'Revealing the Milky Way with Gaia and the Roadmap towards GaiaNIR (GaiaCombo)' Abstracts

Talks

Why is the Milky Way stellar halo slowly rotating?

Authors

Kirill Batrakov (1), Alis Deason (1), Francesca Fragkoudi (1)

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Abstract

Gaia observations have revealed that the Milky Way (MW) stellar halo has a weak net rotation of approximately 10-20 km/s, yet the origin of this rotation remains unexplained. Motivated by this finding, I investigated the rotation of stellar haloes over a redshift range of 0-2.5 in Auriga – a suite of magnetohydrodynamical cosmological zoom-in simulations of MW-like galaxies. I find that rotational velocity at z=0 is lower for haloes which are: 1) formed earlier; 2) underwent a GES-like merger event; 3) experienced a disc flip event (defined as the change in orientation of the disc's angular momentum axis by more than 90 degrees). I also identify a correlation between the rotation of stellar and DM haloes both today and in past, suggesting a common origin of their evolution. I propose that anisotropic satellite accretion onto the host is the most probable reason for this. I found that haloes which experienced disc flips tend to have satellites with more misaligned orbital planes and lower orbital circularities, supporting the argument of anisotropic accretion. These results suggest that the MW likely underwent a disc flip in its formation history, and that its DM halo likely rotates relatively slowly.

Gaia data access and DR4: preparing for 500 terabytes

Authors

Nigel Hambly (1)

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Abstract

I will describe current access facilities for Gaia data and how these have been enhanced to cope with the arrival of approximately 500 terabytes of products in Data Release 4 at the end of the year. I will concentrate on the new, high volume data products, and the code-to-data platforms that will be important for up-scale exploitation of those data. I will demonstrate one particular facility which hosts the full Gaia DR3 and associated data sets and tools now. The service is available for users to familiarise themselves in advance of the avalanche of data at DR4.

Dynamical Models of Gaia Sausage-Enceladus in Tilted and Evolving Haloes

Authors

Adam Dillamore (1), Jason Sanders (1), Richard Brooks (1)

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Abstract

The structure of the Milky Way's accreted stellar halo is widely used to infer its merger history, under the assumption that present-day debris retains memory of its accretion. In particular, the Gaia Sausage-Enceladus (GSE) debris is observed to be triaxial and tilted with respect to the Galactic disc. If this configuration is long-lived, it places constraints on the dark matter halo capable of supporting it in near-equilibrium.

We use a novel method to construct equilibrium orbit-superposition (Schwarzschild) models of the stellar halo embedded in a Milky Way potential with a tilted dark matter halo, matched to density and kinematic constraints of GSE stars over radii 6-60 kpc. We find that spherical haloes cannot support the observed structure in steady state. Instead, the data favour a near-prolate dark matter halo whose long axis is significantly inclined relative to the disc, with a radius-dependent tilt in the stellar halo.

However, the GSE is also susceptible to perturbations from satellites, particularly the Large Magellanic Cloud (LMC). Using test-particle simulations, we show that the LMC can induce triaxiality in high-anisotropy populations, aligning their major axes with its orbital plane and tilting them by up to $\sim 14°$ with respect to the Galactic disc. For strongly radial orbits, this dynamical alignment generates overdensities at heliocentric distances as small as 15 kpc, coincident with the well-known Virgo Overdensity (VOD) and Hercules-Aquila Cloud (HAC). These results suggest that the present-day morphology of accreted debris reflects both the Galactic potential and recent dynamical evolution, complicating attempts to reconstruct the Milky Way's merger timeline from stellar halo structure alone.

Reconstructing the Mass Assembly of the Milky Way Halo with Gaia DR3 XP Metallicities

Authors

Emma Dodd (1)

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Abstract

While CDM successfully explains large-scale structure formation, testing its predictions on small mass scales remains challenging. The lowest-mass satellite galaxies are expected to have been largely destroyed, but their remnants survive as stellar debris in galactic haloes. The study of the Milky Way halo has been transformed by the exquisite data from Gaia, including the release of low-resolution XP spectra in Gaia DR3. From these spectra, large and unprecedented all-sky catalogues of photometric metallicities have been derived. Harnessing the huge increase in statistics provided by these catalogues, I will present a novel method to reconstruct the luminosity function of destroyed dwarf galaxies directly from the Galactic halo's metallicity distribution. This approach exploits the fact that a galaxy's present-day metallicity distribution can be modelled as the superposition of its accreted progenitors, together with the well-established mass–metallicity relation linking metallicity to stellar mass. Using these metallicities, inferred from Gaia DR3 XP spectra, I will present a quantitative reconstruction of the mass spectrum of dwarf galaxies accreted by the Milky Way. Looking ahead, Gaia DR4 will significantly improve the precision and depth of the XP spectra, enabling these techniques to probe even fainter populations and larger halo volumes. Together, this framework, combined with upcoming Gaia releases, provides a powerful way to reconstruct the hierarchical assembly of the Milky Way and extend these methods to Local Group satellites.

Gaia DR4: a glimpse on the photometric content

Authors

Giorgia Busso (1)

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Abstract

Gaia is one of the most successful projects from the European Space Agency. Across more than 10 years since its launch, it has transformed our understanding of the Milky Way by precisely mapping the positions, motions, and properties of almost two billion stars. Gaia Data Release 4 catalogue will contain almost a billion more sources
and a large number and diversity of data products, obtained by the processing of the 5-year nominal mission, including not only the source level parameters for all ~2.8B sources, but also the individual (epoch) observations. My talk will focus in particular on the spectrophotometric data, i.e. the mean and epoch photometry for G, BP, RP, the mean and epoch BP, RP spectra, crowded fields, synthetic photometry, and source environment analysis data.

Radial Velocity Spectrometer (RVS) data in Gaia Data Release 4 (Invited)

Authors

George Seabroke (1)

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Abstract

I will briefly review how Gaia's Radial Velocity Spectrometer (RVS) contributed to Gaia Data Release 3 (2022), Gaia's Focused Product Release (2023) and Gaia's ground-breaking black hole discovery (Gaia BH3, 2024) before presenting the upcoming RVS data products in Gaia Data Release 4.

The Gaia Mission: Status and the Upcoming Gaia DR4 Release. (Invited)

Authors

Nicholas Walton (1)

(1) Institute of Astronomy, University of Cambridge

Abstract

This presentation will give an update of the Gaia mission. It is now in the post-operations phase, with preparations well underway for the upcoming December 2026 Gaia Data Release 4. This will contain full epoch data from the 5 year nominal mission. The presentation will also update on progress in preparing the final extended mission data release 5.

The road to GaiaNIR: time-domain infra-red surveys for inner Galaxy science (Invited)

Authors

Jason Sanders (1)

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Abstract

The inner parts of the Milky Way contain crucial information on the dynamical and chemical history of the Galaxy, but strong extinction and crowding make them difficult to study with optical surveys such as Gaia. Near-infrared time-domain surveys such as VVV(X), PRIME and the forthcoming Roman survey have begun to transform this picture, enabling detailed characterisation of the stellar populations of the Galactic bar-bulge and the nuclear stellar disc (NSD). In this talk, I will discuss what time-domain near-infrared data reveal about the structure, dynamics and chronology of the inner Galaxy, focusing on the use of Mira variable stars as chronological tracers of the still-uncertain bar formation epoch. I will put these results within the broader near-infrared survey landscape, highlighting the role of homogeneity, depth and long temporal baselines in producing robust Galactic archaeology constraints. In this context, GaiaNIR represents the natural next step, extending Gaia's astrometry into the extinguished central regions of the Milky Way and providing homogeneous chrono-dynamical information on the Galactic bar-NSD timeline.

The GaiaNIR mission and the hidden regions of our Galaxy (Invited)

Authors

David Hobbs (1)

(1) Lund University

Abstract

Our Galaxy contains many different types of stars and planets, interstellar gas and dust, and dark matter. These components are widely distributed in age, reflecting their formation history, and in space, reflecting their birth place and subsequent motion. Objects in the Galaxy move in a variety of orbits that are determined by the gravitational force, and have complex distributions of different stellar types, reflecting star formation and gas-accretion history. Understanding all these aspects in one coherent picture is being partially achieved by the Gaia mission, which surveyed a sample of around 1% of the Galaxy. The Gaia mission focused on astrometry which makes precise angular measurements of stellar positions, parallaxes/distances and proper motions on the sky. This field dates back to antiquity with the work of Hipparchus (190-120 BC) and Ptolemy (100-170 AD).

Despite these significant advancements, much more can be achieved by harnessing Near InfraRed (NIR) light using new state-of-the-art detectors to peer through the dust and gas to reveal the hidden regions of the Galaxy. A new all-sky NIR astrometric mission will expand and improve on the science of Gaia using basic astrometry. NIR astrometry is crucial for penetrating obscured regions and for observing intrinsically red objects that are otherwise difficult to detect. The new mission is aimed at surveying around 25% (> 50 billion stars) of the Galaxy, revealing important new regions obscured by interstellar gas and dust while also significantly improving on the accuracy of the previous results from Gaia. The new mission would not launch until around 2045 but work on developing the concept has already begun. This mission promises to revolutionise our understanding of the dynamics of our Galaxy, offering new insights into its hidden ecosystems and generate the first comprehensive map of our Galactic quadrant.

Last year, ESA's governing body - the Council of Ministers, held a meeting where ESA's budget for the coming years was decided. ESA is now starting to make detailed plans for future space missions to fulfil the science themes outlined in Voyage 2050. We are now preparing to submit our proposal for a future L-class mission and are beginning to develop a GaiaNIR consortium. The new consortium will initially be focused on preparing the proposal but will eventually evolve into a structure similar to Gaia’s DPAC. I will briefly outline our plans for this.

GaiaNIR:UK: Status and Science Outlook (Invited)

Authors

Nicholas Walton (1)

(1) Institute of Astronomy, University of Cambridge

Abstract

The Galactic Ecosystems theme is a candidate science topic for the ESA Voyage 2050 Large 5 launch slot. GaiaNIR is proposed, based on the heritage of the Gaia mission, with the notable difference that the detectors would give coverage reaching into near infra-red wavelengths. This enables observations of stars in our Milky Way (MW) in regions of high extinction, the parts of our Galaxy hidden to Gaia, in particular the Galactic centre and inner disk regions, to be observed.

The presentation will update on the GaiaNIR activities in the UK and describe how the UK community can engage with and help refine the GaiaNIR science case. In addition the presentation will discuss underpinning technical work currently in progress in the UK assessing the performance and suitability of novel low noise infrared detectors as an option for a GaiaNIR mission.

Posters

Gaia Data Solves the Hubble Tension

Authors

John Baruch (1)

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Abstract

The errors on the Gaia parallax data are reported to be about one or two micro arc-seconds (Riess et al 2021). These tiny errors are the result of stellar calibration across the sky with over a million quasars which have zero parallax. The colour and brightness are calibrated using nearly a million double stars which have identical parallaxes. The best photometry available today is the Cepheid photometry of the Adam Riess SHoES team using the Hubble Telescope (Riess et al 2021). The photometry gave them the absolute magnitude of the Cepheids and hence their parallax distances. They didn't agree with the Gaia parallaxes from Early Data Release three. Riess team solved the conflict by declaring a zero point error in the Gaia parallaxes. Here I examine in detail whether the Gaia parallaxes EDR3 and the correction software produced by the Gaia team (Lindegren et al 2021a and 2021b) could be out by 10 micro arc seconds. If the Gaia parallaxes are correct to one or two micro arc-seconds, the Gaia data produces breakthrough science in a number of areas. One area will be discussed.

1. Riess A.G. et al 2021, ArXiv:2012.08534v2
2. Lindegren L., Bastian U., Biermann M., et al, 2021b, A&A 649, A4
3. Lindegren L., Klioner S.A., Hernández J., et al, 2021a, A&A 649, A2