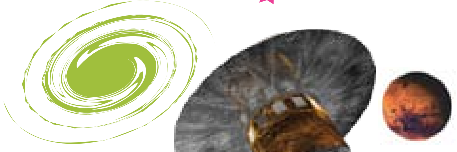
The Little Books of Gaia

EVERYTHING YOU EVER WANTED TO KNOW ABOUT GAIA!



June 2009

What is Gaia?

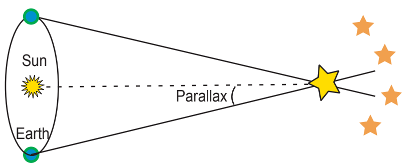
Gaia is a satellite that the European Space Agency will launch in spring 2012. It will measure distances, positions, and velocities of stars in our Galaxy, the Milky Way, to create the most accurate 3-D picture of our Galaxy that we've ever had.

Why bother measuring distances and velocities?

Because knowing the distance to a star allows us to determine many of the essential properties (age, mass, true luminosity, etc) of the star. Velocities give us information about where the star was millions of years ago and where it will be in the future. By measuring these quantities Gaia will determine the nature, formation history and evolution of the Milky Way.

How do we measure the distance to a star?

Astronomers use a quantity called the stellar parallax. It is the apparent angular displacement of a star in the sky when viewed from opposite points of the Earth's orbit around the Sun. Stellar parallax can be converted into distance by using simple geometry.



Why go to space to measure parallaxes?

Stellar parallax is very difficult to measure because it is a very small quantity and it decreases the further a star is from the Earth. Very precise measurements are needed to determine a stellar parallax and this is why we need to get out of the Earth's atmosphere, to get away from the distortions that it creates.

How accurate will these measurements be?

Gaia will have an accuracy of about 20 microarcseconds (approximately 6 billionths of a degree). This accuracy corresponds to the angle subtended by a five-story building at the distance of Mars, when Mars is the furthest away from us.

How many people work in the Gaia project?

Gaia is in the implementation phase during which the elements of the craft and instruments are manufactured, assembled, tested and integrated and plans for Gaia's operations are worked out in detail. Currently about 2500 people are working on Gaia, including ESA staff and members of the space industry, scientific community and academic world.

How long does it take to build a satellite like Gaia?

A mission like Gaia may be studied and discussed for several years before ESA's advisors approve it. Detailed designing and advanced technology studies then take 3 to 4 years, and a further 3 to 4 years are needed to build and test the satellite, and prepare it for launch.

Who builds the satellite?

Many individuals, scientific institutes, and industrial companies contribute to a mission like Gaia. As many as about 400 scientists, 2000 engineers and managers, and 20 to 30 companies might be involved.

Who will have access to the data gathered by Gaia?

The data acquired by Gaia will be converted into useful information (distances, velocities...) by experts in Europe. Results will be available to the general public once the data have been reduced. Scientists from any institute, amateur astronomers, or students will have free access to Gaia's data. The general public will also be informed of any interesting discoveries through the internet and other media.

How will Gaia be transported into space?

The Gaia satellite has been designed to be placed in space by the Soyuz/ST rocket. First the rocket is sent to a low altitude parking orbit. Then the Fregat upper stage of the rocket is fired to send the satellite to its final operational location, L2.

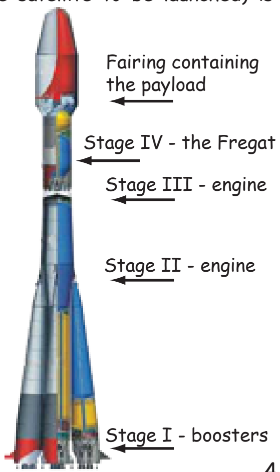
How do rockets work?

Liquid or solid propellants (a mixture of fuel and oxidizer) are burnt inside the rocket producing pressurized gas that escapes through a nozzle. This gas provides a thrust that propels the rocket in the upward direction (just like a balloon starts moving if we release its nozzle).

What is a Soyuz-Fregat rocket?

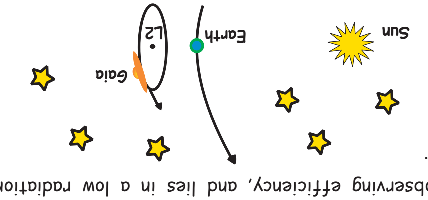
Soyuz launch vehicles have a special place in the history of space flight. They launched the first satellite and the first man into space. Soyuz rockets have launched ESA's Cluster and Mars Express satellites and will launch more ESA satellites in the future, including Gaia.

The main componets of the Soyuz are: the fairing where the payload (the satellite to be launched) is located, and four different engine 'stages'. Each stage performs a different function. Stage I - the boosters - propel the rocket from Earth. Stage II and III are used to put the rocket into orbit above Earth. Stage IV - the Fregat - is a complex stage which is able to start and stop several times. This allows it to perform complex manoeuvres and to place the satellite into many different orbits.



Where will Gaia be in space?

Gaia will be operated in a Lissajous-type orbit, around the L2 Lagrangian point of the Sun-Earth system, at about 1.5 million kilometres from the Earth. This L2 point represents a location where gravitational and repulsive forces are balanced. This orbit is eclipse-free, which allows a very stable thermal environment and a high observing efficiency, and lies in a low radiation region.



How long will it take Gaia to reach this orbit?

Gaia will have to travel for about 1 month to arrive at its chosen orbit.

How much time will Gaia be in space?

Immediately after insertion in its final orbit, Gaia will start taking measurements which will continue for a period of 5 years.

How big is the computation needed to reduce all of Gaia's data?

Gaia's data reduction using an average PC would take about 300 years! The Gaia team will complete this in only 3 years using advanced technology.

How is a satellite controlled from the Earth?

Radio signals are sent to the satellite using large radio dishes which are pointed to the satellite's location in space. The large quantity of information sent from the satellite to the ground is also transmitted by high frequency radio waves.

What will happen to Gaia after it stops functioning?

After Gaia comes to the end of its 'lifetime', it will be left to orbit freely. As its orbit is far from Earth and from other more crowded areas of space, it won't affect other satellites. Only an impact by a meteorite or a comet will destroy the 'dead' satellite.

How many stars will Gaia measure?

Gaia will measure about one billion stars. This constitutes about 1 per cent of the total star content in the Milky Way.

What other objects will Gaia observe?

Gaia will also observe more than 350000 objects in our solar system (mostly asteroids), around 15000 new extrasolar planets, more than 50000 brown dwarfs (stars of very low mass that do not emit much light because no nucleosynthesis takes place in their interior), about 20000 supernovae (stars exploding at the end of their lives), and a large number of galaxies.

How far is the closest star to us?

The closest star to us apart from the Sun is Proxima Centauri, in the Alpha Centauri star system. It lies at a distance of 4.3 light years from the Earth.

How big is our Galaxy?

If we could travel at the speed of light, it would take around 100000 years to reach the other end of our Galaxy.

What is the predicted size and weight of Gaia?

Based on the current design, Gaia will be 3 metres high, about 10 metres across, and will weigh around 2000 kg.

What does Gaia mean?

For ancient Greeks, Gaia was the goddess of Earth, the Universal Mother. More recently, this name was adopted for a theory which states that the Earth (including all living organisms, the biosphere, the rocks, the air, and the oceans) behaves like a living system in its own right. Now it is the name given to this ambitious project to discover the structure, origin and evolution of our Galaxy.

esa

More detailed information can be found on the Gaia web site: http://sci.esa.int/Gaia