Herschel will be positioned at the second Langrange point. This lies 1.5 million kilometres behind the dark side of the Earth.

The ice-cold

GIANT EYE

The largest telescope in space will be a European one. ‘Herschel’ is on the look-out for invisible heat rays, and is always in search of the cosmic beginnings.

BY THORSTEN DAMBECK

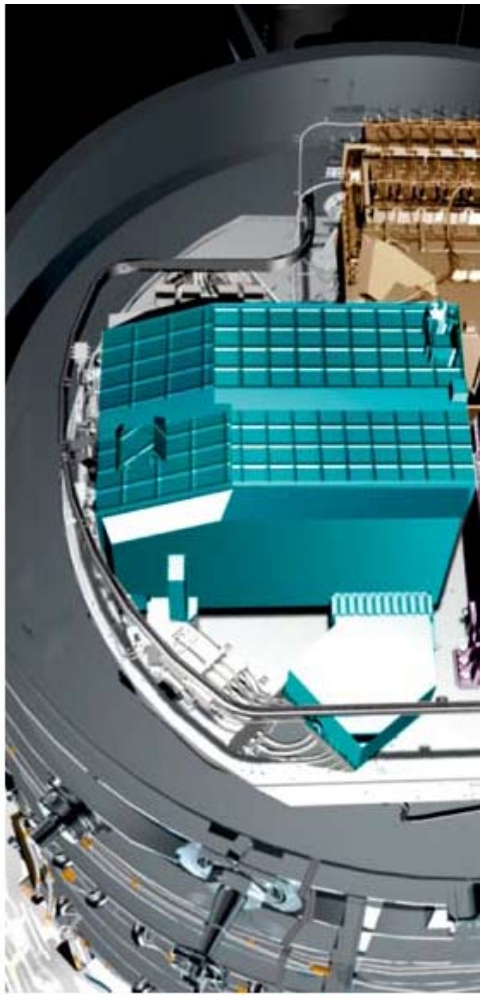
The largest space telescope is getting on in years. HST, the Hubble Space Telescope, was launched into space 17 years ago, and the 2.4 metre mirror has received several visits from space shuttles. NASA has planned the final maintenance flight for this summer. Hubble’s days as king of the castle in space are numbered. Herschel, the ESA satellite with a 3.5 metre lens, is lining up to take the title. However, the European is intended to be Hubble’s complement, not its competitor. While the NASA telescope makes observations predominantly in visible light, Herschel’s field of expertise is the infrared spectrum. Infrared radiation can hardly be detected from the surface of the Earth because the air swallows its waves. The largest infrared lens currently in space is the 85-centimetre mirror of the Spitzer space telescope (AH May/June 2003, p. 26).

“With the Herschel satellite we are opening a new window in space” ***Wolfgang Fricke, Astrium***

Like Hubble, Herschel was named after a famous astronomer. As a young soldier facing French troops, Friedrich Wilhelm ‘William’ Herschel (1738-1822) fled from Hanover to England. There he made a name for himself as a musician and later as a designer of telescopes.

In 1800 he succeeded in discovering rays of sunlight that the human eye cannot see: using a prisma he dispersed light into its individual colours. On the other side of the red light his thermometer registered an increase in temperature - the invisible infrared heat rays had been found.

He had already made a name for himself nineteen years before as he stumbled across a new planet - Uranus - behind his house using a six-inch home-made telescope of Newtonian design.



Astronomy with heat rays

Infrared light (or IR) is quickly absorbed by the Earth's atmosphere, especially by water vapour. Earth-bound IR observations are only possible in the 'near infrared' range for wavelengths under one micrometre and in some narrow 'windows' for those up to around forty micrometres. Dry locations at high altitude are best suited to this. Examples include the observatories in the Chilean Andes or on the Hawaiian volcano Mauna Kea. In comparison: visible light has wavelengths of around 0.5 micrometres.

'With the Herschel satellite we are opening a new window into space', enthuses Wolfgang Fricke, Herschel Project Manager at manufacturer Astrium. Its light intensity and resolution in particular are expected to enable new insights into the birthplaces of stars and the origins of the Universe. ESA is planning the launch for the end of July 2008. An Ariane 5 will tow the 3.3 ton Herschel into space together with the Planck satellite from the Spaceport in Kourou. The observations will commence after the launch, but the real action starts after an approximately three-month trip to the Lagrange point L2. This point is named after the French-Italian physicist Joseph Louis Lagrange. As viewed from the sun, it lies 1.5 million kilometres behind the Earth (see illustration p. 40). There are four additional Lagrange points at which space probes orbit the Sun in virtual formation with the Earth without requiring fuel. This is possible because at these points the centres of gravity of the Earth and the Sun and the centrifugal force exerted on the orbit even each other out. L2 is thus an ideal look-out for space telescopes, and the flight there is a first for ESA.

Exclusive parking lot

The planned European Gaia satellite (AH May 2006, p. 14) and Nasa's Hubble successor, the James Webb space telescope, are expected to drop anchor there in several years time. The only downer: sending a service mission such as was sent to the Hubble cannot be considered as L2 is too far away for this - it is approximately four times further away as the Moon. Even Nasa's planned Orion capsules that are expected to fly in the next ten years (see p. 28) were hardly allowed to advance that far, not to mention the space shuttles that are limited to flight heights of a few hundred kilometres. 'To do that would be completely uneconomical', opines ESA's Herschel and Planck Programme Manager Thomas Passvogel. 'Herschel is costing the European Space Agency around one billion Euros. For an entire replacement telescope you would only need to add an estimated thirty per cent." Sending astronauts with

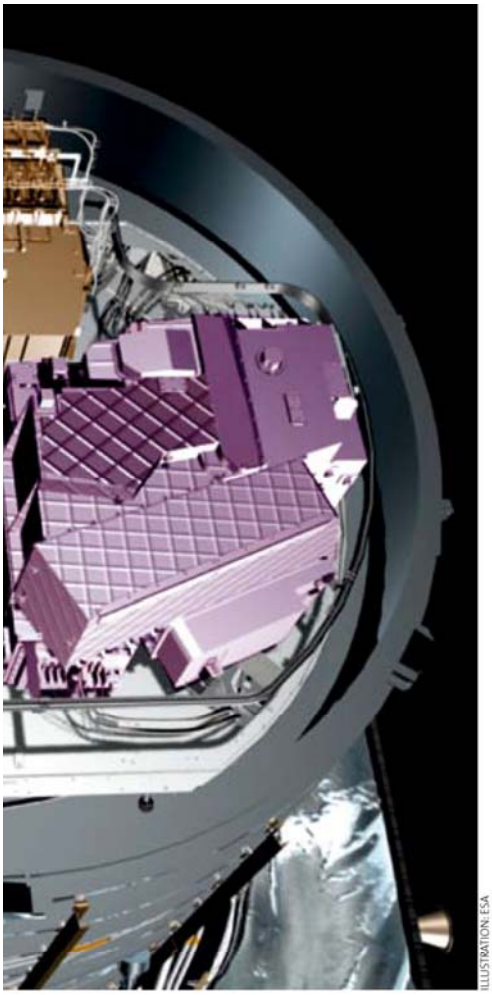
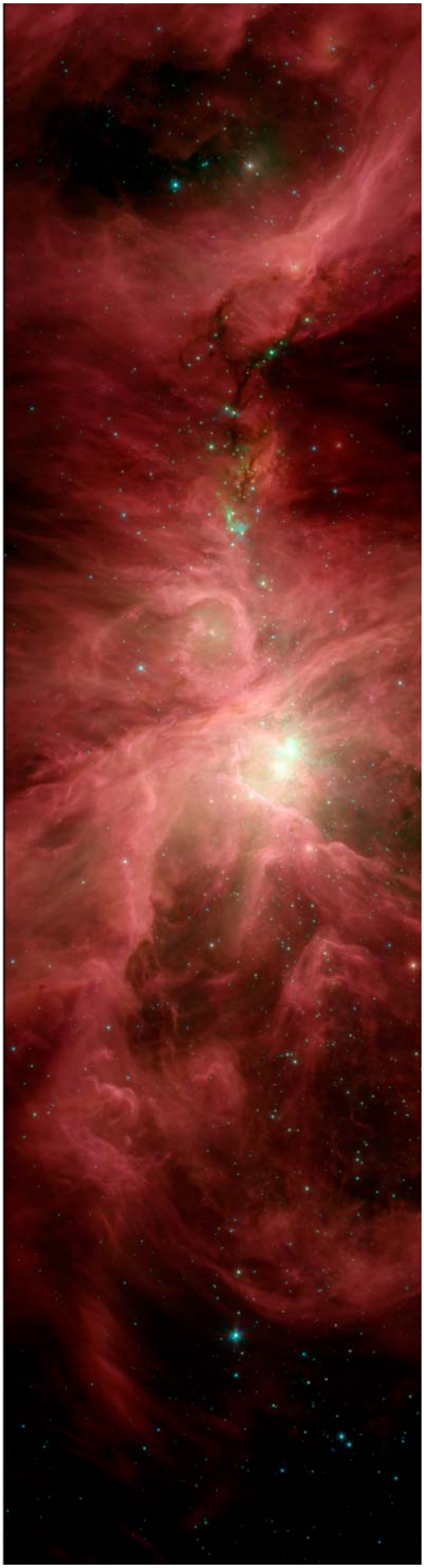


ILLUSTRATION: ESA

The 3.5-metre main mirror makes Herschel the largest space telescope (left). The light path has a classical Cassegrain design. The infrared light is analyzed by three instruments (right) on the level of the focal points: **»PACS«** - Photoconductor Array Camera and Spectrometer by MPE in Garching, **»SPIRE«** - Spectral and Photometric Imaging Receiver from Cardiff University, **»HIFI«**- Heterodyne Instrument for the Far Infrared from the Dutch research institute SRON.



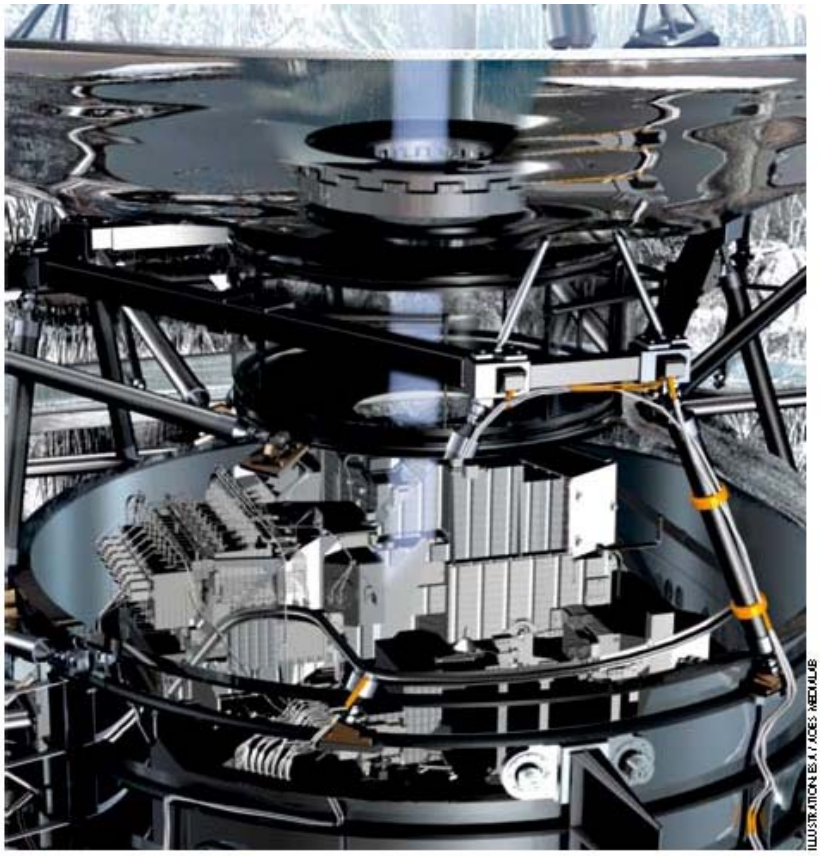
replacement parts in their luggage would be considerably more expensive.

The large distance is important for Herschel: It means that the sensitive detectors will not be disturbed by heat rays from the Sun, Earth and Moon. Because all bodies glow in the infrared, the designers were faced with a difficult task. They had to shield Herschel's instruments from their own radiation. A three metre-high container that resembles an oversized thermos flask serves this purpose. This cryostat is cooled using liquid helium. "We have a good three hundred kilograms of it on board. From a technical point of view the cryostat is similar to that of Herschel's predecessor Iso" (see box p. 44), explains Passvogel, who had a significant role in the Iso project. Its telescope was so small that it was able to be completely cooled. This is no longer possible due to Herschel's enormous main mirror. A design was chosen in which the uncooled Cassegrain mirror sits on the cryostat and the detectors are housed in the thermos flask - at an ultra-cold 0.3 degrees above absolute zero.

Staying cool!

Pacs is also part of the ice-cold payload (illustration top right). Created in the framework of an international collaboration, the instrument can record both pictures and spectra at the same time. The head of the consortium is Albrecht Poglitsch from the Max Planck Institute for extra-terrestrial physics (MPE) in Garching near Munich. The astrophysicist is already looking forward to Herschel's discoveries as the satellite will be making observations at wavelengths at which no satellite has done before: The study of young stars and their precursors will be possible using heat rays. These early stages usually remain hidden from conventional telescopes as they are buried deep inside thick dust clouds. In contrast, the longer wave infrared radiation effortlessly penetrates the dust (AH May/June 2003, p. 26).

One intention on the long list of research projects is aimed at defining the birth-rate of suns of different sizes "As is well-known, not all stars weigh the same. But their distribution of mass appears to be universal throughout the cosmos", explains Poglitsch. Whether in our Milky Way or



If the housing of the cryostat were transparent we could see the instruments onto which the infrared light that is to be analysed falls from above.

in distant galaxies - a few heavy stars and a lot of small ones can be found everywhere. Why is this so?

Looking through, looking inside

Astrophysicists suspect that this distribution is already established in the molecular clouds, the birthplaces of stars. Before the suns ignite their nuclear fire, they concentrate into clumps of gas there. Poglitsch: “With Herschel we can also see the small ones right down to a tenth of the mass of our Sun. We will study their temperatures and their densities. The fascinating question is now whether we will find the distribution of mass for these precursors to be the same as for the fully formed stars."

Outside of our cosmic neighbourhood the astronomers are also interested in distant galaxies, meaning galaxies that are especially young. Here the birth of stars takes place continuously. Such tumultuous phases are probably triggered as a result of collisions with smaller island universes. Large quantities of gas and dust are required as raw materials that block the visible and ultraviolet light of the young star. However the warm dust itself becomes an infrared source in the process. In addition, the light of this star system that is many billions of light years away is powerfully shifted to have longer wavelengths due to the expansion of the Universe. Both of these effects ensure that the especially young spiral nebula shine primarily in the “far infrared”. This is exactly Herschel's sensitivity range.

And how long will Europe’s giant eye be able to last at the distant L2 point? Its time is up when the telescope exhausts its supply of cooling agent. Astrium is guaranteeing a service life of three and a half years, and Wolfgang Fricke is optimistic: “We hope that Herschel will last for at least five years.” <<

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More articles on this topic can be found under:
www.esa.int/Science.

wis
Wissenschaft in die Schulen!

As a supplement to this article you can find a template for a model of the Herschel satellite under www. esa.int/education.
During the assembly on class, the construction of the satellite can be understood as a European Community project, its components are brought into focus, and proportions become clear. The students can become pro-active!

The “Wissenschaft in die Schulen!” project is being conducted in collaboration with the State Academy for Further Training of Teachers in Donaueschingen. It is generously supported by the Klaus Tschira Foundation.

ISO,

HERSCHEL’S PREDECESSOR

From 1995 to 1998 ESA’s “Infrared Space Observatory” made observations in the mid and far infrared using its sixty-centimetre mirror.Its discoveries include finding water, icy compounds and chemical processes in the interstellar medium and in the area surrounding stars as well as determining the energy sources of infrared galaxies.