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GAIA SATELLITE

One billion stars in 3D with the help of mathematics

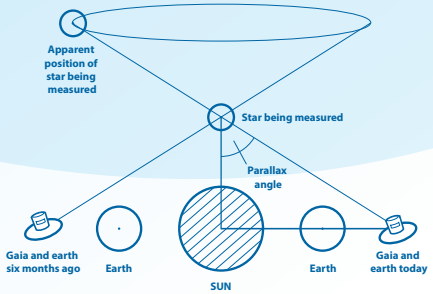
In 2013 the European Space Agency launched a satellite, Gaia, with a five year mission to follow the paths across the sky of over 1 billion stars. The first major release of data by Gaia gives the three-dimensional positions and velocities of 1.3 billion stars. Scientists expect to discover how our Galaxy was assembled and how it is evolving, and to trace the distribution of the Galaxy's mysterious dark matter.

Mathematics is key at every stage of the Gaia mission, from calculating the trajectory and orientation of the satellite, through deciding what data should be gathered, to processing the data into the largest and most complete map ever made of our Galaxy.

The Gaia Satellite orbits around the sun in such a way that the earth is always positioned between the satellite and the sun, enabling the best possible measurements to be taken of stars. Its two telescopes sweep the sky as it spins so it can observe any given piece of sky about 70 times over five years. Every star appears to move across the sky on a wiggly path. This path can be decomposed into a straight line due to the velocity of the star with respect to the sun, and an ellipse due to the motion of Gaia around the sun.

Nearby stars move on the largest ellipses and distant stars move on ellipses too small to detect. The size of the ellipse is called the star's parallax and the variation of parallax with distance is similar to the effect experienced when driving along in a car: a nearby tree will seem to fly past, whereas a distant mountain will move hardly at all.

Simplified diagram demonstrating the Parallax Angle (not to scale)



Every year the tens of billions of positions recorded by Gaia are fed into a giant computer program that compares these positions with the predictions of a model in which each star has an initial position on the sky, a parallax and a velocity across the sky. The computer adjusts the initial position, parallax, etc for each star to find the best match between the model's predictions and the actual observations. From the resulting positions and velocities, researchers plan to produce a fully working computer model of our Galaxy, which encapsulates everything mankind knows about it.

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Image on front: Artist's impression of the Gaia spacecraft, with the Milky Way in the background.