Science & Technology Facilities Council

Herschel

Herschel will be the largest space telescope ever launched. Its 3.5 m-diameter mirror will give astronomers their best view yet of the Universe at far-infrared and sub-millimetre wavelengths. The mission builds upon the legacy of ESA's Infrared Space Observatory and subsequent infrared missions such as NASA's Spitzer and JAXA/ISAS's Akari.

The telescope is named after the British astronomer William Herschel. In 1800 he discovered infrared radiation while studying the Sun. He also famously discovered Uranus, the seventh planet in the Solar System, and performed surveys of the sky assisted by his sister Caroline.

In addition to contributing to the mission through the UK subscription to the ESA Science Programme, the UK has led the international team that built one of Herschel's three scientific instruments, the Spectral and Photometric Imaging Receiver (SPIRE).

SPIRE will operate at wavelengths between 200 and 700 microns (a few hundred times longer than the wavelength of visible light). It will study how stars and galaxies form, how dying stars inject material into interstellar space from which new stars and planets form, and it will examine the composition and chemistry of comets and planetary atmospheres in the Solar System.

SPIRE is made up of a cold unit, which is located inside the Herschel cryostat and detects the astronomical radiation collected by the Herschel telescope, and warm electronics units located outside the cryostat to control the instrument and transmit the data back to Earth. SPIRE has been developed and built by an international consortium comprising 18 institutes in eight countries (UK, France, Italy, Spain, Sweden, Canada, China, and the USA), which contribute in various ways to the instrument hardware, software, and science. In addition to building and testing the instrument hardware, the SPIRE team is responsible for providing the Instrument Control Centre (ICC) which develops software for commanding and monitoring the instrument and processing and calibrating the data to produce scientific results.

UK involvement

Cardiff University: Cardiff University School of Physics and Astronomy is the Principal Investigator (PI) institute of the international SPIRE Consortium. The Cardiff Astronomy Instrumentation Group provided filters and other optical components which select the wavelengths that SPIRE observes, internal calibration sources, thermal hardware for the detector cooling system, and components and support for the ground testing facility at RAL. Cardiff staff have participated in the instrument test programme and are also contributing to the SPIRE ICC, and will be involved in the in-flight testing, calibration and routine operation of SPIRE.

Imperial College London: The Astrophysics Group at Imperial College is a major contributor to the SPIRE ICC, especially in the area of data processing software, and members of the group have supported the testing of SPIRE at RAL. The Imperial team will participate in the in-flight testing, calibration and routine operation of SPIRE.

UCL Mullard Space Science Laboratory (MSSL): The MSSL engineering team designed and built the structure for the SPIRE cold instrument, and was also responsible for the mechanical system engineering of the instrument. This included oversight of the design of all the components that are mounted inside the cold unit, and of the testing that the instrument had to undergo to prove that it can withstand the strong vibration during launch.

STFC Rutherford Appleton Laboratory (RAL): The RAL Space Science and Technology Division provides the overall project management and system engineering for the SPIRE hardware and ICC teams, and the instrument was assembled and tested in a custom-built facility at RAL. The RAL team also led the testing of SPIRE after its installation in the Herschel satellite. In addition, RAL hosts the SPIRE Operations Centre – the ICC "headquarters" – which is responsible for delivering all instrument software to ESA, and for day-to-day instrument monitoring, operation, and calibration.

STFC UK Astronomy Technology Centre (UK ATC): The UK ATC built the SPIRE Beam Steering Mechanism, a moveable mirror inside the cold instrument that allows the instrument field of view to be moved on the sky in a controlled way. In addition, they led the overall system engineering during the instrument design phase, contributed to the optical design, and have participated in the development of the ICC.

University of Sussex: The Astronomy Centre at University of Sussex has contributed to the design and development of SPIRE ICC. Sussex have a specific responsibility for developing and testing software to detect stars and galaxies in the SPIRE images and measure their properties.

Additional information from ESA press kit

The Herschel mission will have an unprecedented view of the cold Universe, bridging the gap in the spectrum between what can be observed from the ground and earlier space missions of this kind. Infrared radiation can penetrate the gas and dust clouds that hide objects from optical telescopes, allowing astronomers to see deep into star-forming regions, galactic centres and planetary systems. Cooler objects, such as tiny stars and molecular clouds, and even galaxies enshrouded in dust (which barely emit optical light) are visible in the infrared. It can even detect emissions from dust itself. Observing in the infrared provides us with a complementary view of the Universe.

But why go into space to do this? The simple reason is that Earth's atmosphere blocks most infrared wavelengths. In addition, the atmosphere produces its own infrared radiation. So, observing in the infrared from the ground is like trying to view stars on a cloudy day!

Herschel will be launched together with ESA's Planck satellite. Once operational, the two missions will study different aspects of the cold cosmos.

Objectives

The key science objectives of the Herschel observatory are to study the formation of stars and galaxies, and to investigate the relationship between the two. The observing programmes will be proposed by the wide astronomical community. Examples of Herschel's specific investigations are:

- A survey of the formation and evolution of elliptical galaxies and the central bulges in other galaxies during the first third of the Universe's history.
- Detailed follow-up observations of particularly interesting objects found in the survey. These will concentrate on understanding the physical processes and energy-generating mechanisms in galaxies.
- Detailed studies of the physical and chemical processes in the gas and dust that are not yet bound into stars and planets. These investigations will be conducted in our Galaxy and others. They will help to investigate how and why stars form from interstellar clouds, and planets form from circumstellar discs. They will also provide fundamental clues about the complex organic molecules found, for instance, in the atmospheres of comets.
- Targeted observations of star formation and both young and old stars, to reveal the physical and chemical processes in the early and later phases of a star's life.
- Detailed observations of the atmospheres of the cool outer worlds in our Solar System and of comets.

Cost

The total cost of the Herschel mission is about €1000 million. This includes the spacecraft and its scientific payload, the launch and the operations.

Launch

Herschel is scheduled for launch on an Ariane 5 from Europe's Spaceport in Kourou, French Guiana, on 14th May 2009. It will be launched together with ESA's Planck spacecraft, in a dual launch configuration.

Mission timeline

Launch:	14 May 2009
About 0.5 hours after launch:	Herschel separates from the upper stage, a couple of minutes before Planck, and starts the cruise to its final orbit around L2 (the second Lagrangian point).
After about 60	Herschel enters its operational orbit, a Lissajous orbit on average 800

days: 000 km from L2, and starts its nominal science phase.

Planned mission lifetime

Herschel is designed to perform routine science operations for a minimum of 3 years at L2. The mission will end when the helium used to cool the focal plane of the scientific instruments is depleted.

Spacecraft

Design

In order to achieve its scientific objectives, Herschel's detectors have to operate at very low and stable temperatures. So the spacecraft cools the detectors close to absolute zero (–273ºC), ranging from –265ºC to only a few tenths of a degree above absolute zero.

Mass

Approximately 3400 kg at launch. This includes 2300 litres of liquid helium that will be used to cool the instruments to their operating temperatures.

Dimensions

Herschel is 7.5 m high and 4.5 m in diameter.

Industrial involvement

The prime contractor is Thales Alenia Space (Cannes, France). It leads a consortium of industrial partners with Astrium (Friedrichshafen, Germany) responsible for the Extended Payload Module (EPLM) and Thales Alenia Space (Turin, Italy) responsible for the Service Module (SVM). There is also a host of subcontractors spread throughout Europe.

What's on board?

Herschel carries the largest mirror ever to be launched into space. It measures 3.5 m across and collects infrared light for three instruments.

Photodetector Array Camera and Spectrometer (PACS)
PACS is a camera and a low- to medium-resolution spectrometer for wavelengths up to about 205 microns. It uses two bolometric detector arrays in the camera and two photo-conductor detector arrays in the spectrometer.

Principal Investigator (PI): Albrecht Poglitsch, Max Planck Institute for Extraterrestrial Physics (Garching, Germany).

PACS was designed and built by a consortium of scientists and institutes – under their own funding – from Germany (country of the PI), Belgium (country of the co-PI), Austria, France, Italy and Spain. They are all led by the PI.

Spectral and Photometric Imaging Receiver (SPIRE)
SPIRE is a camera and a low- to medium-resolution spectrometer for wavelengths longer than 200 microns. It uses five detector arrays: three to take images of infrared sources in three different infrared 'colours' and two to fully analyse the longer infrared light being released from the source.

Principal Investigator: Matthew Griffin, Cardiff University (Wales, UK).

SPIRE was designed and built by a consortium of scientists and institutes – under their own funding – from the United Kingdom (country of the PI), France (country of the co-PI), Canada, China, Italy, Spain, Sweden and USA. They are all led by the PI.

Heterodyne Instrument for the Far Infrared (HIFI)
HIFI is a very-high-resolution spectrometer that can obtain information about the chemical composition, kinematics and physical environment of infrared sources.

Principal Investigator: Frank Helmich, SRON Netherlands Institute for Space Research (Groningen, The Netherlands).

HIFI was designed and built by a consortium of scientists and institutes – under their own funding – from the Netherlands (country of the PI), France, Germany and USA (countries of the co-PIs), and from Canada, Ireland, Italy, Poland, Russia, Spain, Sweden, Switzerland and Taiwan. They are all led by the PI.

Operations

Primary Ground Station: ESA's deep space antenna in New Norcia (Australia).
Mission Operations Centre (MOC): provided by ESA at the European Space Operations Centre (ESOC), Darmstadt, Germany.
Herschel Science Centre (HSC): provided by ESA at the European Space Astronomy Centre (ESAC), in Villafranca, Spain.
NASA Herschel Science Centre (NHSC): provided by NASA at the California Institute of Technology (Caltech) Infrared Processing and Analysis Center (IPAC), Pasadena, California, USA.
Instrument Control Centres (ICCs):
- PACS ICC: Max Planck Institute for Extraterrestrial Physics, Garching, Germany;
- SPIRE ICC: Rutherford Appleton Laboratory, Didcot, UK;
- HIFI ICC: SRON Netherlands Institute for Space Research, Groningen, the Netherlands.

Herschel & Planck Programme Manager: Thomas Passvogel
Herschel Project Scientist: Göran Pilbratt

Images
Images of Herschel: http://www.scitech.ac.uk/herschelimages