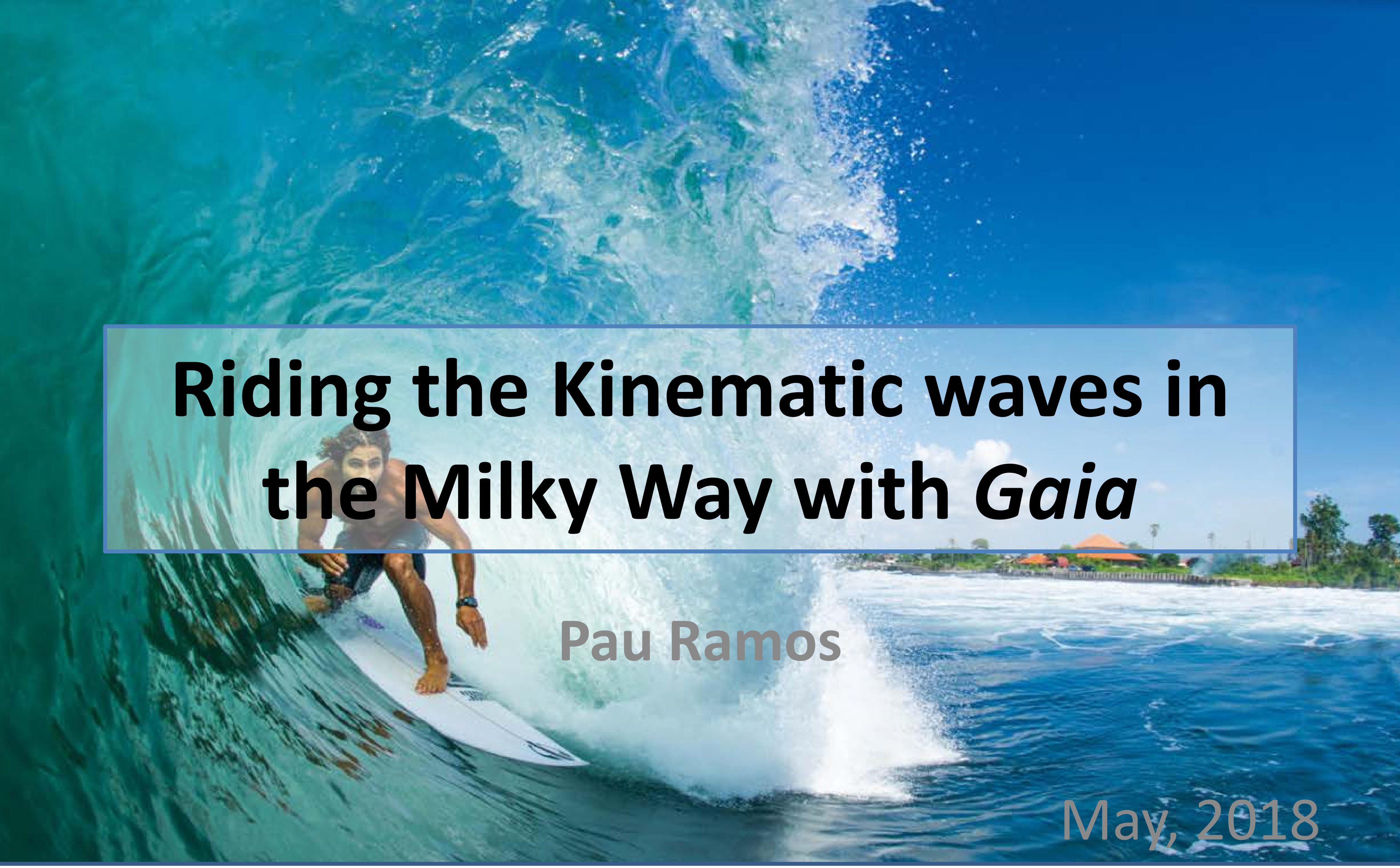


Riding the Kinematic waves in the Milky Way with *Gaia*

Pau Ramos

May, 2018

gaia

ICCUB

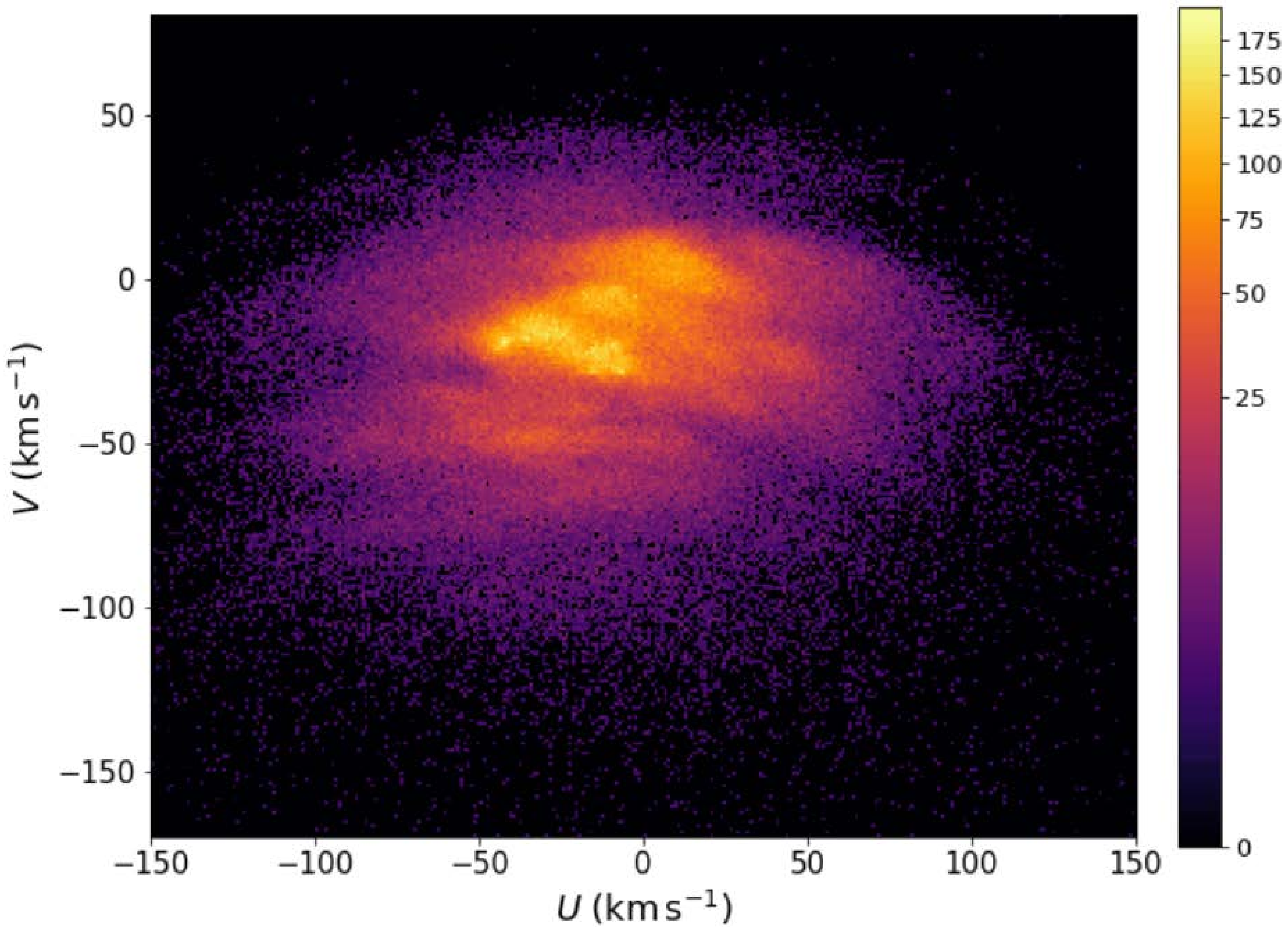
Kinematics

What are we looking at?

The velocity distribution of stars **is not** smooth**,**
it contains much more information

- Imprints of past events
- Gaps and over-densities caused by resonances with bar/spiral/bar+spiral
- Non-axisymmetric potential

Now



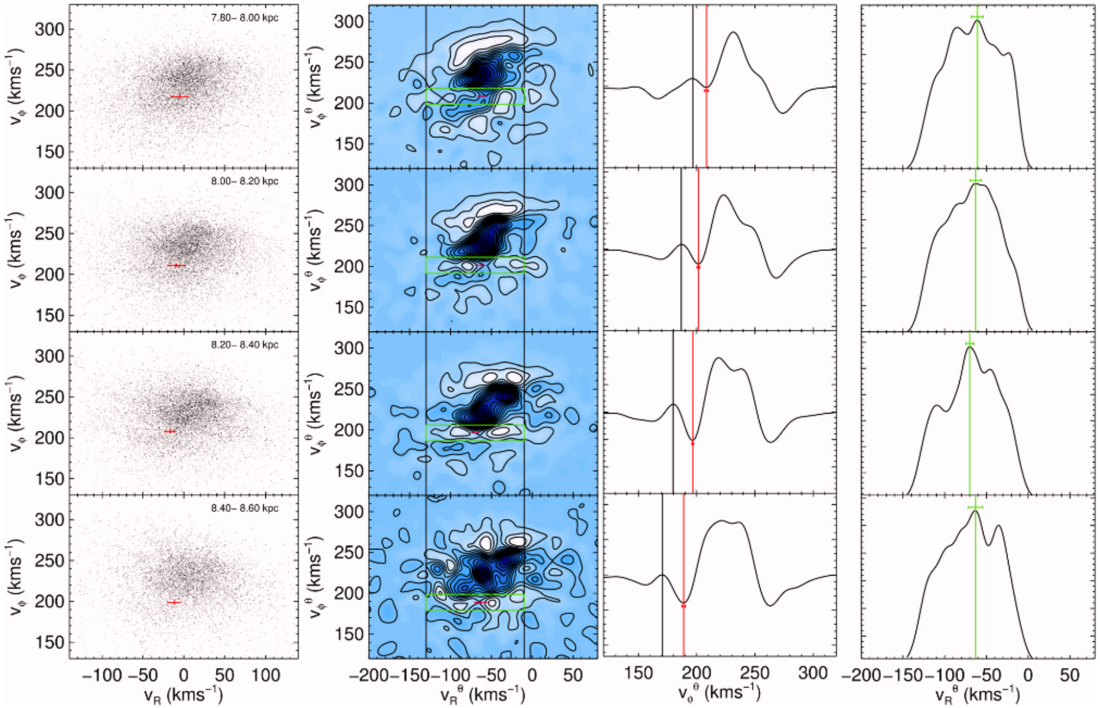
Gaia Collaboration et al.
2018, Fig. 22

Applications

What are we aiming at?

Constrain/learn about:

- Bar
- Spiral arms
- Perturbations
- Potential



Antoja et al. 2014, Fig. 10

Exploiting *Gaia* DR2

We can go **deeper** and **farther** than ever

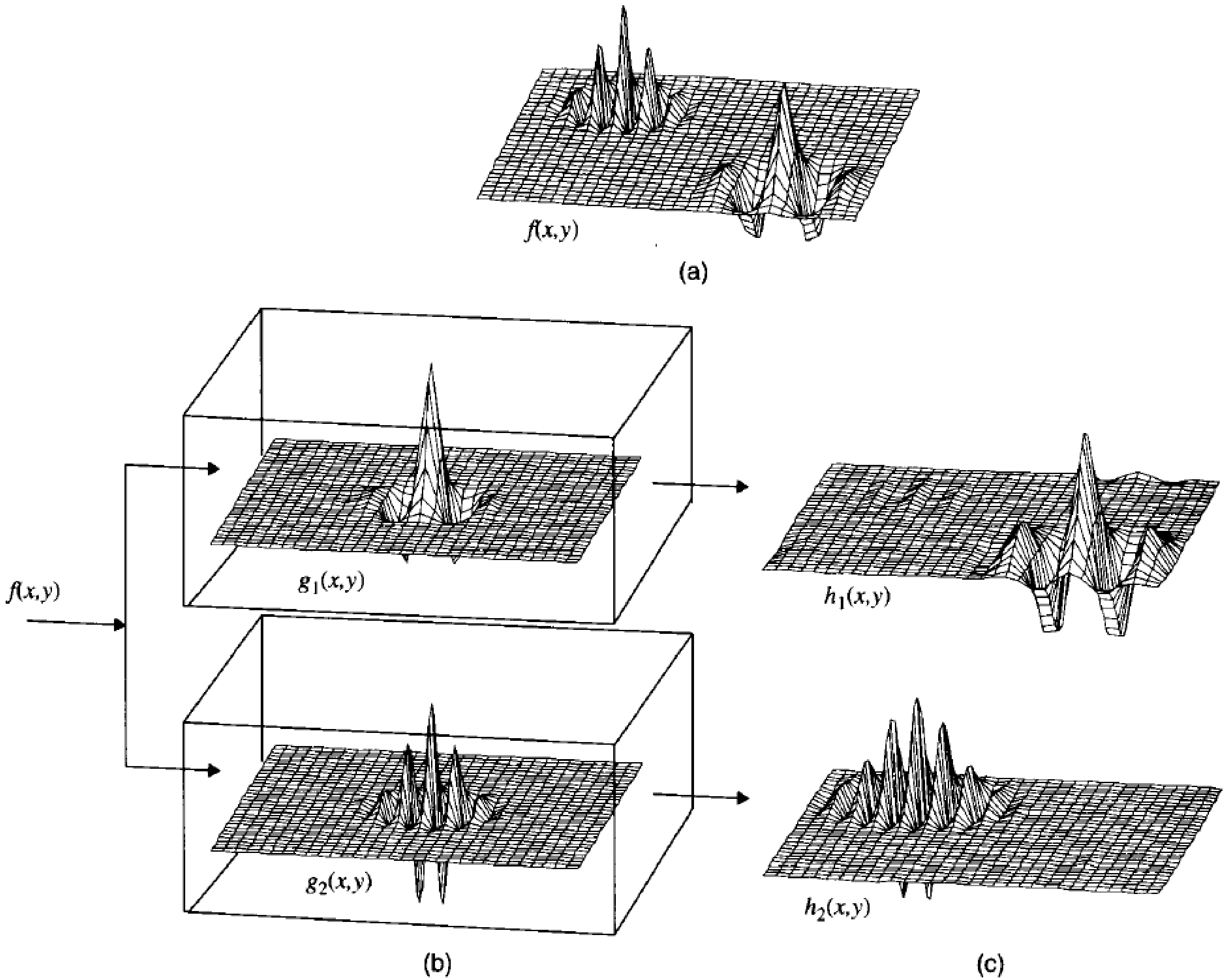
Sample: 5,136,533 stars

- Line of sight velocities
- $\varpi/\sigma_{\varpi} > 5$
- $-500 < Z < 500$ pc

Method:

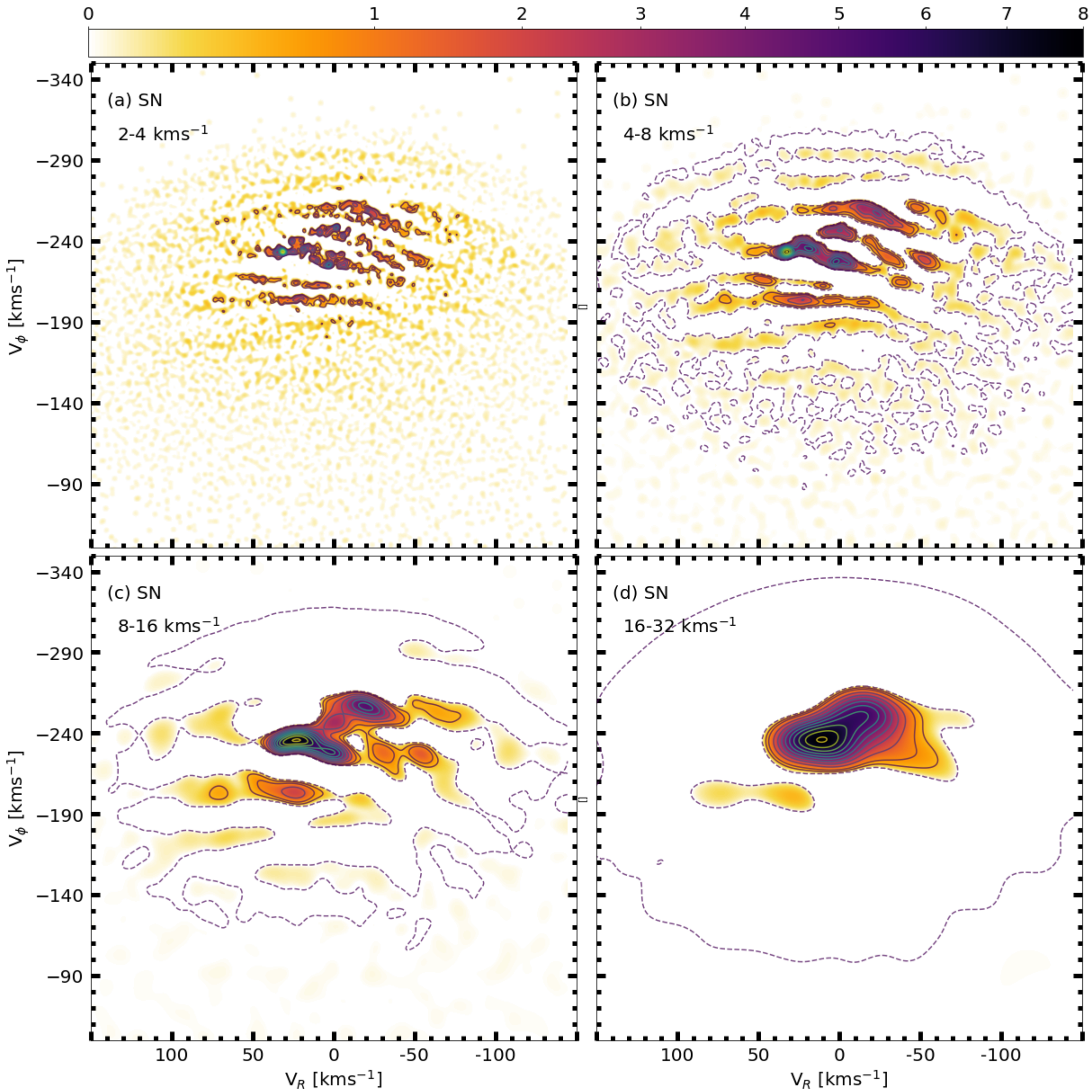
- Wavelet transformation
- Two measures of significance: Poisson + Bootstrap
- Peak finder

Wavelet Transformation



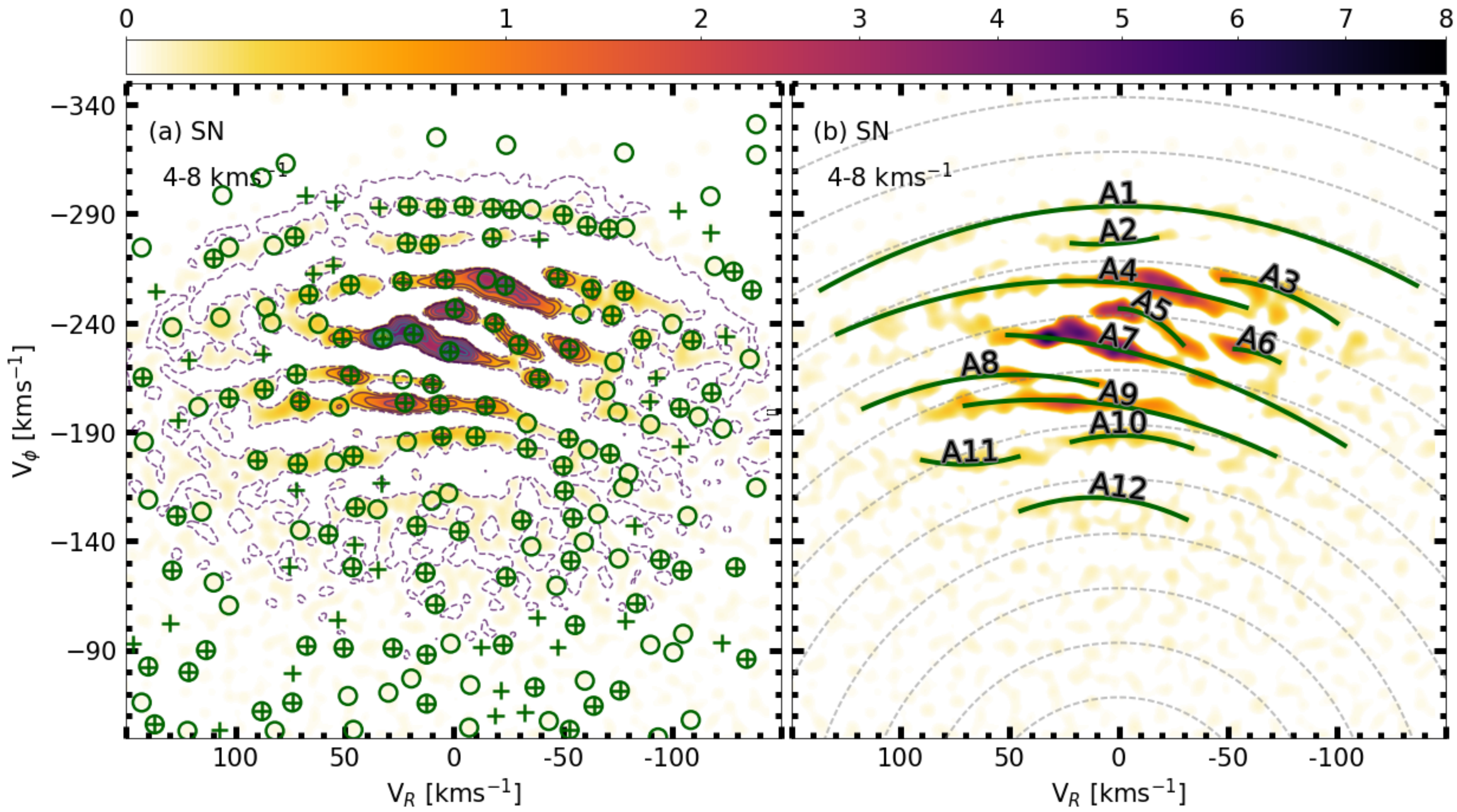
Otazu, X. (PhD thesis) 2001, Fig. 2.2

SN: Wavelet Decomposition



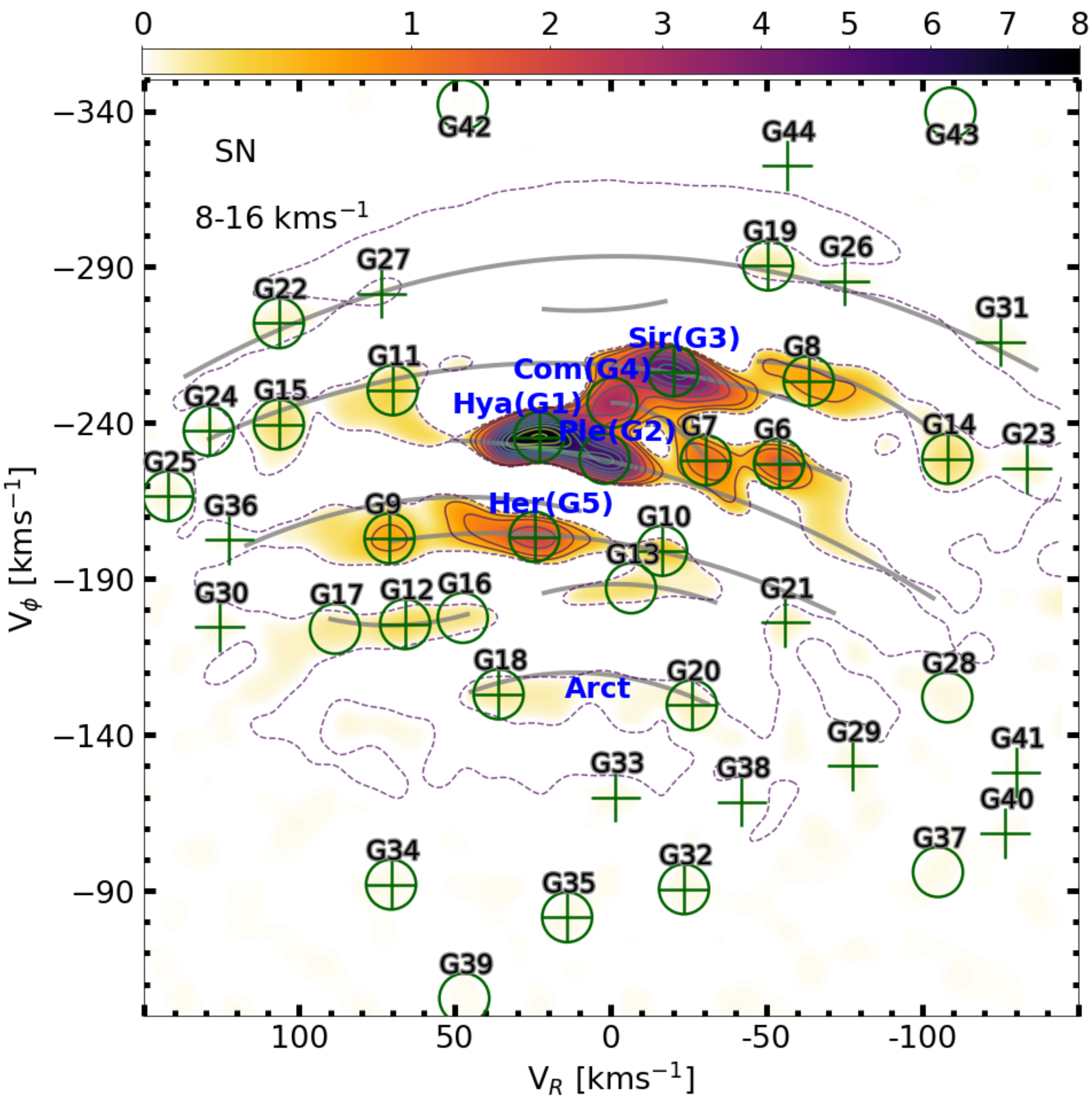
Ramos et al. 2018, Fig. 2

SN: Thin arches



Ramos et al. 2018, Fig. 3

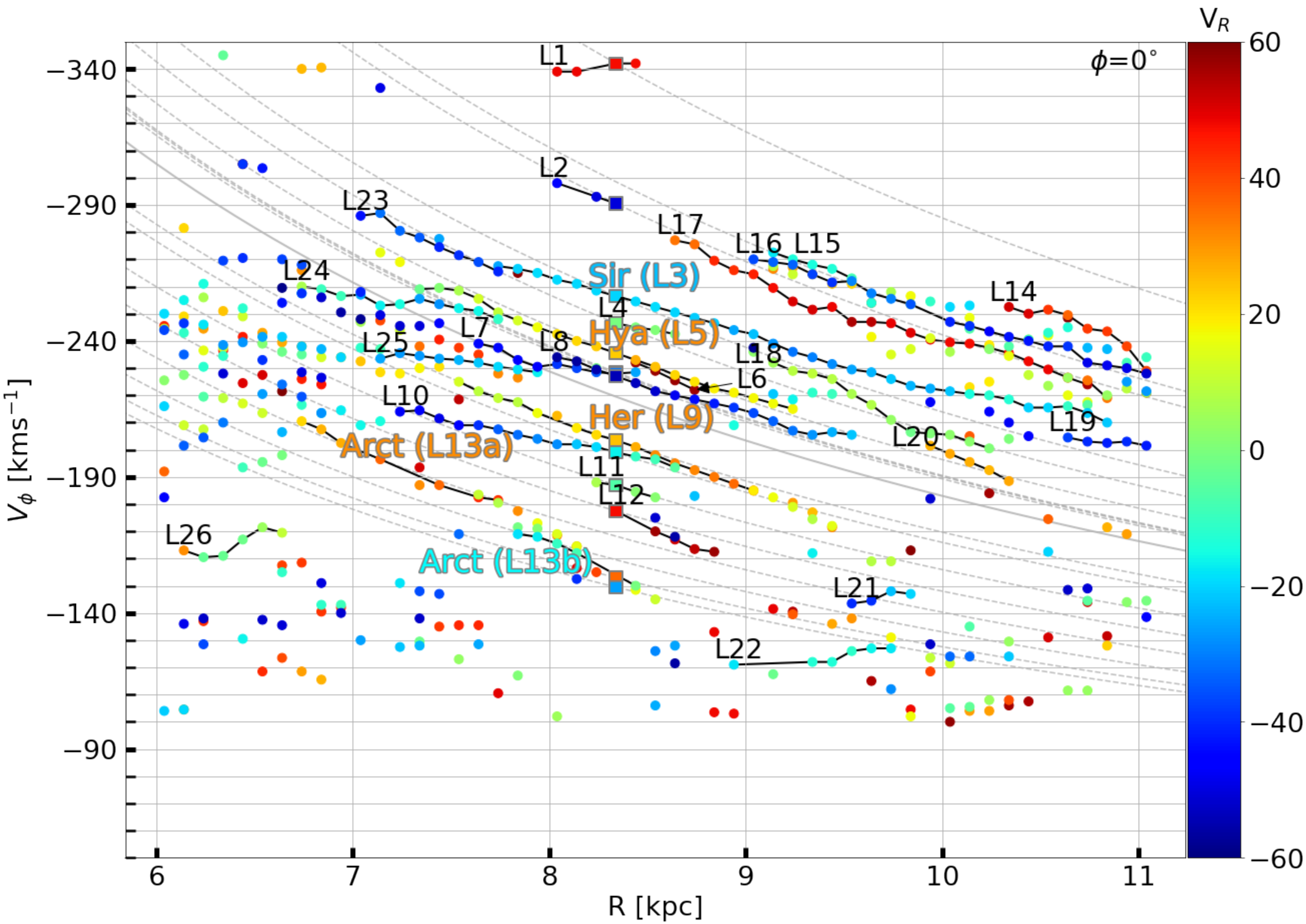
SN: Classic and new kinematic groups



Ramos et al. 2018, Fig. 4

Exploration: radius

Exploration: radius



Ramos et al. 2018, Fig. 6

Exploration: azimuth

Conclusions

- Different morphologies

  The WT reveals conspicuous thin kinematic arches with various morphologies: constant kinetic energy tracks

- Continuity of the structures

  Moving groups show clear continuity, some like Sirius up to 3kpc in radius, with a mean trend of ~23 $kms^{-1}kpc^{-1}$

- Various trends

  We are able to distinguish different types of structures based on their evolution with radius and azimuth: constant angular momentum lines

- Extrasolar MG

  We detect moving groups out of the Solar Neighbourhood with no apparent connection to it (or very weak)

- Hercules

  Consistent with OLR (although some features can be explained with 4:1 OLR). If so, rough estimate of its pattern speed: Ω_b ~54 $kms^{-1}kpc^{-1}$

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Riding the kinematic waves in the Milky Way disk with Gaia

P. Ramos, T. Antoja and F. Figueras

Institut de Ciències del Cosmos, Universitat de Barcelon (IEEC-UB), Martí i Franquès 1, 08028 Barcelona, Spain
e-mail: pramos@fqa.ub.edu

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ABSTRACT

Context. *Gaia* DR2 has delivered full-sky 6-D measurements for millions of stars, and the quest to understand the dynamics of our Galaxy has entered a new phase.
Aims. Our aim is to reveal and characterize the kinematic sub-structure of the different Galactic neighbourhoods, to form a picture of their spatial evolution that can be used to infer the Galactic potential, its evolution and its components.
Methods. We take ~5 million stars in the Galactic disk from the *Gaia* DR2 catalogue and build the velocity distribution of many different Galactic Neighbourhoods distributed along 5 kpc in Galactic radius and azimuth. We decompose their distribution of stars in the V_R-V_ϕ plane with the wavelet transformation and asses the statistical significance of the structures found.
Results. We detect many kinematic sub-structures (arches and more rounded groups) that diminish their azimuthal velocity as a function of Galactic radius in a continuous way, connecting volumes up to 3 kpc apart in some cases. The decrease rate is, on average, of ~23 $\mathrm{km\,s^{-1}kpc^{-1}}$. In azimuth, the kinematic sub-structures present much smaller variations. We also observe a duality in their behaviour: some conserve their vertical angular momentum with radius (e.g., Hercules), while some seem to have nearly constant kinetic energy (e.g., Sirius). These two trends are consistent with the approximate predictions of resonances and of phase mixing, respectively. Besides, the overall spatial evolution of Hercules is consistent with being related to the Outer Lindblad Resonance of the Bar. We also detect structures without apparent counterpart in the vicinity of the Sun.
Conclusions. The various trends observed and their continuity with radius and azimuth allows for future work to deeply explore the parameter space of the models. Also, the characterization of extrasolar moving groups opens the opportunity to expand our understanding of the Galaxy beyond the Solar Neighbourhood.

Key words. Galaxy: kinematics and dynamics – Galaxy: disk – Galaxy: structure – solar neighbourhood

Thank you!