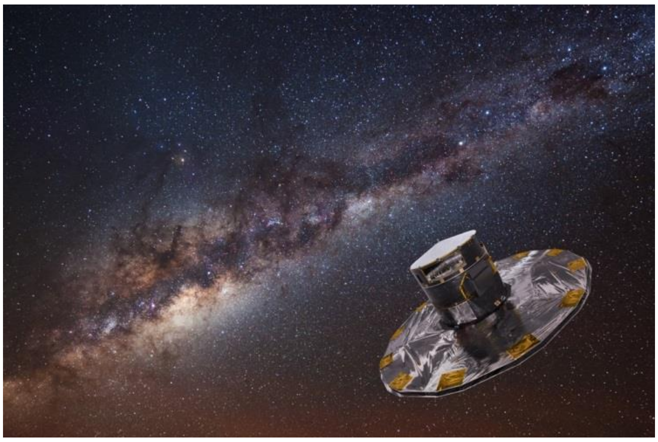
Long summary

Belgian astronomers help to compile the most detailed 3D map of our Galaxy ever made

25 April 2018 - Today, the European Space Agency (ESA) announces the largest and most accurate 3-dimensional map of our Milky Way galaxy ever made. Using the Gaia satellite, the position and motion of more than a billion stars was mapped by a consortium of European astronomers, including Belgian scientists. This map will be a treasure chest to discover the structure, the history, and the future of our Milky Way Galaxy.



The Gaia satellite has been charting the sky since 2014, and its map includes stars that are a million times fainter than what can be seen with the naked eye. Exceptional to Gaia's map is that it also includes the distances to the stars, making it a gigantic 3-dimensional atlas.

Distances to stars are notoriously difficult to estimate because the universe is incredibly vast: even the nearest star to the Sun is 40000 billion km away. Gaia is able to measure distances to stars that are more than 5000 times farther away. The technique used by Gaia requires instruments that are able to measure tiny angles in the sky with extraordinary precision, comparable to the diameter of a human hair from a distance of 1000 km.

Gaia's map also contains measures of how fast and in which direction the stars move through space as they orbit the galactic center, enabling astronomers to study the rotation of our Galaxy. They can also track back the journey of each of these stars over the past million years, and predict where they will be going in the future. Hence, they can predict how the shape of the constellations in the night sky will slowly change in time.

Astronomers had to wait for nearly 20 years for this breakthrough in mapping our Milky Way, but now have at their hands a magnificent atlas unsurpassed both in quality and quantity, which undoubtedly will lead to many discoveries.

Gaia's map will be richly annotated with detailed information about the stars such as surface temperature, chemical composition, possibly brightness variations in time, or whether the star moves around another star. Also objects which are in fact not stars at all but asteroids in our own solar system, or bright objects far outside our galaxy are hidden in the measurements and will be part of Gaia's legacy. Such analysis of Gaia data requires specialized expertise to which Belgian astronomers from KU Leuven, the Royal Observatory of Belgium, Université libre de Bruxelles, Université de Liège and Universiteit Antwerpen contributed. The Belgian participation to the Gaia mission has been made possible through funding provided by the Belgian Federal Science Policy Office (BELSPO) via the PRODEX Programme of ESA.

Image caption: Artist's view of the Gaia satellite in front of the Milky Way. Image credit: ESA/ATG medialab – ESO/S. Brunier

Belgian contributions to the Gaia mission

KU Leuven

"Gaia is the most amazing space mission I ever worked for," says Joris de Ridder Gaia project investigator at KU Leuven." It impacts almost all research fields in astronomy, including my own. Here, at the Institute of Astronomy of the KU Leuven we are leading the task force responsible for classifying all variable stars detected by Gaia. Many stars show tiny brightness variations because their size and temperature changes periodically in time. Like the sound produced by a violin differs much from the sound of a contrabass, different types of stars show different ways of varying their brightness, revealing their nature. We faced a challenging task because of the sheer number of stars observed by Gaia, so we developed artificial intelligence computer codes that are able to recognize variable stars automatically. The current Gaia map already includes more than 550.000 variable stars, but there are many more to come!"

Scientific contact

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Royal Observatory of Belgium

The Royal Observatory of Belgium (ROB) have made a significant contribution to the Gaia project by calculating one important aspect of the star movement: how fast the star is moving in our direction or away from us. This is what scientists called the "radial velocity of the stars". By processing data from the Radial Velocity Spectrometer, an instrument onboard the Gaia satellite, Gaia scientists have computed the radial velocities of more than 7 million stars, data that are published for the first time on this day. "This information will ultimately lead to a better understanding of the structure and formation history of our Galaxy", says Dr. Ronny Blomme, project investigator of the Gaia ROB team.
ROB also contributes to data processing related to asteroids. The present Gaia release contains the precise position of more than 14 000 asteroids
"We are delighted", says Dr. Thierry Pauwels, which works on the software designed to process Gaia solar system object data. "This is the first time our contribution to the Gaia project is made public."

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ULB

"Being part of such a big project, from its early days when it is still a concept on paper till its first big chunk of data comes out is very exciting" says Dimitri Pourbaix, Belgian Principal Investigator for Gaia, "and yet, it is just the premises of the final product to come in a couple of years". Besides the Belgian coordination, Pourbaix also leads the part of the Gaia Data Processing and Analysis Consortium in charge of the object processing (i.e. Solar System Objects (included in this release), Non-Single Stars, and Extended Objects (both to be part of the third data release)). More specifically, the ULB team covers three sub classes of the Non-Single Star segment: the resolved systems (the components can be visually distinguished), the astrometric ones (those seen single but with a disturbed motion), and, finally, the eclipsing systems (objects whose brightness change is caused by a companion blocking some light).

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ULiege

The STARS Institute from ULiège strongly collaborated with the ORB for the measurements of the stellar radial velocities observed by the RVS on-board the Gaia satellite. As explained above, these velocities allow to better understand how the stars are moving around in our Galaxy. "A specific topic held by the Liège team for DR2 is the separation of the observed objects in two categories Single and Non-Single stars (NSS)," as explained by E. Gosset responsible for the spectroscopic NSS channel in Gaia-DPAC. "NSS means that the objects are either in binary or in multiple systems. The Liège team is interested in binary systems per se; but for DR2, the aim is limited to the recognition of NSS in order to eliminate them from the spectroscopic processing. This will allow us to deliver a catalog with well characterized objects." The NSS analysis is delayed to the next Data Release. Already the present release contains more than 7 million stars; it is the first time that such a huge dataset of radial velocity measurements is released.

The Liège team is also involved in the detection of extragalactic objects like quasars (active nucleus of very distant galaxies). "This is the first time that quasars are measured by an astrometric satellite," explains Ludovic Delchambre who recently defended a PhD thesis linked to the Gaia-DPAC processing for quasars. "Some 500000 quasars will be observed by Gaia; this will permit to define a very accurate reference frame".

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UA Universiteit Antwerpen	Scientists from Universiteit Antwerpen contributed to the measurement of radial velocities and to the study of stellar variability. "To get from the first, simulated, light data more than a decade ago to the stunning light curves of tens of thousands of standard candles (my favorite stars, used for measuring cosmic distances), is mindblowing!" says Dr. Katrien Kolenberg from Universiteit Antwerpen. "Moreover, for these stars we now have positions and motions, a 3D map.I feel like a space detective who has just received a new "flashlight" - or rather tens of thousands of them! - to unveil the history and future of our galaxy."

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Short summary

Gaia satellite reveals most detailed 3D map of our Galaxy ever made

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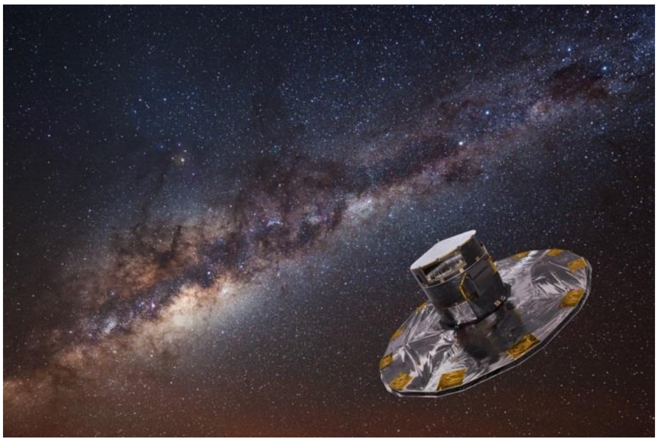

The map covers stars that are a million times fainter than what can be seen with the naked eye, and includes the distances to the stars making it a gigantic 3-dimensional atlas. Gaia also measures how fast and in which direction the stars move through space, which allows astronomers to track back the journey of each of these stars over the past million years, and predict where they will be going in the future.

The release of the new map is a milestone for the astronomical community including scientists from the universities in Leuven, Brussels, Liège and Antwerp as well as the Royal Observatory of Belgium. For decades to come, the map will be a treasure chest to study the structure, the history, and the future of our Milky Way Galaxy.

The Belgian participation to the Gaia mission has been made possible through funding provided by the Belgian Federal Science Policy Office (BELSPO) via the PRODEX Programme of ESA.

Image caption: Artist's view of the Gaia satellite in front of the Milky Way. Image credit: ESA/ATG medialab – ESO/S. Brunier

Appendices

FAQ-FAST FACTS

What is Gaia?

Gaia is an ESA mission launched on 19 December 2013 and observing the sky since 29 July 2014. Its goal is to create the most accurate 3D map of the Milky Way by surveying more than a billion stars. This includes not only star positions and motions but also other key astronomical parameters like their "brightness" (what scientists called magnitude), their colors, and their temperatures. Gaia also maps other objects, such as solar system objects (asteroids, comets and satellites), galaxies and quasars. It will also find new exoplanets and even provide some tests of Einstein's theory of general relativity.

Where is Gaia?

Gaia circles the Sun at a distance of 1.5 million km from Earth away from the Sun, in what is known as the L2 Lagrangian point. The spacecrafts co-rotates with Earth around the Sun.

How does Gaia work?

Gaia's mission relies on repeated observations of star positions in two fields of view, detecting any changes in the object's motion through space. To achieve its mission the spacecraft is spinning slowly, sweeping its two telescopes across the entire celestial sphere to make four complete rotations per day. ESA's ESTRACK stations at Cebreros (Spain), New Norcia (Australia), and Malargüe (Argentina) are used to communicate with the spacecraft. Gaia will communicate with Earth on average about 8 hours per day, transmitting its science and operational data.

What are the Gaia data releases? Why are there several releases?

The huge amount of data Gaia produces (more than a million Gigabyte for the entire mission) requires an enormous amount of computer power and a vast range of scientific expertise that only international networking can provide. Different teams of scientists work on different subsets of the data or on the software designed to process this data abundance. The results of the processing are partially released periodically until the end of the mission, with each new release giving more data and new insights. A first minor data release occurred on 14 September 2016. The present release, the second data release, not only contains the distances to more than a billion stars but also includes new information such as star radial velocities, temperatures, colors, radius and luminosity and an inventory of asteroids. The third data release is expected to occur in the beginning of the 2020s.

Which countries are involved in Gaia?

Scientists involved in Gaia come from twenty European countries (Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Poland, Portugal, Slovenia, Spain, Switzerland, Sweden, and the United Kingdom) as well as from further afield (Algeria, Brazil, Israel, and the United States).

GLOSSARY

Binary stars: A binary star is a system consisting of two stars orbiting around each other, or more precisely, around their common center-of-mass. Recent studies suggest that more than half of all stars are part of binary or multiple-star systems.

Parallax: Parallax is the difference in apparent position of an object viewed along two different lines of sights – just hold a finger out in front of your face, close one eye at a time, and watch your finger and other objects move. The further an object, the less it moves, and thus the smaller the parallax. Astronomers use parallax to measure the distance to nearby astronomical objects, using the different orbital positions of Earth around the Sun as the different line of sights and applying basic geometry.

Proper motion: Stars are not stationary but move around the center of our Milky Way. Our Sun for example rotates at the speed of 220km/second around the galactic center. Proper motion is the rate of the observed changes in the apparent places of stars on the sky, as seen if one places himself or herself in the center of our solar system.

Quasars (or QSD): A quasar, or quasi-stellar object (QSD), consists of a supermassive black hole surrounded by an orbiting accretion disk of gas and dust. As material in the surrounding disk falls toward the black hole, huge amounts of energy are released, making it one of the most luminous objects in our Universe.

Radial velocity: The radial velocity of a star is a measure of how fast the star is moving towards us (negative radial velocity) or away from us (positive radial velocity). The radial velocity of a star is measured using the Doppler effect. Due to the relative motion between the star and the observer, the light coming from the star is shifted to shorter (bluer) wavelenghts when the stars moves towards us, and to longer (redder) wavelengths when moving away from us. This is similar to the change in pitch of a siren passing by.

Variable stars: A variable star is a star whose brightness fluctuates. This variation may be caused by a change in emitted light (intrinsic) or by something partly blocking the light (extrinsic). All stars are variable to a certain degree (our Sun changes about 0.1% in brightness during its solar cycle), but more drastic changes are seen in objects such as eclipsing binary stars, where one star passes in front of another and blocks out some or all of its light, or pulsating giant stars, where the star swells and shrinks, changing its size and brightness. Also dark and bright spots on the stellar surface, such as the Sun's solar spots, can cause observed brightness variations.

ESA GAIA MEDIA KIT:

http://sci.esa.int/gaia/60174-media-kit-for-gaia-data-release-2/

CONTENTS OF MEDIA KIT

A press event about the Gaia Data Release 2 is being organised by ESA at the ILA Berlin Air and Space Show in Germany on Wednesday 25 April 2018, 11:00–12:15 CEST.

The event will be streamed live at: www.esa.int/live