



Planck

Introduction

Planck is Europe's first mission to study the relic radiation from the Big Bang. Ever since the detection of small fluctuations in the temperature of this radiation, announced in late 1992, astronomers have used the fluctuations to understand both the origin of the Universe and the formation of galaxies.

The mission is named after the German physicist Max Planck, whose work on the behaviour of radiation won the Nobel Prize in 1918.

The Planck satellite will observe the cosmic microwave background radiation (CMB). This is the radiation released into the Universe by the Big Bang itself, about 14 thousand million years ago. Since that time, what was once a searing fireball has cooled to become a background sea of microwaves.

Planck will measure the temperature variations across this microwave background with much better sensitivity, angular resolution and frequency range than any previous satellite. The combination of these factors will give astronomers an unprecedented view of our Universe when it was extremely young: just 380 000 years old.

Planck will be launched in tandem with ESA's Herschel space telescope. Together they will study different aspects of the cold cosmos.

Objectives

Planck will make the most accurate maps yet of the microwave background radiation that fills space. It will be sensitive to temperature variations of a few millionths of a degree and will map the full sky over nine wavelength bands. It will measure the fluctuations of the CMB with an accuracy set by fundamental astrophysical limits.

The mission will address a number of fundamental questions, such as the initial conditions for the evolution in the Universe's structure, the nature and amount of dark matter (matter that does not emit or reflect electromagnetic radiation, but whose presence can be inferred from its effects on detectable matter), and the nature of dark energy (a hypothetical form of energy that may account for the Universe's expansion at an accelerating rate).

Planck's maps will allow a number of specific investigations to take place:

- The determination of the Universe's fundamental characteristics, such as the overall geometry of space, the density of normal matter and the rate at which the Universe is expanding.
- A test of whether the Universe passed through a period of rapidly-accelerated expansion just after the Big Bang. This period is known as inflation.
- The search for 'defects' in space, for example cosmic strings, which could indicate that the Universe fundamentally changed state early in its existence.



- Accurate measurement of the variations in the microwave background that grew into the largest structures today: filaments of galaxies and voids.
- A survey of the distorting effects of modern galaxy clusters on the microwave background radiation, giving the internal conditions of the gas in the galaxy clusters.

Cost

The total cost of the Planck mission is about €700 million. This includes the spacecraft and its scientific payload, the launch and the operations.

Launch

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

Mission timeline

Launch:	May 2009.
About 0.5 hours after launch:	Planck separates from the upper stage, a couple of minutes after Herschel, and starts the cruise to its final orbit around L2 (the second Lagrangian point).
In about 2 months:	Planck enters its operational orbit, a Lissajous orbit about 400 000 km from L2.
One month later:	Planck starts its nominal scientific observations.

Planned mission lifetime

Planck's routine science observations at L2 will last 15 months, allowing two sky surveys. The mission could in principle be further extended by one year, depending on the resources still available for cooling the instruments.

Spacecraft

Design

The Planck telescope and instruments are mounted on top of an octagonal service module. A baffle surrounds the telescope and instruments to prevent straylight from the Sun and Moon from spoiling the detection of microwave radiation. The baffle is also used to radiate to cold space the heat generated by the focal plane units of the scientific payload, and to provide to the instrument coolers a cold and stable background environment of about -223°C (or 50K).

Inside the service module are the computers and subsystems that allow the spacecraft to function and to compress the raw data signals from the instrument detectors. At the base of the service module is a flat, circular solar panel to generate electricity from sunlight to power the spacecraft, and to protect the whole spacecraft from direct solar radiation.



In order to achieve its scientific objectives, Planck's detectors have to operate at very low and stable temperatures. The spacecraft is therefore equipped with the means of cooling the detectors to levels close to absolute zero (-273.15°C), ranging from about -253°C to only a few tenths of a degree above absolute zero.

Mass

Approximately 1950 kg at launch.

Dimensions

Planck is 4.2 m high and has a maximum diameter that is also 4.2 m.

Industrial involvement

The prime contractor is Thales Alenia Space (Cannes, France). It leads a consortium of industrial partners with Thales Alenia Space (Turin, Italy), who are responsible for the Service Module. There is also a host of subcontractors spread throughout Europe, with a few more in the USA. ESA and the Danish National Space Centre (Copenhagen, Denmark, funded by the Danish Natural Science Research Council) are responsible for the provision of Planck's telescope mirrors, manufactured by EADS Astrium (Friedrichshafen, Germany).

What's on board?

Planck carries a telescope with an effective aperture of 1.5 m that feeds microwave radiation to two instruments:

Low Frequency Instrument (LFI)

LFI is an array of 22 tuned radio receivers that is located in the focal plane of the Planck telescope. LFI will image the sky at three frequencies between 30 GHz and 70 GHz.

Principal Investigator (PI): Nazzareno Mandolesi of the Istituto di Astrofisica Spaziale e Fisica Cosmica in Bologna (Italy).

LFI was designed and built by a consortium (led by the PI) of scientists and institutes from Italy, Finland, the United Kingdom, Spain, the United States, Germany, the Netherlands, Switzerland, Norway, Sweden and Denmark.

High Frequency Instrument (HFI)

HFI is an array of 52 bolometric detectors that is also placed in the focal plane of the Planck telescope. HFI will image the sky at six frequencies between 100 GHz and 857 GHz.

Principal Investigators: Jean-Loup Puget (PI) of the Institut d'Astrophysique Spatiale in Orsay (France)
François Bouchet (co-PI) of the Institut d'Astrophysique de Paris.

HFI was designed and built by a consortium (led by the PIs) of scientists and institutes from France, the United States, the United Kingdom, Canada, Italy, Spain, Ireland, Germany, the Netherlands, Denmark and Switzerland.



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Many funding agencies contributed to the LFI and HFI instrument hardware; the major ones are: CNES (France), ASI (Italy), NASA (the United States), STFC (the United Kingdom), Tekes (Finland), the Ministry of Education and Science (Spain), and ESA.

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.

Planck Science Office (PSO): provided by ESA at the European Space Astronomy Centre (ESAC) in Villafraanca (Spain).

Data Processing Centres (DPCs): HFI DPC, led by the Institut d'Astrophysique Spatiale, is located at the Institut d'Astrophysique de Paris, France; LFI DPC, led by the Istituto di Astrofisica Spaziale e Fisica Cosmica (IASF) is located at the Osservatorio Astronomico di Trieste, Italy.

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General information about this and other ESA Science missions can be found at:
<http://www.esa.int/science>

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Last updated: 17 April 2009