Press release: UK astronomers open new window on the Universe

The detailed information of this census of over one billion stars, which comes from the Gaia mission, allows their positions and distances to be mapped to unprecedented precision giving us a 3-dimensional map of our Milky Way Galaxy.

This new release of information shows us 600 times more stars than previously available, covering a volume 1,000 times larger than Gaia's own first data release two years ago, with precision some one hundred times improved. These results allow improved study of almost all branches of astronomy: from traces of the formation of the Solar System; through how stars evolve; through the current structure, the assembly and evolutionary history of the Milky Way; to mapping the distribution of Dark Matter in the Galaxy; to establishing the distance scale in the Universe; to discovery of rare objects.

This second data release allows progress in all these studies by providing not only distances and apparent motions across the sky for 1.3billion sources, but also very precise measurements of brightness and colour for an even larger catalogue of 1.7billion sources. Seven million stars have their line of sight velocities measured, providing full 6-dimensional – three space positions, 3 space motions – information, determining full orbits for those stars in the Milky Way. This is the information needed to weigh the Galaxy, and determine the distribution – and perhaps the properties – of Dark Matter, the mysterious substance which dominates the mass of the Galaxy and the Universe.

Credit: ESA/Gaia/DPAC

The mission is reliant on the work of UK teams at the Universities of Cambridge, Edinburgh, Leicester, Bristol, the Mullard Space Science Laboratory (MSSL) at UCL London and the Science and Technology Facilities Council's (STFC) RAL Space facility, all of whom are contributing to the processing of the vast amounts of data from Gaia, in collaboration with industrial and academic partners from across Europe.

Professor Gerry Gilmore from the University of Cambridge, UK Principal Investigator for the UK participation in the Gaia Data Processing and Analysis Consortium, and one of the original proposers of the mission to ESA, said:

"The combination of all these unprecedented measures provides the information for astronomers to take the next big steps in mapping the formation history and evolutions of stars and our Milky Way Galaxy. There is hardly a branch of astrophysics which will not be revolutionised by Gaia data. The global community will advance our understanding of what we see, where it came from, what it is made from, how it is changing. All this is made freely available to everyone, based on the dedicated efforts of hundreds of people. There are

so many exciting things to do better with the exquisite Gaia data we anticipate new science papers appearing every day after this release."

UK participation in the European Space Agency mission itself has been funded by the UK Space Agency and scientists and engineers from around the UK played key roles in the design and build of Gaia.

The UK Space Agency has already contributed £15 million to Gaia and is committed to spending a further £4 million on processing and analysing the data.

Dr Graham Turnock, Chief Executive of the UK Space Agency, said:

"We're working with industry and academia to support cutting-edge science that will lead to new discoveries about our Galaxy.

"The UK involvement in this exciting mission shows that our academics and engineers are world leaders in the space sector. As part of ESA we will continue to be at the forefront of research and deeply involved in missions such as ExoMars, with its Airbus-built rover, and the BepiColombo mission to Mercury."

One of the new aspects of the Gaia data released today are radial velocities derived from Gaia spectra. Gaia releases radial velocities for some 7million stars, many times more than have been measured in the history of astronomy up to now, with vastly more to come in future releases.

Professor Mark Cropper leads the team at Mullard Space Science Laboratory/UCL that made the UK contribution to this spectroscopic processing effort and said:

"Spectra provide the critical information to complement Gaia's astrometry, providing line of sight (radial, Doppler-shift) velocities and precise measures of stellar chemical element abundances. Gaia measures huge numbers of individually low-signal spectra – nearly 20 billion separate spectra to date – which must be carefully combined to deliver their full value. This demanding process is worth the effort! The remarkable map of the changing average radial velocity as we look around the sky is direct evidence of the rotation of our Galaxy."

Dr Floor van Leeuwen from the University of Cambridge has been Project Manager for the UK and European photometric processing work, and is a leading co-author on the example science papers illustrating Gaia's impact on our knowledge of star clusters and satellite galaxies in the outer Milky Way. Speaking of the new findings he said "Groups of dwarf galaxies, including the Magellanic Clouds, can now be observed to be moving around in very similar orbits, hinting at a shared formation history. The accurate observed motions and positions of the globular clusters and dwarf galaxies provide tracers of the overall mass distribution of our galaxy in a way that has not been possible with this level of accuracy before."

STFC helped the set-up of the data applications centre for the project and STFC's current support involves the UK exploitation of the scientific data

that is now being yielded from the mission. In addition the photometric data processing software to which STFC contributed, as part of the UK-led team, offers the ability to precisely measure the brightness of the billion objects that Gaia is observing, while contributions from the rest of Europe are charting the positions, distances and movements of those one billion stars.

Professor Ian McCrea, Space Physics and Operations Division Head at STFC's RAL Space said:

"Four years into the Gaia mission and it is incredible to see that our work in the UK on developing the photometric data processing software, that precisely measures the brightness of the billion objects that Gaia is seeing, is now successfully giving us comprehensive and detailed information that helps us better understand our true place in the Milky Way, our home galaxy. With this new data release and those that will follow, I am excited to see what new celestial objects, such as extra-solar planets, brown dwarfs, supernovae, asteroids, and of course, things that we have not even imagined have now been recorded."

Gaia orbits the sun at a distance of 1.5 million kilometres from the earth and was launched by the European Space Agency in December 2013 with the aim of observing a billion stars and revolutionising our understanding of the Milky Way. During its expected five-year lifespan, Gaia will observe each of a billion stars about 70 times.

A special aspect of the Gaia mission is that the teams involved do not keep the results for their own science interests. Instead the Gaia data is released with free access to everyone for analysis and discovery.