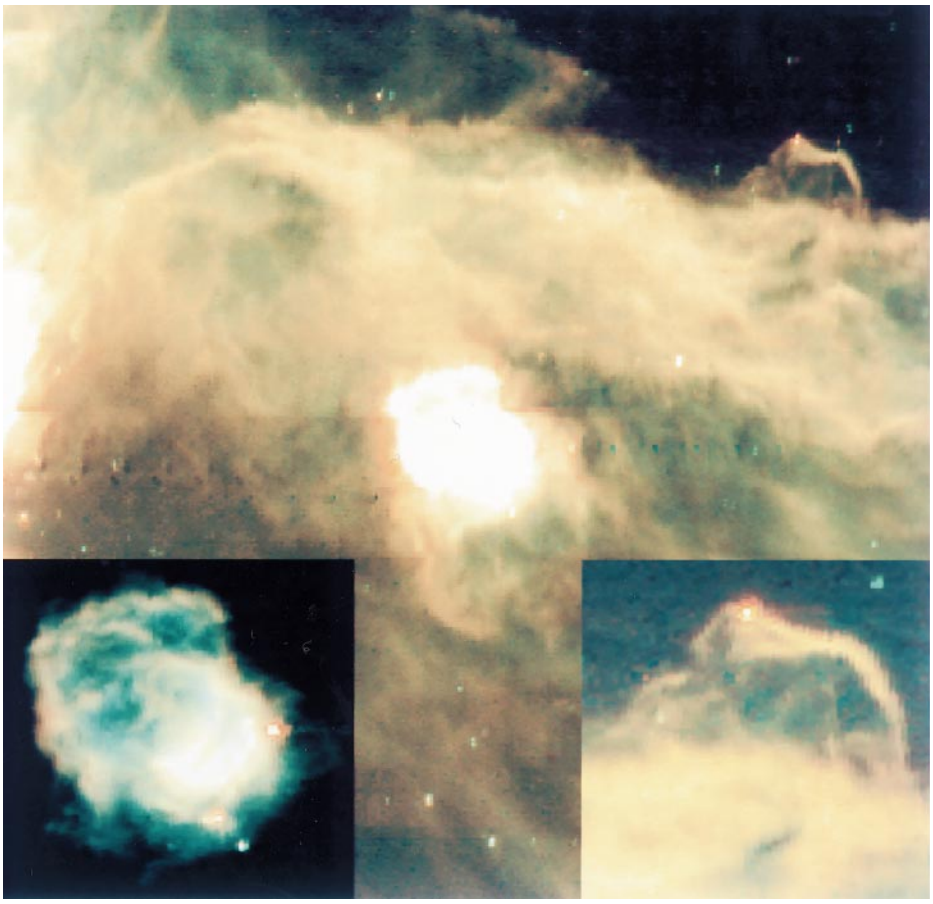
In Brief

New Discoveries Complete ISO's Observations

Water vapour detected on Saturn's largest moon, Titan, and infrared galaxies identified at immense distances are among the latest results from the European Space Agency's Infrared Space Observatory (ISO). At a press briefing in London on 7 April, ESA's Director of Scientific Programmes, Roger Bonnet, said "ISO is one of the most successful space observatories, and in the infrared it has had no rival."

On 8 April, ISO's operational teams at ESA's ground station at Villafranca, near Madrid, reported that ISO's observational phase had come to an end when the temperature of the instruments had risen above -269°C. They had been hurrying to provide the world's astronomers with as many observations as possible due to the long anticipated exhaustion of ISO's vital supply of liquid helium, which cooled the infrared telescope and its instruments to their operating temperatures close to absolute zero.



The famous Horsehead nebula region imaged by ISOCAM at wavelengths of 7 and 15 microns. Clearly visible in the insets are 3 bright reddish dots, which are recently-born stars

Thanks to superb engineering by European industry, which built the spacecraft and its super-cool telescope, ISO has given astronomers almost a year longer than the originally foreseen 18 month liftetime. During this extra time, the count of ISO's observations of cosmic objects has risen from 16 000 to about 26 000. Among the benefits of ISO's longevity has been the chance to examine an important region of the sky in and around the constellation of Orion. This was not accessible in the nominal mission but has now been observed in two periods.

Four international teams, supported by national funding agencies, supplied the instruments to analyse the infrared rays received by ISO's telescope. The Principal Investigators leading the teams are Dietrich Lemke (Heidelberg, Germany) for the versatile photometer ISOPHOT, Catherine Cesarsky (Saclay, France) for the camera ISOCAM, Thijs de Graauw (Groningen, The Netherlands) for the Short Wavelength Spectrometer (SWS), and Peter Clegg (London, UK) for the Long Wavelength Spectrometer (LWS).

Water vapour on Titan

A big difference between ISO and the only previous infrared astronomy satellite IRAS (1983) has been its ability to examine individual objects across a wide range of accurately defined infrared wavelengths. Many spectra showing patterns of intensities at the different wavelengths have enabled astronomers to deduce the presence of diverse materials in interstellar space, in the surroundings of stars and in other galaxies.

As previously reported, ISO has identified stony materials, tarry compounds of carbon and vapours, and ices like water and carbon monoxide. Together they give the first clear picture of how Mother Nature prepares, from elements manufactured in stars, the ingredients needed for planets and for life itself.

Particularly striking for the human imagination are ISO's repeated discoveries of water in the deserts of space. They encourage expectations of life elsewhere in the Universe. Water has turned up around dying stars, new-born stars, in the general interstellar medium, in the atmospheres of the outer planets and in other galaxies too. A link to the Earth's oceans and the water we live by comes in the water-ice long known to be a major ingredient of comets,

which are relics from the era of planet-building.

A further link to the investigation of the origin of life is the detection of water vapour in the mysterious atmosphere of Saturn's largest moon, Titan. A preliminary announcement comes from an international team headed by Athena Coustenis of Paris Observatory and Alberto Salama of the ISO Science Operations Centre at Villafranca.

The team used ISO's Short Wavelength Spectrometer during several hours of observations last December, when Titan was at its farthest from Saturn as seen by ISO. Emissions at wavelengths of 39 and 44 microns showed up, as an expected signature of water vapour. The news will excite the scientists involved in ESA's probe Huygens, launched last year aboard NASA's Cassini spacecraft. It will parachute into Titan's atmosphere to see what the chemistry of the Earth may have been like before life began.

"Water vapour makes Titan much richer," comments Athena Coustenis. "We knew there was carbon monoxide and carbon dioxide in Titan's atmosphere, so we expected water vapour too. Now that we believe we've found it, we can expect to better understand the organic chemistry taking place on Titan and also the sources of oxygen in the Saturnian System. After ISO, the Huygens probe will reveal the actual degree of complexity in a mixture of elaborate organic molecules closely resembling the chemical soup on the young Earth."

Colliding galaxies

Some galaxies are unusually bright in the infrared because of cosmic traffic accidents that bring them into collision with other galaxies. The result is a frenzy of star formation called a starburst. The explosion of short-lived stars then creates a pall of warm dust, which ISO observed in the infrared. The relative intensities of different wavelengths enable astronomers to distinguish starburst events from other sources of strong infrared rays, such as the environment of a black hole in the nucleus of a galaxy. Collisions and starbursts play an important part in the evolution of galaxies.

A famous pair of colliding galaxies called the Antennae was one of the first objects to be examined by ISO. Continuing study of the Antennae over the past two years has revealed a clear picture of a starburst occurring exactly where the dense discs of the galaxies intersect. The nuclei of the two galaxies are also plainly distinguished.

Centaurus A is a galaxy that first attracted the attention of astronomers by its strong radio emissions. In its visible appearance, a large round (elliptical) galaxy has a dark band across its face. This turns out to be the result of a galactic collision as well. The dark band is a flat, disc-shaped galaxy seen almost edge-on. Centaurus A is the nearest case of a phenomenon seen elsewhere by ISO in which a flat galaxy has merged with an elliptical galaxy while preserving its flat configuration.

ISOCAM gives an image of Centaurus A in which the disc galaxy is the more conspicuous object. The disc is oriented at right angles to the axis of the radio-emitting regions, which are powered by jets of electrons driven by a black hole in the centre of the galaxy. Excited emissions detected by ISO's Short Wavelength Spectrometer also indicate the presence of an active black hole.

"Centaurus A is an example of ISO's magic," says Catherine Cesarsky of CEA Saclay in France, leader of the ISOCAM instrument team. "It transforms opaque clouds seen by visible light into glowing scenes in the infrared. The same thing happens in dust clouds hiding new-born stars, and on a huge scale in dusty starburst galaxies, which become infrared beacons lighting our way deep into the Universe."

Distant galaxies seen through the holes in the sky

When ISO was launched, one of the hopes for the space observatory was that it would detect galaxies made luminous by starburst events, or by black-hole activity, very far away in space and, therefore, far back in time. Dust in our own Milky Way Galaxy usually obscures the remotest and faintest galaxies. But when they look northwards and southwards, at right-angles to the disc of the Milky Way, astronomers find holes in the dust clouds through which distant galaxies are discernible.

Both for ISO and the Hubble Space Telescope (HST) these holes have been special targets for observations with long exposures, to reveal faint galaxies. ISOCAM results through the northern hole, by a Japanese-led team, were reported last year. They revealed many infrared-luminous galaxies billions of light-years away, from an era corresponding with about half the present age of the Universe. Even more distant and earlier galaxies may be present in ISO's observations, including some objects not yet seen by visible light.

Results released at the London press briefing on ISO include 'deep field' examinations by groups of astronomers led by Catherine Cesarsky of CEA Saclay and Michael Rowan Robinson of Imperial College, London, analysing the northern and southern images, respectively. In the northern deep field, when ISOCAM observations are superimposed on an HST picture of the same region, they pick out spiral galaxies experiencing starbursts. A different signature comes from large elliptical galaxies whose visible light has been shifted into the infrared by the expansion of the Universe. The astronomers estimate that some of the objects seen by ISOCAM are so far away that the Universe was only one-third of its present age when they emitted the radiation seen today.

The first ISO images from the opposite direction in the sky, in the southern deep field, show similar objects, again at great distances. A preliminary analysis indicates the presence of 30-40 remote galaxies seen at a wavelength of 7 microns and 22-30 at 15 microns. One interesting source, bright in the infrared, is not seen by visible light even in a prolonged examination by the CTIO 4-metre telescope in Chile. Astronomers suspect that this object is undergoing an especially violent period of star formation. The interpretation can be checked when HST and other telescopes have had a chance to examine this scene.

Besides illuminating the evolution of the galaxies, ISO's deep field results are encouraging for scientists planning another of ESA's astronomical space projects, FIRST. Its longer wavelengths will penetrate even deeper into the unknown.

Non-stop discoveries

The extended life was not the only outcome that made ISO such a triumph for ESA, European industry and those responsible for its operations. The pointing accuracy of the telescope turned out to be

ten times better than required in the specification and its jitter was one-fifth of what was considered tolerable. Stray light in the optical system was too small to measure. The scheduling systems achieved science observations for 90-95 per cent of the available time. Much of the rest of the time, when ISO was turning to new targets, was spent in mapping parts of the sky at a wavelength of 200 microns.

Activity concerning ISO will continue at the Villafranca ground station until the year 2001, long after the completion of the observational phase of the mission. During the space operations, the main objective was to make as many observations as possible. Thorough analysis and interpretation of the results will take several years.

“We still have plenty to do,” says Martin Kessler, ESA’s project scientist for ISO. “Our team at Villafranca is preparing a complete archive of ISO data on 500-1000 compact disks, after reprocessing with improved software. We’ll release part of this archive to the world-wide astronomical community in the autumn of this year, and the rest in 1999. We shall also advise the astronomers who have used ISO about the particular requirements for handling the data from each instrument, and we’ll be doing some astronomy ourselves. There are far more results still to come from ISO.”

Meanwhile, Europe’s space astronomy programme continues in other directions. ESA’s participation in the Hubble Space Telescope and its eventual successor assures access to important instruments for Europe’s astronomers. The release, in1997, of the Catalogues from ESA’s unique star-mapping mission*, Hipparcos, provided astronomers with amazingly precise data for sizing up the stars and the wider Universe. Next year will see the launch of ESA’s XMM satellite to observe X-rays from the Universe with the most ingenious and sensitive X-ray telescopes ever made. It will be followed by Integral in 2001, which will investigate cosmic gamma-rays with clever imaging devices called coded masks, and ultra-sensitive detectors.

“Our aim in space astronomy is that every ESA mission should be the best in the world at the time of its launch,” says Roger Bonnet, ESA’s Director of Scientific Programmes. “ISO has been a shining example. It has revolutionised infrared astronomy. It has given us wonderful insights into cool and hidden places in the Universe, and into the origins of water and other materials to which we owe our very existence. A mission of this scale and complexity was feasible for Europe only through the multinational collaboration coordinated by ESA.”

Further information about ISO and its results, including a picture gallery, is available via the Internet: http://isowww.estec.esa.nl

* Available from ESA Publications Division

Signing for the Fluid Science Laboratory (FSL) for the ISS on 7 April are J. Feustel-Büechl, ESA Director for Manned Spaceflight and Microgravity (right), and G. Viriglio, Head of the Divisione Spazio for Alenia Aerospazio

ESA Signs Fluid Science Laboratory Contract

The contract for the development and delivery of ESA’s Fluid Science Laboratory (FSL) for Columbus was signed on 7 April 1998 at ESTEC by Mr J. Feustel-Büechl, ESA Director of Manned Spaceflight and Microgravity, and Mr G Viriglio, Head of prime contractor Alenia Aerospazio’s Divisione Spazio. The ceremony took place in the High Bay area of ESTEC’s Erasmus building.

FSL is one of the large multi-user facilities being developed under ESA’s Microgravity Facilities for Columbus (MFC) Programme. Extending ESA’s earlier fluid science research programmes, FSL will investigate areas such as flows and induced instabilities, double diffusive instabilities, interfacial tension and adsorption, mechanisms of boiling, critical point phenomena, crystal growth and directional solidification. Owing to its modular and adaptable experiment equipment, complementary science areas such as colloid and aerosol physics, particle agglomeration and plasma crystal physics are envisaged.

FSL’s most important diagnostics equipment are four different, convertible interferometers, a ‘first’ in the history of microgravity facilities. Compared with earlier facilities, such as the Bubble, Drop and Particle Unit (BPDU) flown on Spacelab, FSL offers a greatly enhanced observation bandwidth for refractive index resolution, improved control and support capabilities, extended experiment processing and research autonomy (telescience), and enhanced Experiment Container features, such as doubling the useful volume.

The industrial consortium led by Alenia comprises seven subcontractors: Verhaert DD (B), OHB System (D), DASA/Dornier (D), Laben SpA (I), MARS (I), Officine Galileo (I) and Sener (E). The Authorisation To Proceed with the Phase-C/D activities was issued to the consortium on 15 April 1998, and the Final Acceptance is planned for December 2001 (end of the Phase-C/D contract). This will be followed by related mission preparation activities aimed at a launch date in October 2002 aboard ESA’s Columbus Orbital Facility (COF).

Hipparcos Reveals Milky Way is Changing Shape

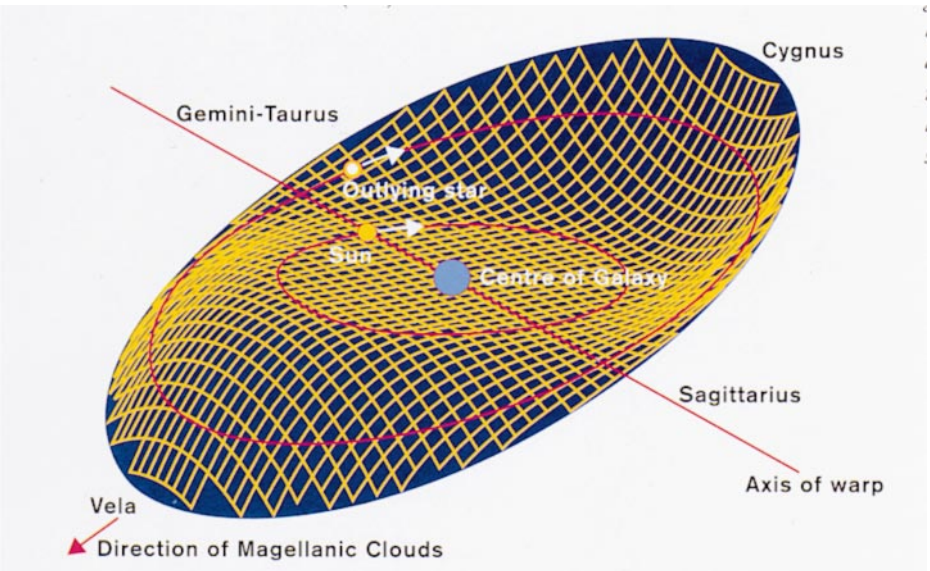
Hipparcos data has revealed that distant stars are moving in unexpected directions. Their strange behaviour could mean that the shape of the Milky Way Galaxy is changing. A team of astronomers from Turin Observatory and Oxford University announced the discovery in the 2 April issue of *Nature**.

Our home galaxy, the Milky Way, is roughly flat, with a bulge in the middle. As inhabitants of the disc we see it edge-on, as the band of light across the night sky from billions of distant stars, which gives the Milky Way Galaxy its name. Astronomers have known for many years that the disc is slightly warped. What surprises them now is that distant stars are travelling in directions that, if continued, will change the warped shape.

Richard Smart of Turin Observatory, the lead author of the *Nature* article, recounted, "Our results surprised us, but the extraordinary accuracy of Hipparos convinces us that distant stars have altered course. If we knew why, we'd be a lot wiser about the unseen hand of gravity at work in our Galaxy and others."

The Hipparcos satellite measured the positions and motions of stars far more precisely than ever before. Even before ESA's publication last year of the Hipparcos and Tycho Catalogues, of 118 000 and a million stars, respectively, the Turin-Oxford group of astronomers had privileged access to some of the more exact Hipparcos Catalogue data. They obtained positions and motions of 2422 very luminous blue stars spread half-way around the sky, selecting stars that turned out to be lying more than 1600 light-years away, towards the outskirts of the Galaxy.

Like the billions of other stars inhabiting the disc of the Milky Way, the Sun slowly orbits around the centre of the Galaxy, taking 220 million years to make one circuit. Inside the Sun's orbit, astronomers see no warp in the disc of the Milky Way. But outlying stars in the direction of the Cygnus constellation lie north of, or above, the plane of the Sun's orbit. Those in the opposite direction, in the Vela constellation, are displaced southward, below their expected positions if the Milky Way were truly flat.



Outside the Sun's orbit, stars follow tilted orbits. According to Hipparcos results, the tilts become more pronounced at increasing distances, such as in the curved shape of the disc shown here, resembling the brim of a hat (for clarity's sake, the height of the warping is exaggerated x10)

The first use made of the Hipparcos data by the Turin-Oxford group was to check the precise shape of the warped disc of the Galaxy. Before Hipparcos, observations of stellar positions indicated that the warp started outside Sun's orbit and had general upward and downward turns. The very precise star-fixing by Hipparcos showed the warp starting inside the Sun's orbit, with the more distant outlying parts of the Galaxy slanting more than the nearer parts do. As a result, the disc has an elegantly curved shape, like the brim of a hat.

If this shape of the warped disc were long-lasting, astronomers would expect the stars to follow corresponding orbits. Thus outlying stars in the Taurus constellation, midway between Vela and Cygnus, should be climbing 'uphill' if they are to replace the stars lying high in Cygnus at present. The appropriate track for each star can be calculated, on the assumption that the warp will persist.

Before they could accurately compare the calculated motions with those detected by Hipparcos, Richard Smart and his colleagues had to take into account the Sun's own vertical motion. Like many stars, the Sun jumps and swoops like a dolphin as it proceeds in its orbit around the centre of the Galaxy. Hipparcos data show that the Sun is at present rising at 7 km/s, relative to the disc of the Milky Way.

Outlying stars also show dolphin-like behaviour, so a statistical approach is needed to gauge their average vertical motion. At a distance of 6000 light-years, in the direction of Taurus, the stars should, on average, be climbing northwards, relative to the Sun's orbit, at about 8 km/s. The amazing conclusion by the Turin-Oxford group is that stars at that distance are, on average, descending southwards at 7 km/s.

They cannot therefore replace the present stars in the Milky Way in Cygnus. Instead, they will go to positions shifted southwards in relation to the disc of the Milky Way – unless some new disturbance makes the stars change course again.

The Milky Way is not the only galaxy to show deformations of its disc. About half of all other disc galaxies are seen to have the same effect. This remarkably high proportion may mean that galaxies are so rigid that any warp, once established, lasts for billions of years. Alternatively, galaxies may be very floppy, with new warps being created all the time.

The Hipparcos result on the Milky Way may favour the latter, more dynamic interpretation. The riddle of what warps galaxies has puzzled astronomers for decades. Explanations on offer range from intergalactic winds to magnetic contortions. A popular theory blames the

* *Nature*, Vol. 392, pp. 471-473. The authors are R.L. Smart, R. Drimmel, M.G. Lattanzi (Osservatorio Astronomico di Torino, Italy) and J.J. Binney (Dept. of Physics, University of Oxford, UK).

warp in the Milky Way on the gravitational pull of invisible dark matter in the halo of the Galaxy. This would imply that the present warp should be a long-lived phenomenon. As the warp may now be only temporary, other explanations will be favoured.

Mario Lattanzi, of the Turin group, puts it this way, “As is often the case in experimental science, better experimental data challenge our current understanding of how the Milky Way works.”

Prominent among the rival proposals about the warping of galaxies is the gravitational (tidal) effect of other galaxies passing close by. In the case of the Milky Way, the Magellanic Clouds and the recently discovered Sagittarius Dwarf Galaxy are candidates as warping agents. But Smart and his colleagues confess themselves to be baffled, “We are obliged to conclude,” they write, “that there is currently no convincing interpretation of the implications of Hipparcos data for the dynamics of the warp in the Galactic disc.”

Hipparcos Accurately Charts Important Star Cluster in 3D

A landmark result in the science of the stars comes with a complete and accurate description of the Hyades cluster – more than 200 stars – from measurements by ESA’s star-mapping Hipparcos satellite. With the distances to each star of this historically important group pinpointed, theories of the evolution of stars are, at last, much more secure. Star clusters are crucial for understanding the lives of stars because all the members of a cluster formed at the same time and from the same raw materials.

Astrophysicists can see how the evolution of each star depends on its mass and chemical composition. The heavier a star is, the more intensely it burns and the faster it consumes its thermonuclear fuel. But the accuracy of certain theories has hitherto been limited by inaccuracies in the observations.

The brightest members of Hyades are visible to the naked eye in the constellation of Taurus. As the nearest, moderately rich, star cluster, the Hyades cluster has loomed importantly in astrophysics for more than a century. Contradictory results for the distance of the star cluster left big question marks for the theorists, and recent observations with the Hubble Space Telescope (HST) seemed only to deepen the mystery.

Astronomers from ESA, Leiden Observatory, Observatoire de Paris-Meudon, University of Lausanne and Observatoire de la Côte d’Azur joined forces to analyse the data on the Hyades cluster contained in the Hipparcos Catalogue published last year (see page 40 of this issue of the ESA Bulletin for availability). Their results appeared in the March issue of the *European Journal of Astronomy & Astrophysics*.

The distance to the centre of the Hyades cluster is 151 light-years (46.34 parsecs) with an uncertainty of less than one light-year (0.27 parsec). From astrophysical theory, astronomers can date the birth of the cluster at 625 million years ago, when only the most primitive animals lived on the Earth. The cluster has done well to survive so long. The individual stars of the Hyades are bound together by the gravity of the cluster as a whole.

Their collective and individual motions have also been plotted by Hipparcos. The result is a crisp 3-D motion picture* of the cluster.

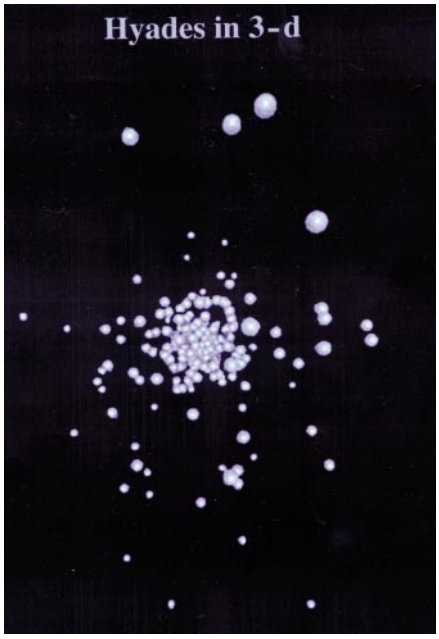
Hipparcos has also revealed almost imperceptible internal motions. Relatively massive stars have sunk towards the cluster’s centre of gravity, while some others are quitting the group. They slowly ‘evaporate’ from the cluster’s gravitational field as a result of near-collisions with other stars in the cluster or because the Hyades cluster has been stressed by gravitational encounters with other massive objects in the Milky Way Galaxy.

“The Hyades cluster has almost assumed the role of the Rosetta Stone of astronomy,” comments Michael Perryman of ESA’s Astrophysics Division in Noordwijk, The Netherlands, who is the lead author of the Hyades study and the Hipparcos Project Scientist. “It allows us to decipher many of the mysteries of stars. But until now, uncertainties in the observations left it muddy and hard to read with confidence. Let’s say we’ve now cleaned this Rosetta Stone to the point of complete legibility.”

The multinational research team has found out why previous measurements of the distance to the Hyades cluster gave incompatible results. Estimates relying on the motions of the cluster exaggerated the distance, because of small systematic errors in the ground-based reference system used in assessing the motions. When astronomers tried to measure the distances of the stars directly by parallax (shifts in apparent positions as the Earth orbited the Sun) small systematic differences in the ground-based determinations typically led to a smaller estimated distance. Hipparcos, from its vantage point in space, gives much better parallaxes and stellar motions, and these fit together in a perfectly consistent and comprehensive description.

The distance to the Hyades cluster is also the starting point for astronomical distance measurements, which extend throughout the Milky Way Galaxy and beyond. Its accurate measurement will therefore impact upon the overall distance scale and the age of the Universe, which have already emerged as salient areas of research in which Hipparcos results are making historic contributions.

* For details on the Hipparcos mission and its scientific results, including the Catalogues and a 3-D animation of the Hyades star cluster, see: http://astro.estec.esa.nl/Hipparcos



This image shows the 3D structure of the Hyades as seen from the position of the Sun in Galactic coordinates. Note that all spheres, representing the stars, are of the same size. Therefore, anything that appears bigger is thus physically closer to us

European Astronaut Corps

ESA will set up a single European astronaut corps by merging existing national astronaut programmes with the Agency's programme. The ESA Council approved the proposal during its meeting held in Paris on 25 March 1998.

Astronauts from national agencies, such as France (CNES), Germany (DLR) and Italy (ASI), will join ESA's astronauts J.F. Clervoy (F), P. Duque (E), C. Fuglesang (S) and C. Nicollier (CH) to form one corps. Together they will prepare for the mission opportunities available to ESA as the European partner in the International Space Station, and for other missions agreed upon between the national agencies and the United States or Russia. Moreover, a number of new astronauts will be chosen from previously selected candidates in order to maintain an appropriate representation of ESA Member States.

Integration of astronauts from the various national corps into ESA will begin this year and is to be completed by mid-2000, totalling sixteen active astronauts. After that period, the normal ESA procedure for selection will be applied, with recruitment occurring approximately every two years to make up for normal attrition and to enable ESA to continue supporting its planned missions.

The astronauts will be involved in the assembly of the International Space Station or in future operations on board. Their home base will be ESA's European Astronaut Centre in Cologne, Germany – where all new ESA astronauts will also undergo introductory training. Additionally, four of the new ESA astronauts are slated to begin training at NASA's Johnson Space Center in Houston, Texas by the autumn of this year.

The Astronaut Centre will also provide training for astronauts world-wide on the facilities that ESA is contributing to the Space Station, including the Columbus Laboratory and a resupply craft called the Automated Transfer Vehicle (ATV). esa

Ariane V106 Launches SKYPLEX

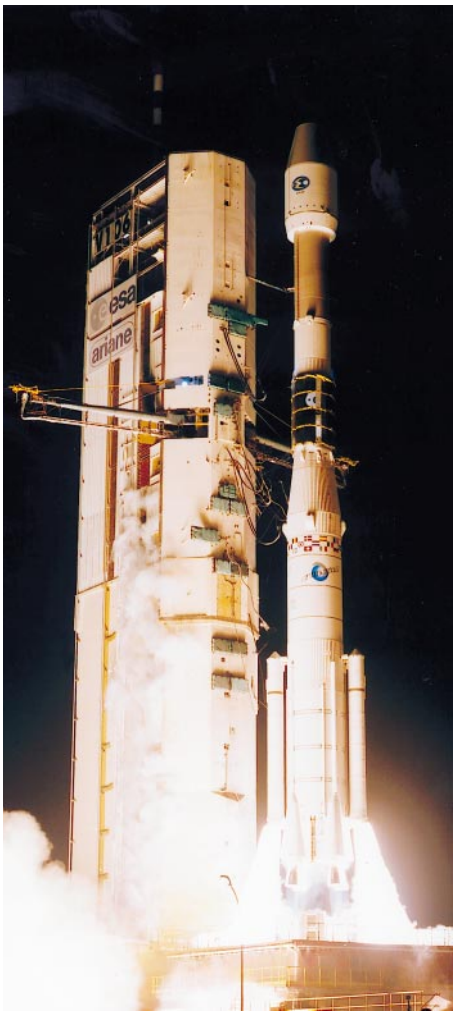
On 27 February at 19h38 Kourou time (22h38 GMT), the 106th Ariane launch (V106) – an Ariane-4 2P version – successfully lifted off from the Guiana Space Centre and placed the telecommunications satellite Hot Bird 4 into geostationary transfer orbit for the European Telecommunications Satellite Organisation (EUTELSAT).

Hot Bird 4 is carrying SKYPLEX, a new processor that allows a stream of multimedia information such as video, audio and data to be packaged, for the first time, on board a satellite. Traditionally, the various multimedia signals would need to be conveyed through standard communication networks to a ground multiplexing centre where they are combined into a single high-rate multi-programme stream and transmitted to the satellite. Thanks to SKYPLEX, the satellite can instead be accessed directly, simplifying broadcasting and reducing costs so that many more broadcasters and service providers will be able to make use of satellite systems.

Any television production facility, radio station or Internet provider can directly access the satellite: a system the size of a low-cost satellite news-gathering station (typically a 1.8 m dish and a 50 W transmitter) is sufficient to uplink to the satellite. The SKYPLEX processor on board Hot Bird 4 demodulates the incoming low-rate signals and re-combines them into a single, high-rate multi-channel digital broadcast signal which is transmitted directly to users' homes.

Transmission is fully compliant with the existing European digital television standard. Therefore, the SKYPLEX signal is indistinguishable from a conventional direct-to-home signal and can be received by any standard digital television receiver.

The SKYPLEX system is the result of a cooperative venture between ESA and EUTELSAT. The first model of the SKYPLEX payload was developed under ESA contract. The Hot Bird prime contractor Matra Marconi Space (F-UK) has been responsible for the satellite interface whilst the payload prime contractorship was awarded to Alenia Aerospazio (I), with Alcatel Espacio (E),



Mier Comunicaciones (E) and AME Space (N) as sub-contractors. The first model of the ground facilities was developed by Newtec (B).

The SKYPLEX programme is an example of how ESA, in partnership with industry and operators, aims to develop Europe's satellite multimedia market. The SKYPLEX programme is also an example of how success-oriented cooperation with industry leads to very short time-to-market initiatives (less than 20 months from contract signature to launch).

In its recently launched multimedia activities, ESA is negotiating the development of a second-generation SKYPLEX processor which will be designed to further reduce costs and to provide new Internet-ready functionality to cope with interactive multimedia communications. This next generation will be available in late 1999. esa

Ariane V107 Launches SILEX

The first civil high-data-rate optical communications system, SILEX (Semiconductor Intersatellite Link Experiment) was launched on board the French Earth observation satellite Spot-4 by Ariane flight V107. The successful launch by an Ariane-40 version (no strap-on boosters) took place on 23 March at 22h46 Kourou time (01h46 GMT on 24 March) placing Spot-4 into a Sun-synchronous orbit.

Developed by ESA, SILEX will transmit picture data from Spot-4 via the ESA Artemis satellite (scheduled for launch in late 1999/early 2000) to a data-processing centre near Toulouse, France. The advantage of the double-hop is that data can be relayed from Spot-4 for much longer periods since Artemis will be in a higher (geostationary) orbit. Present systems transmit data directly to the ground on a less frequent basis.

SILEX has both experimental and pre-operational purposes. Part of the experiment activities includes exploring the behaviour of the optical terminal; the short- and long-term stability of the various electrical, mechanical and optical elements; and the communication link quality characteristics. Also, operational procedures will be optimised.

The pre-operational part of the mission consists of transmitting (via the optical link to the ground) image data from the Spot-4 Earth observation instrument. This instrument generates data at 50 Mbps, which can be received at a ground station in southern France in real time. The SILEX service will thus eliminate the need for an extended ground station network and extends the direct visibility of the spacecraft to the central ground station. SILEX will also be used by Spot-4 to dump the content of the data memory collected during periods when the spacecraft is neither in the visibility zone of a ground station nor within reach of the Artemis terminal.

SILEX will also support an experiment between ESA's Artemis satellite and the OICETS spacecraft built by the Japanese Space Agency (NASDA).

A more detailed account of SILEX and its in-orbit commissioning will appear in the next issue of the ESA Bulletin (no. 95, August 1998).

ULYSSES Comes Full Circle

On 17 April, after travelling for more than seven years and covering 3.8 billion kilometres, the space probe Ulysses completed its first orbit of the Sun. This intrepid explorer has ventured into regions never before visited by any spacecraft. It has journeyed far away from the realm of the planets and gone over the poles of the Sun. From its unique perspective, Ulysses has provided scientists with the very first all-round map of the heliosphere, the huge bubble in space filled by the Sun's wind.

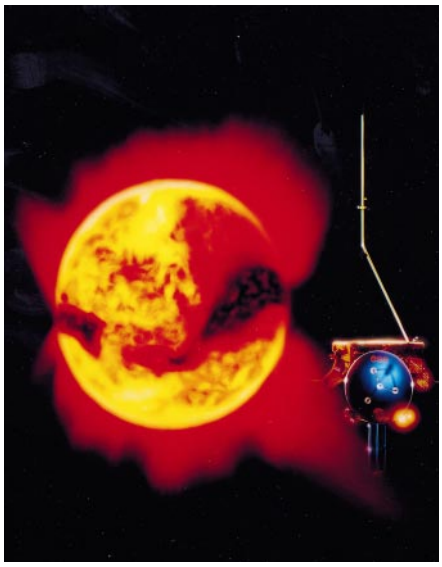
In a project of international cooperation between ESA and NASA, Ulysses was launched towards Jupiter in October 1990 by the Space Shuttle. Arriving in February 1992, Ulysses stole energy from the giant planet in a slingshot manoeuvre and was propelled back towards the Sun in an elongated orbit almost at right angles to the ecliptic plane, where the Earth and other planets circle the Sun.

"This month Ulysses returns to the point in space where its out-of-ecliptic journey began, but Jupiter isn't there," explains Richard Marsden, ESA's project scientist for Ulysses. "Following its own inexorable path around the Sun, Jupiter is far away on the opposite side of the Solar System. So Ulysses' course will not be changed a second time. The spacecraft is now in effect a man-made comet, forever bound into a 6-year polar orbit around the Sun."

Ulysses now starts its second orbit. It will travel over the poles of the Sun in 2000-2001 just as the count of dark sunspots is expected to reach a maximum. With its operational life extended for the Ulysses Solar Maximum Mission, the spacecraft will find the heliosphere much stormier than during its first orbit. Obeying a cycle of roughly eleven years, the Sun is once again becoming restless as sunspot activity builds towards the next peak around 2000.

"Gone will be the stable picture dominated by the fast solar wind," Richard Marsden predicts. "Most likely this will have been replaced by variability at all latitudes, with slow and fast wind streams jostling one another for prime position. But what exactly awaits Ulysses remains to be seen. Just like the first orbit, the second is truly a voyage into the unknown."

More details on the key results of the Ulysses mission at solar minimum can be found in the *ESA Bulletin*, no. 92, pp. 75-81, Nov. 1997 and on the WWW at: http://helio.estec.esa.nl/ulysses/



Metop/EPS Given Green Light

At a meeting of the Metop-1 participants on 12 December 1997, ESA's Member States took a major decision concerning the Metop* Programme by declaring the programme started and, subject to an adequate commitment by Eumetsat, confirmed their intention to proceed with industrial activities. The relevant budgets were approved, but blocked pending the Eumetsat decision.

This was followed by the Eumetsat Council on 28 January 1998, which established very positive decisions, particulary with respect to the financial commitments for Metop-1. Consequently, the ESA Earth Observation Programme Board (PB-EO) removed the block on the 1997 and 1998 Metop-1 budgets on 30 January.

The ESA Executive together with Eumetsat released an Authorisation to Proceed to industry for a total of 115 MECU (90 MECU from ESA and 25 MECU from Eumetsat) with immediate effect. The activities covered include the procurement of long-lead-time equipment items and start of work by all contractors. These activities will run until end of September 1998 by which time a full approval of the EPS** Programme by the Eumetsat Council is anticipated and both organisations are expected to sign a Cooperation Agreement.

The industrial contract will be managed by a joint ESA-Eumetsat Single Space Segment team led by Peter Edwards, the Metop-1 Project Manager. esa

* Metop is a series of three meteorological operational polar orbiting satellites, the first of which, Metop-1, is the prototype.

** The Eumetsat Polar System, which comprises the space segment, launches and operations of the Metop satellites. It is planned to be implemented in cooperation with ESA, CNES (F) and NOAA (the US National Oceanic and Atmospheric Administration).

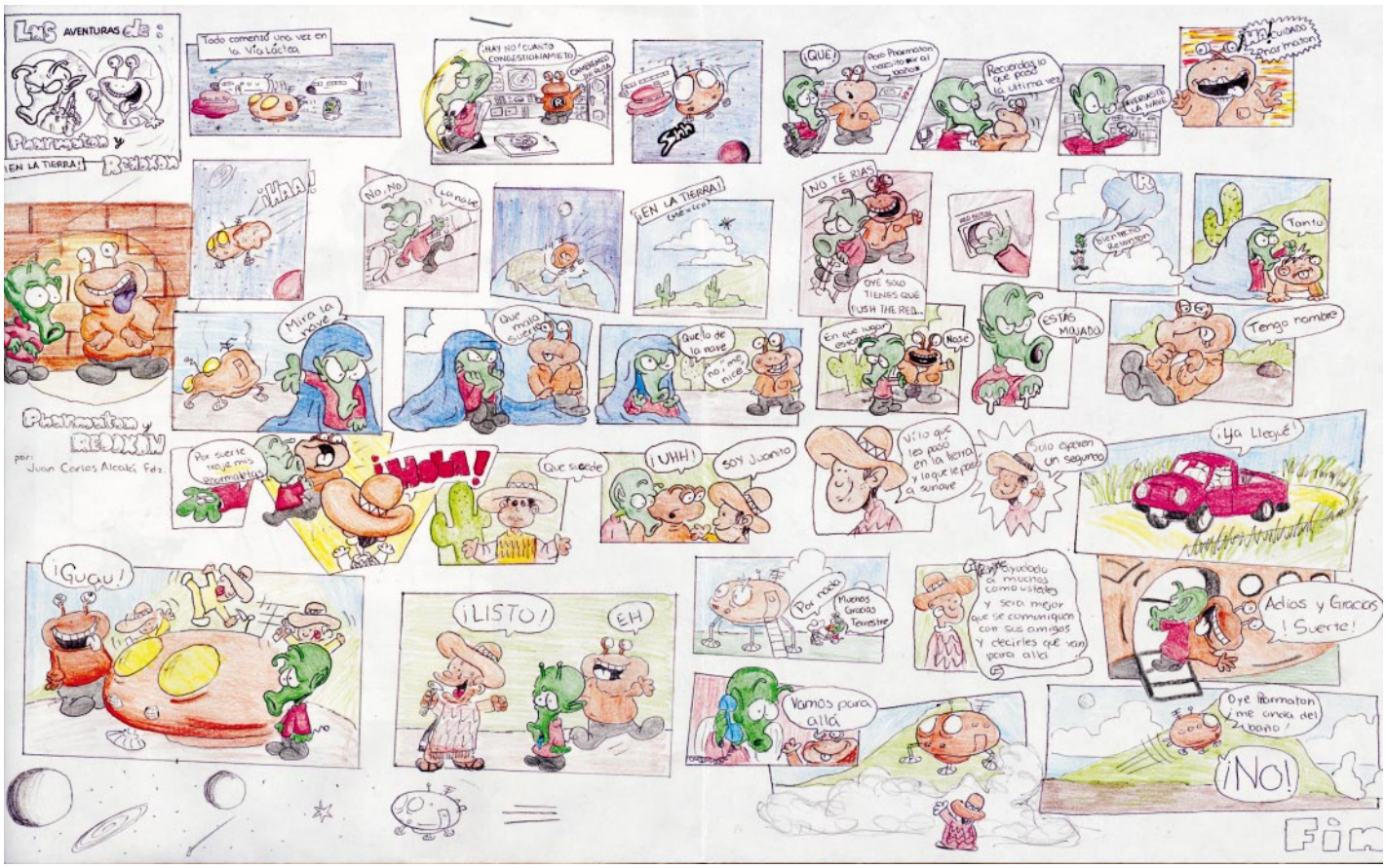
Space Days Cartoon Competition

The Third Euro-Latin American Space Days, organised by ESA and COFETEL (Comisión Federal de Telecomunicaciones of Mexico) were held from 10-14 November 1997 in Mexico City. The conference programme covered Earth observation (including ground stations, data processing and applications), small satellites and technology, with a round table discussion on launchers, telecommunications (including services and providers, systems, disaster management, and satellite navigation). In addition, a special one-day session was organised by International Space Brokers (ISB) and Arianespace Finance. As in previous years, the event also featured an industrial exhibition.

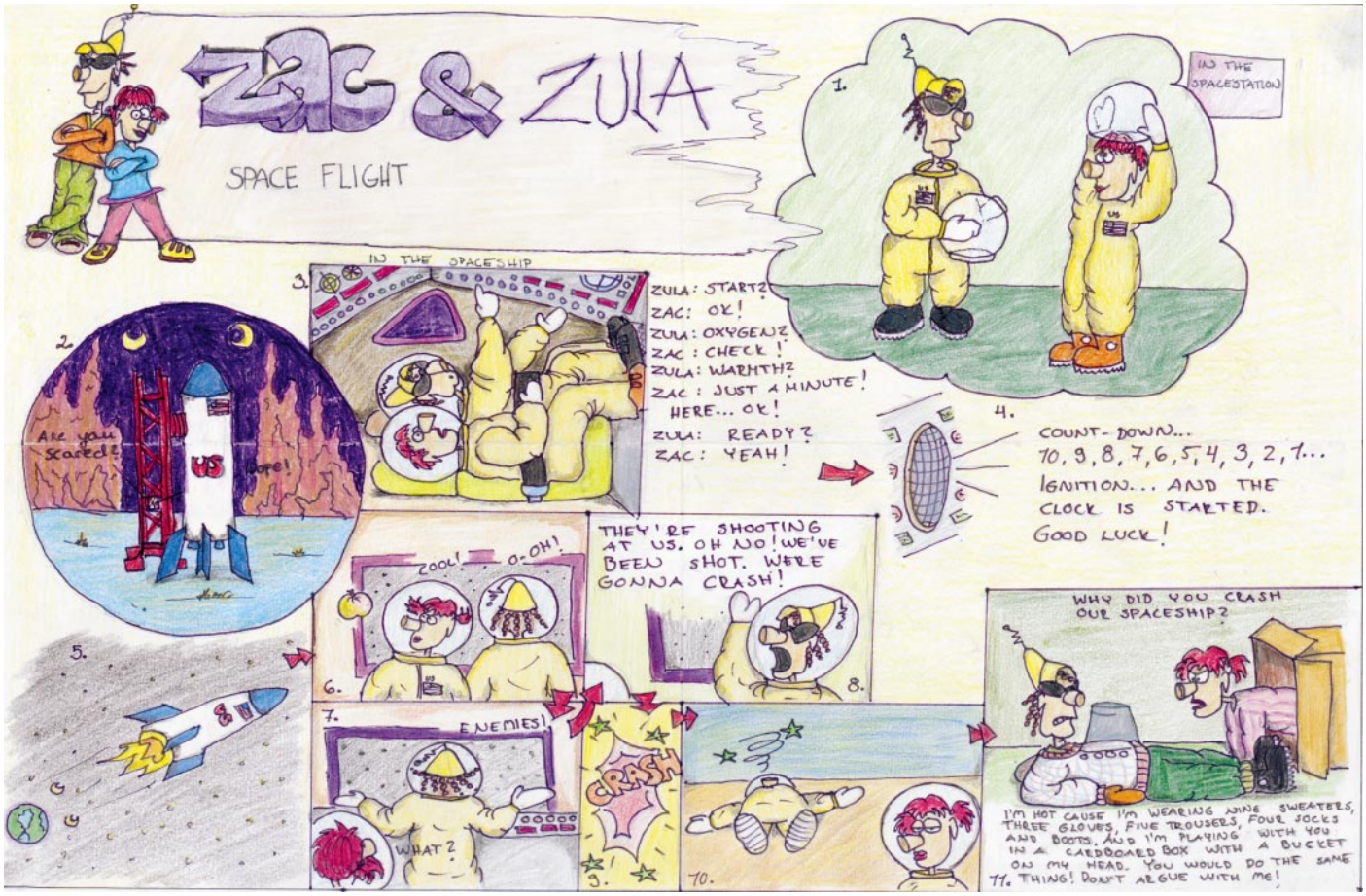
All in all, 280 people attended the conference, the majority coming from Mexican institutions. There were also representatives from all Latin American countries, some Central American countries and the Caribbean region.

ESA and COFETEL also organised a competition open to 14-16 year olds from Latin American and ESA's Member States, inviting them to draw a cartoon relating to a space theme. The two winners, Juan Carlos Alcalá Fernández (Mexico) and Stina Rükonen (Finland) have been invited to see an Ariane launch in Kourou. The five finalists from Latin America were invited to attend the Space Days in Mexico to meet ESA Astronaut Claude Nicollier. esa

2nd prize - The European winner of the competition was Stina Rükonen (Finland, age 16)



1st prize - The latin American Winner of the Space Days cartoon competition was Juan Carlos Alcalá Fernández (Mexico, age 14)



3rd prize - The European runner-up was Mari Kortemaa (Finland, age 14)

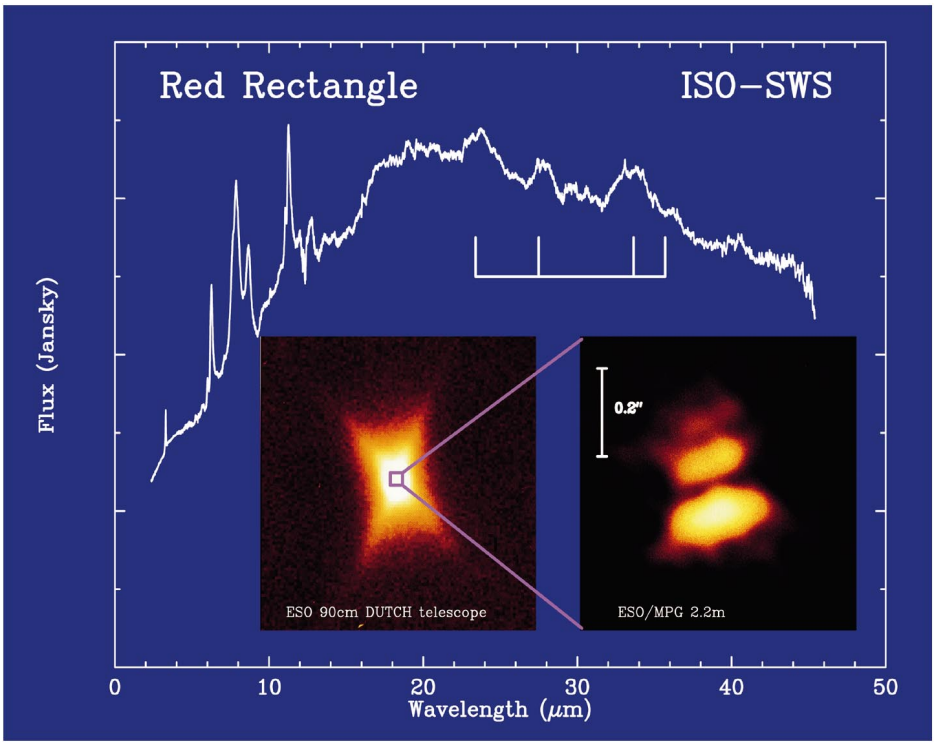
Planet Formation around Dying Stars

European astronomers at the universities of Amsterdam, Louvain, Groningen and Utrecht have found proof that planets can form around old, dying stars. In the vicinity of the Red Rectangle – old binary stars in the Monoceros constellation – they detected a ring of matter constituting the first stage of planet formation. It had previously been assumed that planets can only form around new-born stars. The results were published in *Nature* on 26 February.

Young stars are frequently surrounded by a flattened ring of gas and particles left over from the star formation process. The particles can join together to form larger and larger pieces that eventually grow to the size of planets. Observations made using the Dutch-German short wavelength spectrometer (SWS) on board ESA's Infrared Space Observatory (ISO) have shown that such rings are rich in silicates. The particular form and composition of the silicate – crystalline olivine – occurs on the Earth and in comets, which are the remnants of abortive planet formation. It thus appears to be an important constituent in the formation of planets.

From SWS observations it now appears that the ring of matter around the Red Rectangle binary contains large particles with a great deal of crystalline olivine. The Red Rectangle consists of two old neighbouring stars, one of which was a red giant and is now in the process of becoming a white dwarf. The olivine is of the same type as that found in the rings around young new-born stars, on the Earth and in comets. Towards the end of their lives, stars of the same type as our Sun swell up to form red giants and emit large quantities of gas and matter. Most of this matter escapes the star's gravity and is lost in space. But if the dying star is part of a binary system, its companion may prevent the gas and material from escaping. This will give rise to a stable, flat ring around the double star, which may remain in existence for a considerable time. In this ring, planet formation may occur. esa

This illustration shows two infrared images of the Red Rectangle. The left-hand picture shows the cloud of gas and matter emitted by the red giant (Dr H. van Wickel, Louvain). The right-hand picture shows a detail of the cloud nucleus (Prof G. Weigelt and Dr R. Osterbart, Bonn), in which the ring can be seen as a dark band. Above each picture is the spectrum made with the SWS. It exhibits a number of conspicuous peaks, which are caused by the presence of crystalline olivine.



Present and Future ESA/UK Space Activities

John Battle MP, UK Minister for Science, Energy and Industry, and ESA's Director General Antonio Rodotà held a joint Press Conference on current issues and future activities in space on Monday, 16 March in London.

The Press Conference took place immediately after Mr Battle officially opened the Science, Engineering and Technology Exhibition where Research Councils and Government Departments exhibited new technologies and demonstrated new initiatives. The exhibition marked the beginning of the UK's Science, Engineering and Technology Week.

In his opening address, Mr Battle announced a £21.2 million package of investments in three ESA programmes to "help position the British space industry on the multi-billion dollar information market of the next century". The package will be distributed as follows:

- £6.7 million over the next three years for the ARTES-3 Programme, which is developing satellite technologies providing new services for business and enabling the development of areas such as tele-medicine and tele-education
- £8.1 million over the next two years for the ERS-2 (European Remote Sensing Satellite) Programme
- £6.4 million over the next five years for EOPP (Earth Observation Preparatory Programme). esa