mechanical engineering.

JOINT UK-NL ENHANCEMENT PROGRAMME

The table below shows the expenditure on the Joint UK/NL Enhancement Programme for 1996/97. At its May 1996 meeting, the Joint Steering Committee approved an overall allocation of £300k, which included a £20k shadow cut to fit within the reduced funding guideline specified at that meeting. Cost reductions and some slowing down of projects were required to meet this revised guideline. The scientific capabilities that were not achieved as a result included the provision of large area high quantum efficiency CCDs, faster readout of CCDs, the improved spatial and spectral resolution and sensitivity in FOS, the improved pointing performance of the INT, and a delay of some 6 months in providing a higher throughput image rotator for the UES.

ING Operations
Allocations and expenditure for financial year 1996/97

Budget centre	Allocation k£	Allocation Mptas	Allocation Total k£	Expenditure k£	Expenditure Mptas	Expenditure Total k£	Exp-Alloc k£
Local staff costs	2.0	164.0	850.4	2.2	165.6	858.9	8.5
UK/NL shared staff costs	6.1	2.0	16.4	5.5	2.1	16.4	0.0
Common services	0.0	8.2	42.4	0.0	11.8	61.0	18.6
Site services	1.0	31.1	161.9	0.2	31.7	164.2	2.3
Sea-level Base	0.0	26.9	139.2	8.7	28.2	154.6	15.4
Communications	3.0	22.4	118.9	4.4	23.1	123.9	5.0
Residencia costs	0.0	20.3	105.0	0.0	22.3	115.4	10.4
Transport fleet maintenance	0.0	11.0	56.9	1.7	8.7	46.7	-10.2
Transport fleet replacement	0.0	0.0	0.0	0.0	0.6	3.1	3.1
Safety	21.5	1.7	30.3	22.6	1.5	30.4	0.1
Site works	0.0	8.7	45.0	0.0	9.7	50.2	5.2
Electrical services	53.8	6.3	86.4	42.7	6.2	74.8	-11.6
Mechanical engineering	51.5	2.6	65.0	65.4	3.1	81.4	16.4
Electronics engineering	23.2	8.9	69.2	27.7	6.1	59.3	-9.9
Computing services	55.2	3.0	70.7	39.9	7.0	76.1	5.4
Astronomy support	26.0	3.0	41.5	16.8	3.6	35.4	-6.1
Library	31.0	0.2	32.0	11.3	5.8	41.3	9.3
UK/NL support	26.5	0.1	27.0	10.1	0.2	11.1	-15.9
Re-engineering programme	131.9	0.0	131.9	125.9	0.0	125.9	-6.0
Sea-level Base start-up	15.0	22.6	131.9	0.0	25.6	132.4	0.5
Total	**447.7**	**343.0**	**2,222.0**	**385.1**	**362.9**	**2,262.5**	**40.5**

Joint UK/NL Enhancement Programme
Allocations and expenditure for financial year 1996/97

Description	Allocation £k	Expenditure £k	Exp-Alloc £k
TELESCOPE ENHANCEMENTS			
WHT performance	30.0	22.0	-8.0
INT performance	15.0	9.0	-6.0
JKT performance	35.0	32.6	-2.4
Sub-total	80.0	63.6	-16.4
HALF-ARC SECOND PROGRAMME	30.0	16.9	-13.1
DETECTOR ENHANCEMENTS			
CCDs and cryostats	31.0	38.3	7.3
FOS upgrade	24.0	16.5	-7.5
CCD read-out modes	16.0	5.0	-11.0
Sub-total	71.0	59.8	-11.2
INSTRUMENT ENHANCEMENTS			
Optical components	22.0	28.5	6.5
ISIS enhancements	5.0	10.8	5.8
INTEGRAL	27.0	12.5	-14.5
WYFFOS enhancements	40.0	37.6	-2.4
UES derotator	14.0	12.4	-1.6
JKT tip-tilt study	5.0	5.9	0.9
Sub-total	113.0	107.7	-5.3
COMPUTER ENHANCEMENTS	22.0	12.9	-9.1
PROGRAMME MANAGEMENT	4.0	3.3	-0.7
SHADOW CUT	-20.0	0.0	20.0
Total	**300.0**	**264.2**	**-35.8**

Appendix H

Committee Membership

DURING 1997 THE MEMBERSHIP OF THE JOINT STEERING COMMITTEE AND ASSOCIATED bodies was as follows.

JOINT STEERING COMMITTEE

Professor M F Bode – **Chairman** (to 31.8.97)	*Liverpool John Moores University*
Professor C Frenk – **Chairman** (from 1.9.97)	*University of Durham*
Professor P C van der Kruit – **Vice Chairman** (to 31.8.97)	*University of Groningen*
Professor T de Zeeuw – **Vice Chairman** (from 1.9.97)	*University of Leiden*
Professor P A Charles	*University of Oxford*
Professor M Rowan-Robinson (from 1.9.97)	*University of London*
Dr W H W M Boland	*NWO*
Dr P G Murdin	*PPARC*
Dr C Vincent – **Secretary**	*PPARC*

INSTRUMENTATION WORKING GROUP

Professor P A Charles – **Chairman**	*University of Oxford*
Dr M Cropper	*University of London*

Dr R M Meyers	*University of Durham*
Mr M R Johnson	*RGO*
Dr R G M Rutten	*ING*
Dr C Jenkins – **Technical Secretary** (to 6.97)	*RGO*
Dr V S Dhillon – **Technical Secretary**	*RGO*

PATT ING TIME ALLOCATION GROUP

WHT TAG

Dr C N Tadhunter – **Chairman**	*University of Sheffield*
Dr A Aragón-Salamanca	*University of Cambridge*
Dr M Redfern	*University of Galway*
Dr H Henrichs	*University of Amsterdam*
Dr P B Byrne (to 31.8.97)	*Armagh Observatory*
Dr R D Jeffries (from 1.8.97)	*University of Keele*
Dr T Marsh	*University of Southampton*
Dr T Ponman	*University of Birmingham*

INT/JKT TAG

Dr J Davies – **Chairman** (to 31.8.97)	*University of Wales, Cardiff*
Dr E A Fitzsimmons – **Chairman** (from 1.9.97)	*Queen's University Belfast*
Dr C Crawford	*University of Cambridge*
Dr T Naylor	*University of Keele*

Note: Dr N Tanvir, *University of Cambridge* and Dr T Shanks, *University of Durham* were *ad hoc* members for the December 1997 meeting.

Appendix I

Addresses and Contacts

Isaac Newton Group of Telescopes (ING)

Apartado de correos 321
E-38780 Santa Cruz de La Palma
Canary Islands
SPAIN
E-mail: <username>@ing.iac.es
URL: http://www.ing.iac.es/
http://www.ast.cam.ac.uk/ING/ (UK mirror)

Sea-level Base:

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c/ Alvarez de Abreu, 68, piso 2
E-38700 Santa Cruz de La Palma
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Tel: +34 922 425400
Fax: +34 922 425401

Open from 08:30 to 17:00 Monday to Thursday and from 08:30 to 16:30 on Friday, closed for lunch from 13:00 to 14:00.

Mountain Top:

Reception is on the first floor of the INT building.

Open from 09:00 to 16:00 Monday to Thursday and from 09:00 to 15:30 on Friday, closed for lunch from 12:30 to 13:30.

Tel: +34 922 405655 (Reception)
559 (WHT control room)
640 (INT control room)
585 (JKT control room)
Fax: +34 922 405646 (Reception)

Director:

Dr René G M Rutten
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Fax: +34 922 425408
E-mail: rgmr@ing.iac.es, miles@ing.iac.es (*secretary*)

Particle Physics and Astronomy Research Council (PPARC)

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Stichting Astronomisch Onderzoek in Nederland
Netherlands Foundation for Research in Astronomy (ASTRON/NFRA)

P O Box 2
7990 AA Dwingeloo
THE NETHERLANDS
Tel: +31 (0)521 595 100
Fax: +31 (0)521 597 332
URL: http://www.nfra.nl/

Enquiries about the operation of the Roque de Los Muchachos Observatory can be made to:

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URL: http://www.iac.es/

IAC at Roque de los Muchachos Observatory:

Tel: +34 922 405500 (Residencia/Switchboard)
Fax: +34 922 405501
E-mail: adminorm@orm.iac.es

Enquiries about observing time on the ING telescopes allocated by the *Panel for the Allocation of Telescope Time* (PATT) should be made to the *Executive Secretary*, *PATT*, at the PPARC address given above.

Enquiries about the share of time at the disposal of Spain should be made to the *Comité para la Asignación de Tiempos* (CAT), at the IAC address given above.

Enquiries about the *International Time Scheme* should be made to the *Secretary*, *Comité Científico Internacional* (CCI), at the IAC address given above.

CONTACTS AT ING

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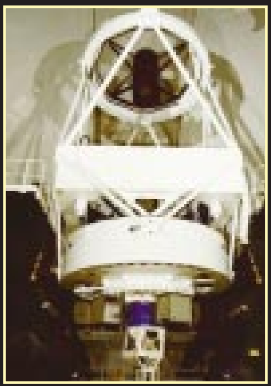
Appendix J

Acronyms and Abbreviations

Astron Astrophys	Astronomy and Astrophysics Journal
Astron Astrophys Suppl	Astronomy and Astrophysics Journal Supplement Series
Astron J	Astronomical Journal
Astrophys J	Astrophysical Journal
Astrophys J Suppl	Astrophysical Journal Supplement Series
Astrophys Space Science	Astrophysics and Space Science Journal
AU	Astronomical Unit (1.496×10^8 km)
Aux	Auxiliary Port at the WHT Cassegrain focus
Bull Am Astron Soc	Bulletin of the American Astronomical Society
Cass	Cassegrain focus
CAT	Comité para la Asignación de Tiempos (Spanish panel for the allocation of telescope time)
CCD	Charge-Coupled Device
CCI	Comité Científico Internacional (International Scientific Committee)
CIRSI	Cambridge Infra Red Survey Instrument
DAS	Data Acquisition System
DIAS	Dublin Institute for Advanced Studies
DIMM	Differential Image Motion Monitor
ELECTRA	Enhanced Light Efficiency Cophasing Telescope Resolution Actuator
Fib	AUTOFIB fibre positioner
FOS	Faint Object Spectrograph
FWHM	Full Width Half Maximum
GHRIL	Ground Based High Resolution Imaging Laboratory
HST	Hubble Space Telescope
IAC	Instituto de Astrofísica de Canarias
ICS	Instrument Control System

IDS	Intermediate Dispersion Spectrograph
ING	Isaac Newton Group
INGRID	ING Red Imaging Device
INT	Isaac Newton Telescope
INTEGRAL	Integral field fibre feed for WYFFOS
IR	Infrared
Irish Astron J	Irish Astronomical Journal
ISIS	ISIS double spectrograph
ITP	International Time Programme
JKT	Jacobus Kapteyn Telescope
JOSE	Joint Observatories Seeing Evaluation programme
JSC	Joint Steering Committee
LDSS	Low Dispersion Survey Spectrograph
LIRIS	Long-Slit Intermediate-Resolution Infrared Spectrograph
MARTINI	Multi-Aperture Real Time Image Normalisation Instrument
Mem Soc Astron Ital	Memorie della Società Astronomica Italiana
MNRAS	Monthly Notices of the Royal Astronomical Society
NAOMI	Natural guide star Adaptive Optics system for Multiple-Purpose Instrumentation
NBST	National Board of Science and Technology of Ireland
NWO	Nederlandse Organisatie voor Wetenschappelijk Onderzoek
ORM	Observatorio del Roque de Los Muchachos (Roque de los Muchachos Observatory)
PASA	Publications of the Astronomical Society of Australia
PASP	Publications of the Astronomical Society of the Pacific
PATT	Panel for the Allocation of Telescope Time
PF	Prime Focus
PFC	Prime Focus Camera
PP	People's Photometer
PPARC	Particle Physics and Astronomy Research Council
RBS	Richardson-Brealy Spectrograph
RGO	Royal Greenwich Observatory
TAG	Time Allocation Group
TAURUS	TAURUS Fabry-Perot spectrograph
TCS	Telescope Control System
UES	Utrecht Echelle Spectrograph
UKIRT	United Kingdom Infrared Telescope
WHIRCAM	William Herschel Infrared Camera
WFC	Wide Field Camera
WHT	William Herschel Telescope
WYFFOS	Wide Field Fibre Optics Spectrograph
ZAMS	Zero-Age Main Sequence



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