



Lund Observatory's map of the Galaxy.

Even though understanding our Galaxy's origin, structure, and evolution is the main objective of Gaia, other scientific implications of this project are immense and will profoundly revolutionise diverse areas of astrophysics including those described below.

STELLAR ASTROPHYSICS

Knowing the distance to a star and its apparent luminosity, we can derive essential information about the star. Gaia's measurements of distances and energy distributions for all types of stars in our Galaxy will allow determination of their absolute luminosity, metallicity, rotational velocity and temperature, and from stellar modelling their mass and age.

These quantities will be used for testing and refining theories of how stars evolve and how their interiors behave throughout their lifetime. Theories of stellar structure and evolution will deeply benefit from Gaia's survey. Gaia will observe stars from all over the Galaxy, even stars that are extremely rare and cannot be found near to our Sun.



Gaia

At present, we have accurate spatial and dynamical information for stars in a reduced area of the galaxy, around the Sun (see drawing). This has been achieved with the data gathered by the Hipparcos satellite, launched by ESA in 1989. But clearly, conclusions about the large-scale structure and dynamics of our Milky Way need a much deeper and more extensive survey. Gaia will measure accurate positions, distances, velocities and chemical composition for a truly significant fraction of the galaxy's stellar population. It will in this way construct a dynamic three-dimensional map of the Milky Way, containing also information about the nature of stars within it. ★

★ Gaia, a satellite that the European Space Agency will launch in 2013, will finally be able to solve these questions. ★

Here are some examples: Did the central bulge form before or after the disc? How many spiral arms does the Galaxy contain, what do they look like and what is their origin? What is the mysterious dark matter that affects the motions of stars in our Galaxy? When were stars in our Galaxy born? Did the Milky Way form by the collapse of a cloud of material or by accretion of smaller building blocks? ★

EXTRASOLAR PLANETS

In recent years more than 750 planets have been discovered outside our Solar System. Gaia will drastically increase this number, detecting about 15000 Jupiter mass planets around stars other than the Sun. This corresponds to more than 5 new planets per day, for each day of the 5-year mission! It will do so by observing the wobble of the star due to the gravitational pull of the planet. Such a large number of detections will revolutionise our knowledge of planet formation theories and in particular will bring light to one of mankind's most thought-provoking considerations: how did our own Solar System form?



SOLAR SYSTEM BODIES

As it sweeps the sky, Gaia will observe everything that crosses its sensitive fields of view. Within our Solar System it will provide a whole range of spectacular results. Between the orbits of Mars and Jupiter lies the asteroid belt. At present about 460000 asteroids or minor planets have been detected, but Gaia may observe up to 250000 of them. Detection and classification of asteroids is of tremendous interest for studies of the formation and evolution of our Solar System, as their composition is thought to have remained unchanged since the birth of our planetary system. In the outer limits of the Solar System, Gaia will be able to answer another exciting question: have other Pluto-like bodies escaped detection so far? ★

Many puzzles about our Milky Way remain to be solved.

PAST, PRESENT AND FUTURE OF OUR GALAXY

★ The galactic bulge in the central part of the disc has an ellipsoidal shape and contains mainly old stars. It is thought that a massive black-hole lies at its centre. ★ The disc and the bulge are surrounded by a spherical halo of old stars, about 140 globular clusters (large groups of old stars with a common origin) and a few small and faint satellite dwarf galaxies. ★ The entire system is thought to be embedded in a massive halo of dark matter of unknown composition and poorly known spatial distribution.



DYNAMICS OF LOCAL GROUP GALAXIES

Our Milky Way Galaxy belongs to a cluster of galaxies named the Local Group. Gaia will determine the orbits of other members of the Local Group like the Large Magellanic Cloud, the Small Magellanic Cloud, or the Andromeda galaxy (M31). The orbits of these nearby galaxies will give us hints on how the Universe looked soon after the Big Bang.

FUNDAMENTAL PHYSICS

Einstein's General Theory of Relativity states that light is deflected when passing close to a massive body. When observing stars from the Earth or from a satellite like Gaia, we can measure the displacement of the stellar image due to the Sun. Gaia will determine the light-bending term to extraordinary accuracy. It is important to measure this and other relativistic numbers and see if they fit predictions of General Relativity, in view of recent suggestions that Einstein's theory might break down at such levels. ★

Gaia will open our eyes to the Galaxy we live in, telling us about its birth, life and future. Whether you're an astronomer or not, your concept of the Milky Way will surely be revolutionised by Gaia!



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

★ The disc is a thin flattened system containing stars of many different types and ages, gas (predominantly hydrogen), and dust, orbiting around the galactic centre. The disc has a spiral structure, with our Solar System lying in one of the spiral arms. ★ We believe that our galaxy consists of four main components: the disc, the central bulge, a spherical halo, and an outer halo. ★ The Earth orbits the Sun together with 7 other planets and numerous satellites, asteroids, and comets, forming what we know as the Solar System. Our Solar System together with billions of other stars, planets, gas, dust, radiation, and invisible material (dark matter), are gravitationally bound forming a much larger structure: our Milky Way Galaxy. There are huge numbers of galaxies apart from our own, constituting the basic structural units of the Universe. ★

On a clear dark night and with only the naked eye, we can see a faint white band of light across the sky, which is just a projection of the disc of our Milky Way galaxy as seen from the Earth. Because of our position in the galaxy, it is extremely hard to obtain a direct global picture of it, and observing other galaxies gives us enormous clues about large-scale features of our galaxy that remain hidden to us. Nevertheless, complicated observing techniques and calculations have allowed us to construct rather reliable maps of our Milky Way. ★

The Little Books of Gaia

THE GALAXY IN WHICH WE LIVE

