

Astrowatch

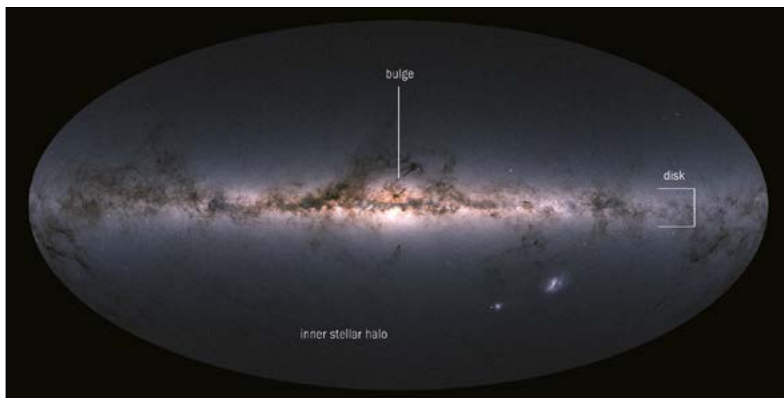
COMPILED BY MERLIN KOLE, DEPARTMENT OF PARTICLE PHYSICS, UNIVERSITY OF GENEVA

Gaia finds evidence of old Milky Way merger

Many of the stars appearing in the night sky did not originate from within our galaxy, concludes a new study of data from the European Space Agency's Gaia observatory. Instead, Gaia has found evidence that these stars formed in a smaller galaxy that merged with ours about 10 billion years ago.

Gaia was launched in 2013 with the aim of measuring the positions and distances of more than one billion astronomical objects (mainly stars) in and around our galaxy with unprecedented precision. Using Gaia data containing about seven million stars, Amina Helmi of the University of Groningen in the Netherlands and colleagues have found that a subset of these stars is different from the bulk of the stars in the Milky Way. Earlier research had shown that some stars in the galaxy's inner stellar halo, which surrounds the central bulge and disk, have different chemical abundances from the bulge and disk stars (see figure). But the latest study found that these halo stars also exhibit orbits around the galactic centre that differ significantly from the rest of the stars.

The orbits of the stars in a galaxy typically follow that of the gas cloud in which they were born, which means that a proto-galaxy consisting of an orbiting gas cloud will produce stars orbiting along with the cloud. However, Helmi and co-workers show that many of the Milky Way's halo stars orbit backwards relative to the rest of the galaxy, suggesting that their origin is probably different. The team then compared the Gaia observations with simulations in which the Milky Way merged in the past with a smaller galaxy with 25% of its mass, finding a remarkable similarity between



Gaia's all-sky view of the Milky Way and neighbouring galaxies, based on measurements of nearly 1.7 billion stars. A recent analysis of Gaia data shows that stars from the galaxy's inner stellar halo, which surrounds the central bulge and disk, formed in a smaller galaxy that merged with the Milky Way in the past.

the observed and simulated orbits.

Additional analysis of spectral data from APOGEE-2 (Apache Point Observatory Galactic Evolution Experiment), which is part of the Sloan Digital Sky Survey, revealed that the halo stars contain fewer of the chemical elements that are produced in specific types of supernovae, indicating that they are significantly older than the bulk of the Milky Way's stars.

Taken together, the results suggest that, after the smaller galaxy (named Gaia–Enceladus by the authors) merged with the Milky Way, it lost all the gas it needed to produce new stars. As a result, only the old stars survived and no new stars were born. The age of the youngest stars from Gaia–Enceladus – about 10 billion years – can

therefore tell astronomers when the merger took place. A final piece of evidence that this dramatic event occurred comes from Gaia data of 13 star clusters orbiting the Milky Way at large distances. The orbits of these clusters, which contain millions of gravitationally bound stars, match those that would be expected for the remnants of Gaia–Enceladus.

The results, published in *Nature*, constitute one of the first major discoveries to emerge from Gaia data. They shed light on the origin of our galaxy and galaxy mergers in general, but much more will no doubt be learned from the vast amount of data that the satellite has gathered.

● Further reading

A Helmi *et al.* 2018 *Nature* **563** 85.

Picture of the month

This single image captures three objects with very different lifetimes. The bright yellow line is the result of a meteor that disintegrated in Earth's atmosphere and was visible for less than a second (*CERN Courier* October 2018 p19). The meteor was probably a piece of debris from comet 21P/Giacobini–Zinner. This comet is also captured in the centre of the image (white streak of light) and is responsible for the yearly Draconid meteor shower. The comet and its long dust tail have been visible across the night sky for several months but are now slowly fading as the comet moves away from Earth. The image is completed by the Seagull Nebula (pink), which consists of gas illuminated by surrounding stars (*CERN Courier* May 2018 p17) and will probably remain visible for many thousands of years.



ESA/Gaia/DPAC

T. Saitoh/m2su



Introducing...Best Cyclotron & Best Particle Therapy Systems from TeamBest® Companies!

Best Cyclotron Systems provides 15/20/25/30/35/70 MeV Proton Cyclotrons as well as 35 & 70 MeV Multi-Particle (Alpha, Deuterons & Protons) Cyclotrons

- Currents from 100uA to 1000uA (or higher) depending on the particle beam
- Best 20u and 30u are fully upgradeable on site



Installation of Best 70 MeV Cyclotron at Italian National Laboratories (INFN), Legnaro, IT

Cyclotron	Energy (MeV)	Isotopes Produced
Best 15	15	^{18}F , $^{99\text{m}}\text{Tc}$, ^{11}C , ^{13}N , ^{15}O , ^{64}Cu , ^{67}Ga , ^{124}I , ^{103}Pd
Best 20u/25	20, 25–15	Best 15 + ^{123}I , ^{111}In , $^{68}\text{Ge}/^{68}\text{Ga}$
Best 30u (Upgradeable)	30	Best 15 + ^{123}I , ^{111}In , $^{68}\text{Ge}/^{68}\text{Ga}$
Best 35	35–15	Greater production of Best 15, 20u/25 isotopes plus ^{201}Tl , $^{81}\text{Rb}/^{81}\text{Kr}$
Best 70	70–35	$^{82}\text{Sr}/^{82}\text{Rb}$, ^{123}I , ^{67}Cu , ^{81}Kr + research



Proton-to-Carbon High Energy Particle Delivery System:

- Intrinsically small beams facilitating beam delivery with precision
- Small beam sizes – small magnets, light gantries – smaller footprint
- Highly efficient single turn extraction
- Efficient extraction – less shielding
- Flexibility – protons and/or carbon, future beam delivery modalities



ion Rapid Cycling Medical Synchrotron (iRCMS)

