RSN 2: The Milky Way and the Local Universe

esa

A large community:

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How galaxies form and evolve?

Investigate galaxy formation through the study of resolved stellar populations

- Local Volume galaxies (20 Mpc): reconstruction of hierarchical formation history
- Times and modes of star formation: SFHs (HST, JWST, ELT)
- Evolution of the baryonic component of the Universe (nucleosynthesis, feedback processes, GCE models)

**MW formation history in the age of large surveys**

- The MW and its past and present satellites as cosmological products
- Formation of Galactic substructures (Halo, Bulge, thick and thin disks)
- Chemo-dynamical evolution of the MW
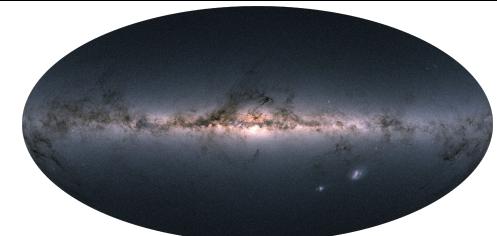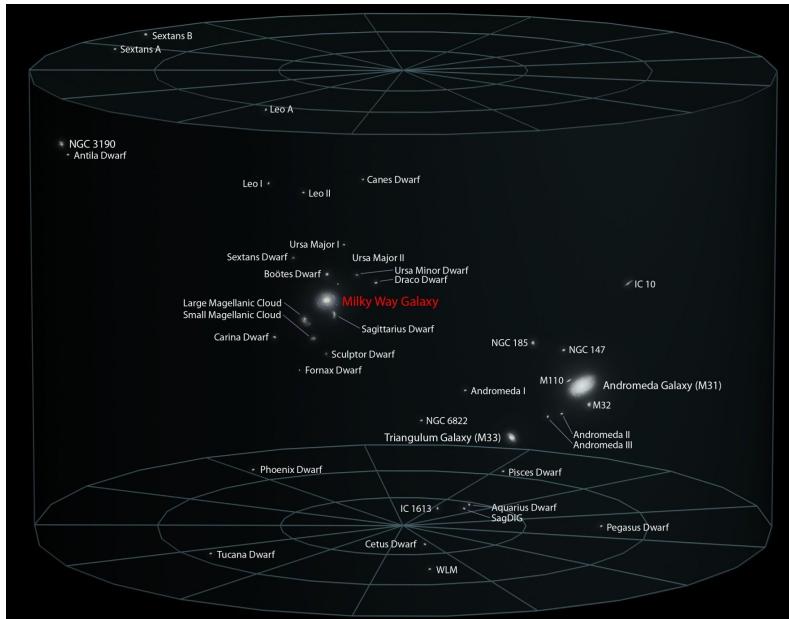
Clusters and streams

Stellar Clusters

- Formation of Globular clusters and their multiple populations
- Stellar Clusters as laboratory for chemical evolution and stellar dynamics and as tracers of the assembly of the Milky Way and nearby galaxies
- Open Clusters and formation and evolution of the disk stellar population
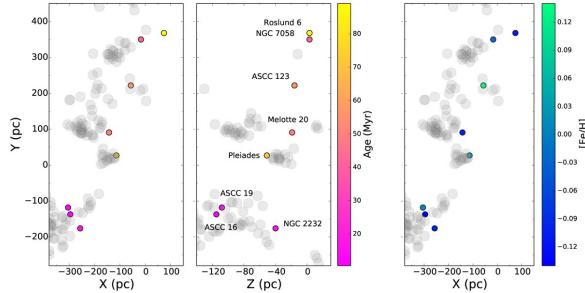
Streams

- Characterization of stellar streams as relics of satellite accretion
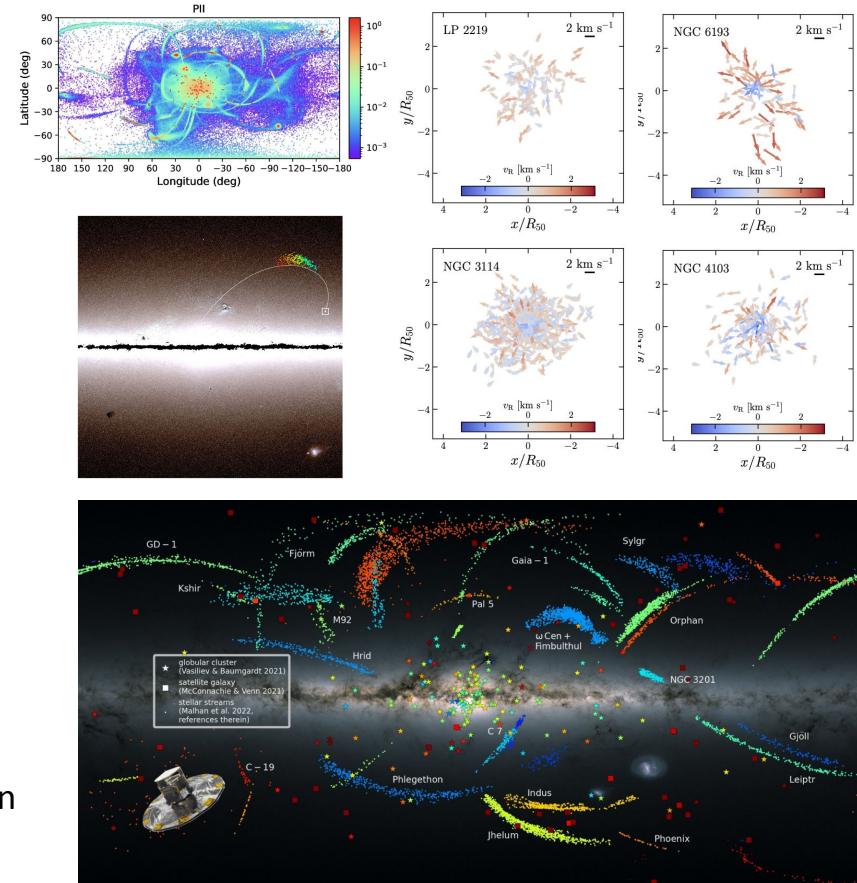
(Large) surveys and Galactic Archaeology

- **Photometry, velocities, positions, and distances:** Gaia (DPCT), LSST, Euclid, ROMAN… (VMC@VISTA for MCs, PHAT/PHAST@HST for Andromeda…)
- **Detailed chemistry, stellar parameters/velocities, reddening: WEAVE,** LAMOST, 4MOST, **MOONS,** SDSS V MWM, PFS, DESI…
- **Ages:** K2, TESS, **PLATO,** Haydn

Multi-dimensional maps which allow to:

- Probe in detail the structure of Galactic components and other galaxies in the Local Group
- Study the structure and origin of the Galactic warp, vertical corrugations and waves in the Galactic disc (Galactic seismology)
- Map the spiral arms and the central bar of the Milky Way
- Effectively and systematically identify stellar streams
- Assess the role of mergers in building up the Halo
- Investigate the role of Stellar Clusters in the build up of Galactic components
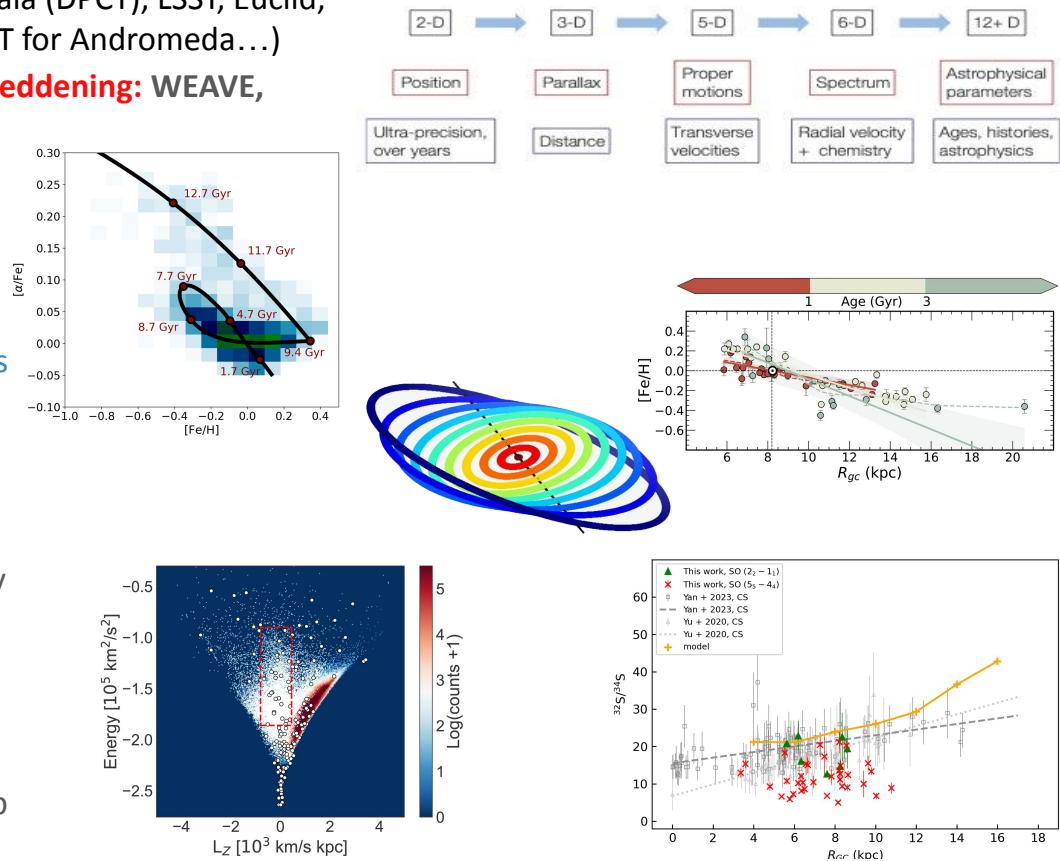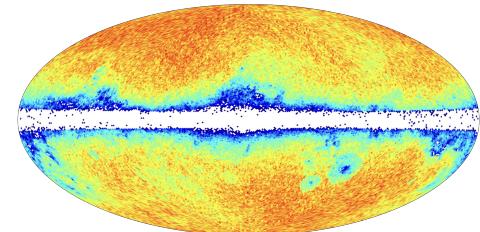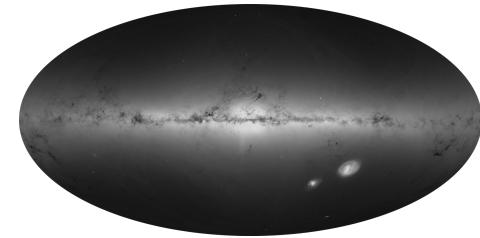
Local Cosmology: the Galaxy as cosmological product at different scales, from the Solar System to its outskirts

Theoretical, analytical and/or numerical models, completely based on General Relativity for the processing and analysis of increasingly accurate astronomical data to guarantee the scientific outputs

e.g. **relativistic astrometry with Gaia**:
- Highly accurate stellar density map of the MW
- First direct materialization of a dense absolute reference frame at visual bands, one of the most important fundamental physics task
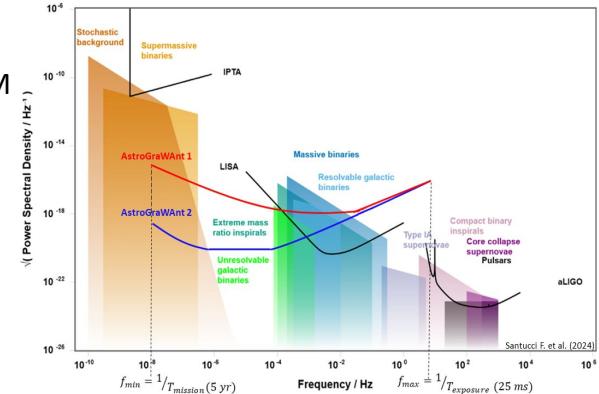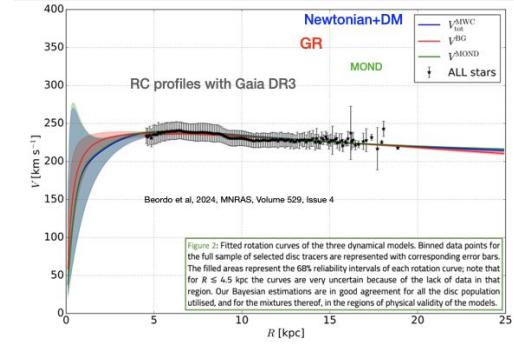
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Gravitational astronomy for data interpretation, **Fundamental Physics, GW scenarios**

The observables of relativistic astrometry through data from the Gaia mission and Euclid, combined with spectroscopic surveys from Earth (APOGEE, WEAVE, ...), PTA or future GW detectors will allow us to:

- test the standard gravity theory and its alternative, investigate the role and nature of dark matter and dark energy
- reveal the cosmological formation of the MW as alone, compare local predictions of the LCDM model with local data,
- reveal chemical-kinematic signatures of the evolution of the Milky Way
- use stars as natural "antenna" for monitoring passing GWs, "dual" analogue of the extant linear antennas, to infer the GW strength and immediately determine the direction to the GW source for a wide range of GW frequencies, from few hertz to nanohertz, i.e. GW signals from local to early-universe sources

Figure 2: Fitted rotation curves of the three dynamical models. Binned data points for the full sample of selected disc tracers are represented with corresponding error bars. The filled areas represent the 68% reliability intervals of each rotation curve; note that for R ≤ 4.5 kpc the curves are very uncertain because of the lack of data in that region. Our Bayesian estimations are in good agreement for all the disc population utilised, and for the mixtures thereof, in the regions of physical validity of the models.

Beordo et al, 2024, MNRAS, Volume 529, Issue 4

Santucci F. et al. (2024)

Future outlook