The Halo-Disc dynamical coupling

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Gaia blind detection of the Monoceros and ACS structures

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The astrometric sample provided by *Gaia* allows us to study the disc far from the Sun, in the halo and at their interface. It is at the very edge of the disc where the effects of external perturbations is most noticeable, but also where there could be the remnants of accreted satellites. Our goal is to characterise the kinematic substructure present at the edge of the Milky Way (MW) disc to provide observational constrains that can help us identify their origin. We present the most precise characterisation of Monoceros and the Anticentre stream (ACS), detected for the first time exclusively in phase-space, without limiting ourselves to a particular stellar type. Our results allow future works to model their orbital parameters, chemistry and star formation history, to establish their origin and, ultimately, understand the most influential processes that shaped the MW over its history.

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Context

- The Milky Way (MW) is out of equilibrium. Structures in the halo like satellite galaxies or dark-matter subhalos, can perturb the phase-space distribution of the particles both in the internal parts of the Galaxy, like the disc (Antoja+18), as well as the outer halo (Erkal+19).

- The Sagittarius dwarf galaxy (Sgr) can induce a significant amount of kinematic substructure in the MW disc (e.g., Purcel+11, Widrow+12, Gomez+13, Antoja+18, Laporte+18-19).

- In particular, the interaction with a dwarf galaxy similar to Sgr can 'kick' the stars at the outer regions of the disc, which will then start to behave like streams as a result of the self-gravity of the disc being weak so far out.

- Newberg+02, and latter Crane+03, detected an unexpected over density of MSTO stars towards the anticenter, and at positive Galactic latitudes, known as the Monoceros structure. Latter, Grillmair+06 detected a similar feature at even greater latitudes, the Anticentre stream (ACS), which also seemed to be a stellar stream.

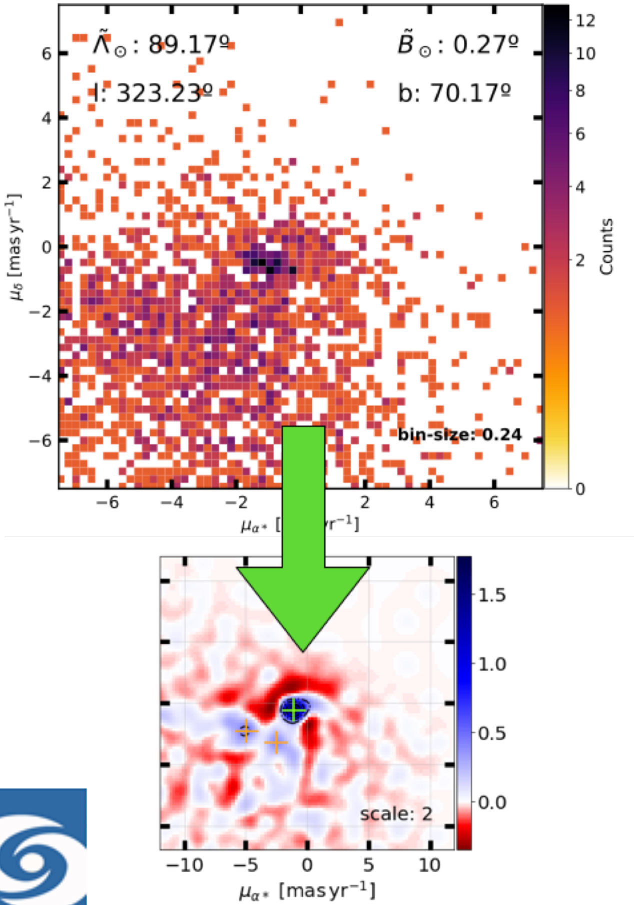
- Although the external origin was the preferred explanation for some time (i.e., accreted galaxies), the chemistry and age distribution of the stars in Monoceros and ACS point towards a perturbative origin (e.g., Laporte+20).

- Obtaining a precise measurement of the kinematic properties of these structures will allow us to constrain the mass and time of the (external) perturbation as well as learn about the chemical and dynamical evolution of our Galaxy.

Data and Methods

- *Gaia* data: all stars with parallax-parallax_error < 0.1 mas & bp_rp > 0.2 mag

- Total sample: 700 412 152 sources



- For each HEALpix level 5 (~3deg^2), we download **directly** the proper motion histogram from the *Gaia* Archive.

- We apply the Wavelet Transformation, detect significant over-densities (based on Poisson-noise test) with a peak-detection algorithm.

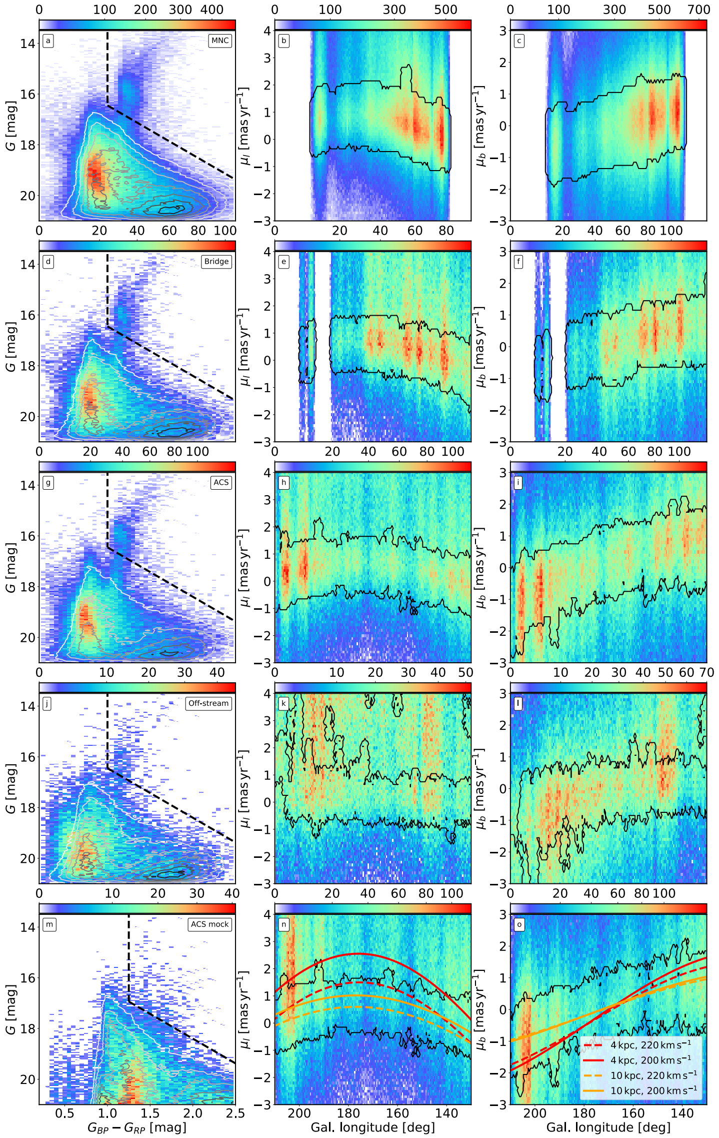
- Select only the most significant kinematic structure at each HEALpix.

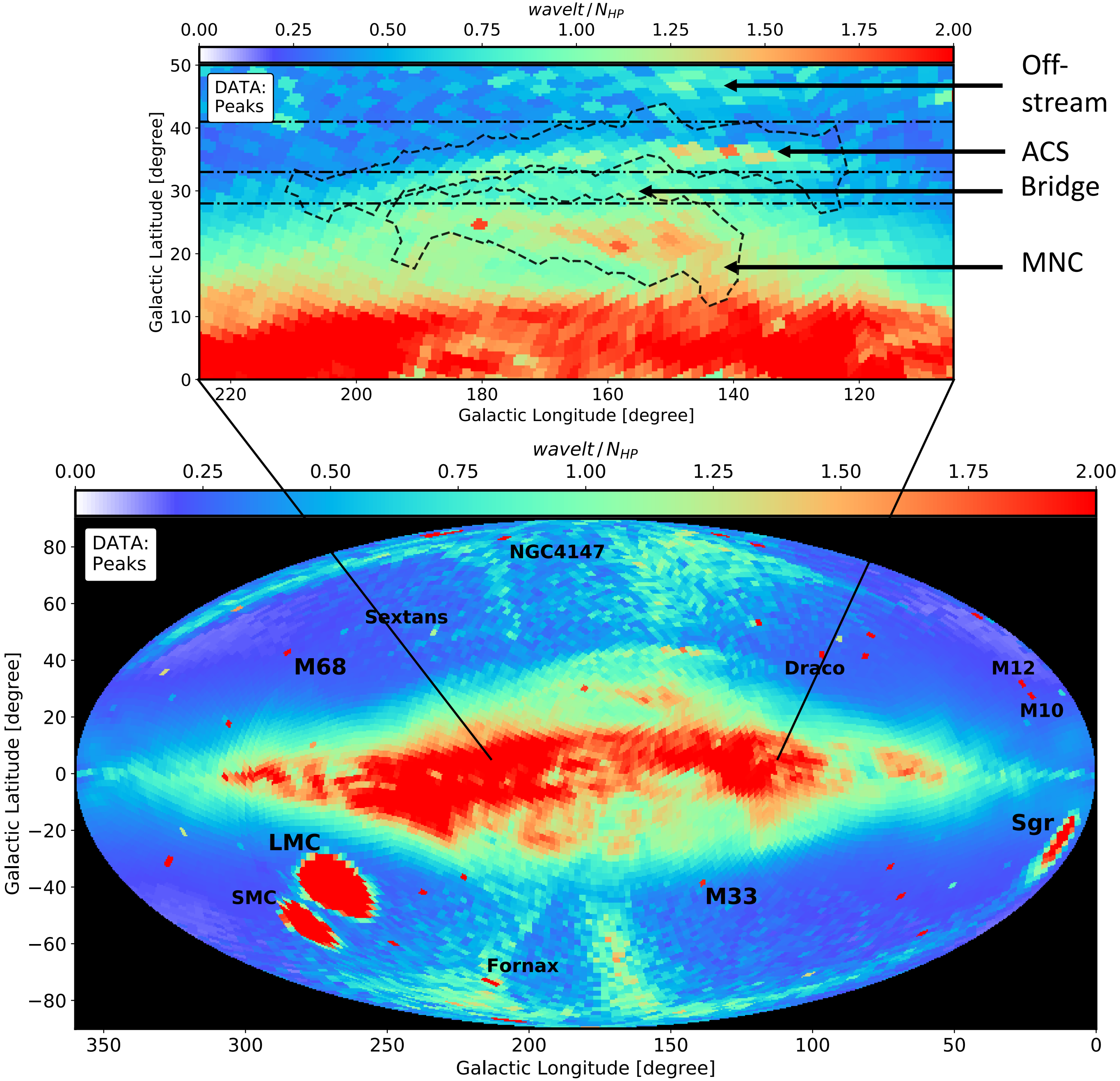
Results

- Kinematics compatible with disc-like stars at ~10 kpc

- Conspicuous Red Clump compatible with a population at ~10 kpc

- This population is not expected in an axisymmetric disc in equilibrium.

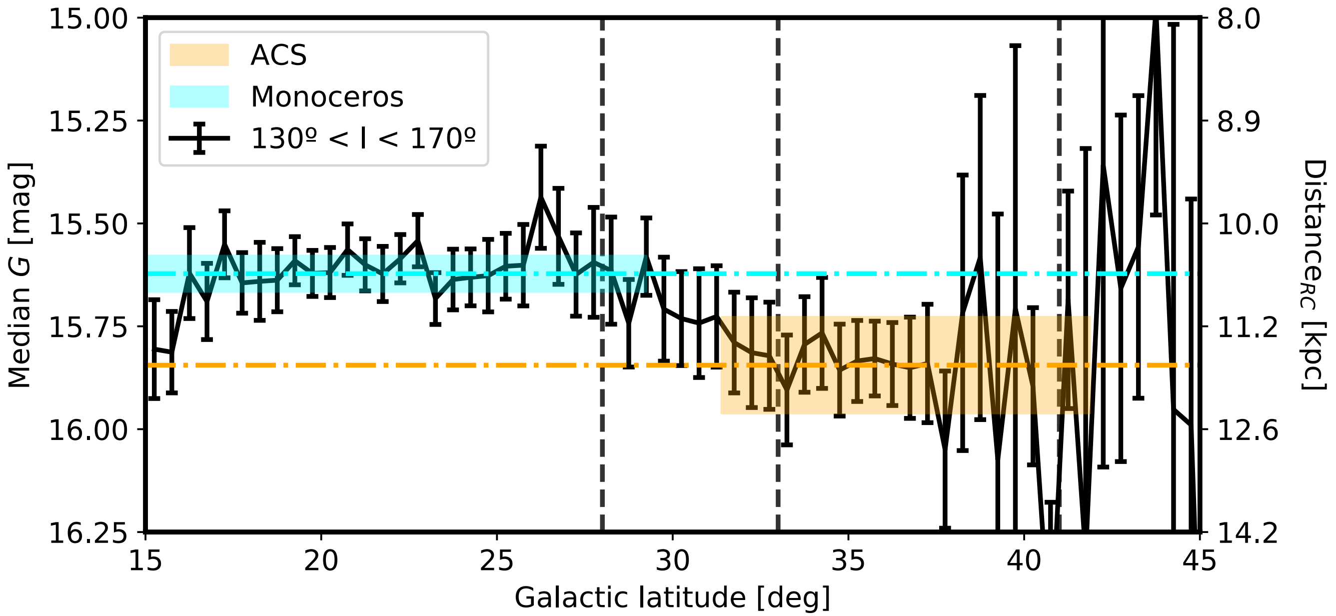


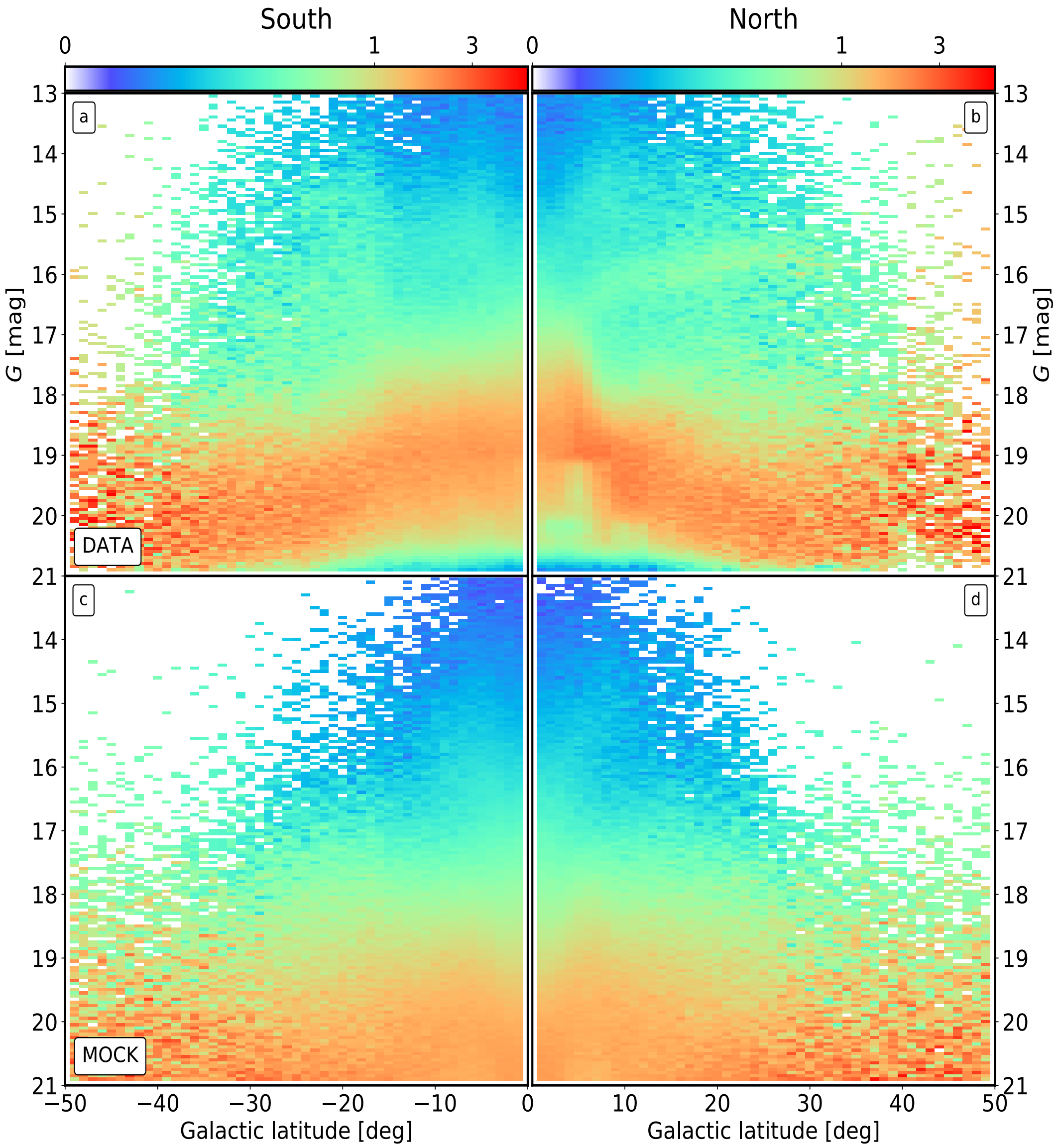


Results

- The apparent magnitude of the Red Clump in Monoceros allows us to trace this structure up to b~5º, closer to the disc than ever before.

- Monoceros and ACS are two different structures that, being so extended in 5D, overlap in physical and kinematical space.





Conclusions and prospects

- Blind detection of the kinematic substructure in the anticentre, without selecting any population before hand.

- *Gaia*, combined with a smart use of the Archive and the Wavelet Transform, has revealed the sharpest picture of the anticentre to date.

- We observe a clear arch-like for Monoceros, which we can trace down to latitudes of roughly 5º, between longitudes 120º to 230º, with no clear continuity in the South hemisphere.

- ACS presents the highest intensity at longitudes of ~140º, after which suddenly vanishes.

- Based on its kinematics and its CMDs, we prefer a disc origin for both.

- Our excellent data allows for the precise modelling of Monoceros and ACS and compare, quantitatively, the different models available to explain their origin.

- *Gaia* EDR3 will improve significantly the quality of the kinematic data and, as a result, also the membership.