

# Science performance of Gaia, ESA's space-astrometry mission

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**Abstract** Gaia is the next astrometry mission of the European Space Agency (ESA), following up on the success of the Hipparcos mission. With a focal plane containing 106 CCD detectors, Gaia will survey the entire sky and repeatedly observe the brightest 1,000 million objects, down to 20<sup>th</sup> magnitude, during its 5-year lifetime. Gaia's science data comprises absolute astrometry, broad-band photometry, and low-resolution spectro-photometry. Spectroscopic data with a resolving power of 11,500 will be obtained for the brightest 150 million sources, down to 17<sup>th</sup> magnitude. The thermo-mechanical stability of the spacecraft, combined with the selection of the L2 Lissajous point of the Sun-Earth/Moon system for operations, allows stellar parallaxes to be measured with standard errors less than 10 micro-arcsecond ( $\mu\text{as}$ ) for stars brighter than 12<sup>th</sup> magnitude, 25  $\mu\text{as}$  for stars at 15<sup>th</sup> magnitude, and 300  $\mu\text{as}$  at magnitude 20. Photometric standard errors are in the milli-magnitude regime. The spectroscopic data allows the measurement of radial velocities with errors of  $15 \text{ km s}^{-1}$  at magnitude 17. Gaia's primary science goal is to unravel the kinematical, dynamical, and chemical structure and evolution of the Milky Way. In addition, Gaia's data will touch many other areas of science, e.g., stellar physics, solar-system bodies, fundamental physics, and exo-planets. The Gaia spacecraft is currently in the qualification and production phase. With a launch in 2013, the final catalogue is expected in 2021. The science community in Europe, or-

ganised in the Data Processing and Analysis Consortium (DPAC), is responsible for the processing of the data.

**Keywords** Astrometry · Photometry · Spectroscopy · CCD · Telescope · Data reduction · Calibration

## 1 Science objectives

The primary objective of the Gaia mission is to survey 1,000 million stars in our Galaxy and beyond. Data from this census will foremost allow to address fundamental questions about the formation, structure, and evolution of our Galaxy, but will also provide unique insight into many other areas of astronomy.

### 1.1 Galactic structure

Gaia will perform a unique all-sky survey to map the three-dimensional position and velocity of all objects down to 20<sup>th</sup> magnitude. The Gaia data will encompass at least 1,000 million stars that together cover a significant fraction of the Galaxy's volume: the accuracy and sensitivity of Gaia allows stars to be detected, and their position and velocity to be measured, from the solar neighbourhood, all the way through the disc of the Milky Way, to the bulge at the Galactic centre, and even further out into the halo. Accurate knowledge of stellar velocities and three-dimensional positions gives insight into the structure and dynamics of our Galaxy, including the build up of its different stellar components through past accretion and merger events with smaller satellite galaxies (Fig. 1).

The distributions of stars in the Galaxy over position and velocity are linked through gravitational forces and the star-formation rate and history as a function of position and time.

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