



## Herschel

### Introduction

Herschel is the largest space telescope ever launched. Its 3.5 metre-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 later infrared missions such as the American Spitzer and Japanese 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.

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, barely emitting optical light, are visible in the infrared. Observing in the infrared provides us with a complementary view of the Universe.

But why go into space? The simple reason is that Earth's atmosphere blocks most infrared wavelengths. In addition, the atmosphere produces its own infrared radiation. So, to observe 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 not yet bound into stars and planets. These investigations will be conducted in our Galaxy and others. They will help to investigate why and how stars form from interstellar clouds, and planets from circumstellar discs. It will also provide fundamental clues about the complex organic molecules found, for instance, in the atmospheres of comets.
- Targeted observations of star formation and young (and old) stars to reveal the physical and chemical processes in the earlier (and the 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 Euros. This includes the spacecraft and its scientific payload, the launch and operations.

### Launch

Herschel will be launched on an Ariane-5 from the Guiana Space Centre, Kourou, French Guiana, at the end of July 2008. It will be launched together with ESA's Planck spacecraft, in a dual launch configuration.

### Mission timeline

Launch: end of July 2008

Launch plus about 2.5 hours: Herschel separates from Planck, and then starts its cruise to L2 (second Lagrangian point), its destination.

Within less than 6 months: Herschel arrives in its operational orbit around L2.

### 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

Herschel is a tall 'tube'. The most obvious feature is the 3.5 metre-diameter primary mirror that sits on top of the cryostat and is protected by a sunshield from direct solar illumination. The mirror focuses infrared light, via a smaller secondary mirror, down into the focal plane inside the cryostat. This sits under the mirror and provides cooling of the scientific instrument package to within a fraction of absolute zero. The sunshield protects the cryostat from the Sun and is partially covered with solar cells that provide the power required to operate the space telescope. Below the cryostat is the service module. It contains the essential computers and other subsystems that allow the spacecraft and its instruments to function and also allow handling and compression of the raw scientific data.

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 ( $-273^{\circ}\text{C}$ ), ranging from  $-265^{\circ}\text{C}$  to only a few tens of a degree above absolute zero.

#### Mass

Approximately 3300 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 metres high and 4 metres 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 the Thales Alenia Space industry branch of 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 to be launched into space. It measures 3.5 metres 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 micrometres. It uses two bolometer detector arrays in the camera and two photo-conductor detector arrays in the spectrometer.

*Principal Investigator:* Albrecht Poglitsch, MPE (Garching, Germany).

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

#### Spectral and Photometric Imaging Receiver (SPIRE)

SPIRE is a camera and a low- to medium-resolution spectrometer for wavelengths longer than 200 micrometres. 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 Principal Investigator), France (country of the co-Principal Investigator), and from Canada, China, Italy, Spain, Sweden and USA. They are all led by the Principal Investigator.

#### Heterodyne Instrument for the Far Infrared (HIFI)

HIFI is a highly accurate spectrometer that can obtain information about the chemical composition, kinematics and physical environment of infrared sources.

*Principal Investigator:* Thijs de Graauw, SRON Netherlands Institute for Space Research, The Netherlands.

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



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**Fact sheet**

**European Space Agency**

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## **Operations**

**Herschel Science Centre (HSC):** provided by ESA at the European Space Astronomy Centre (ESAC), Villafranca, Spain.

**Mission Operations Centre (MOC):** provided by ESA at the European Space Operations Centre (ESOC), Darmstadt, Germany.

**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-Institut für extraterrestrische Physik Garching, Germany; SPIRE ICC, Rutherford Appleton Laboratory, UK; HIFI ICC, SRON Netherlands Institute for Space Research, The Netherlands.

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