

Galactic Astronomy

2022-2023

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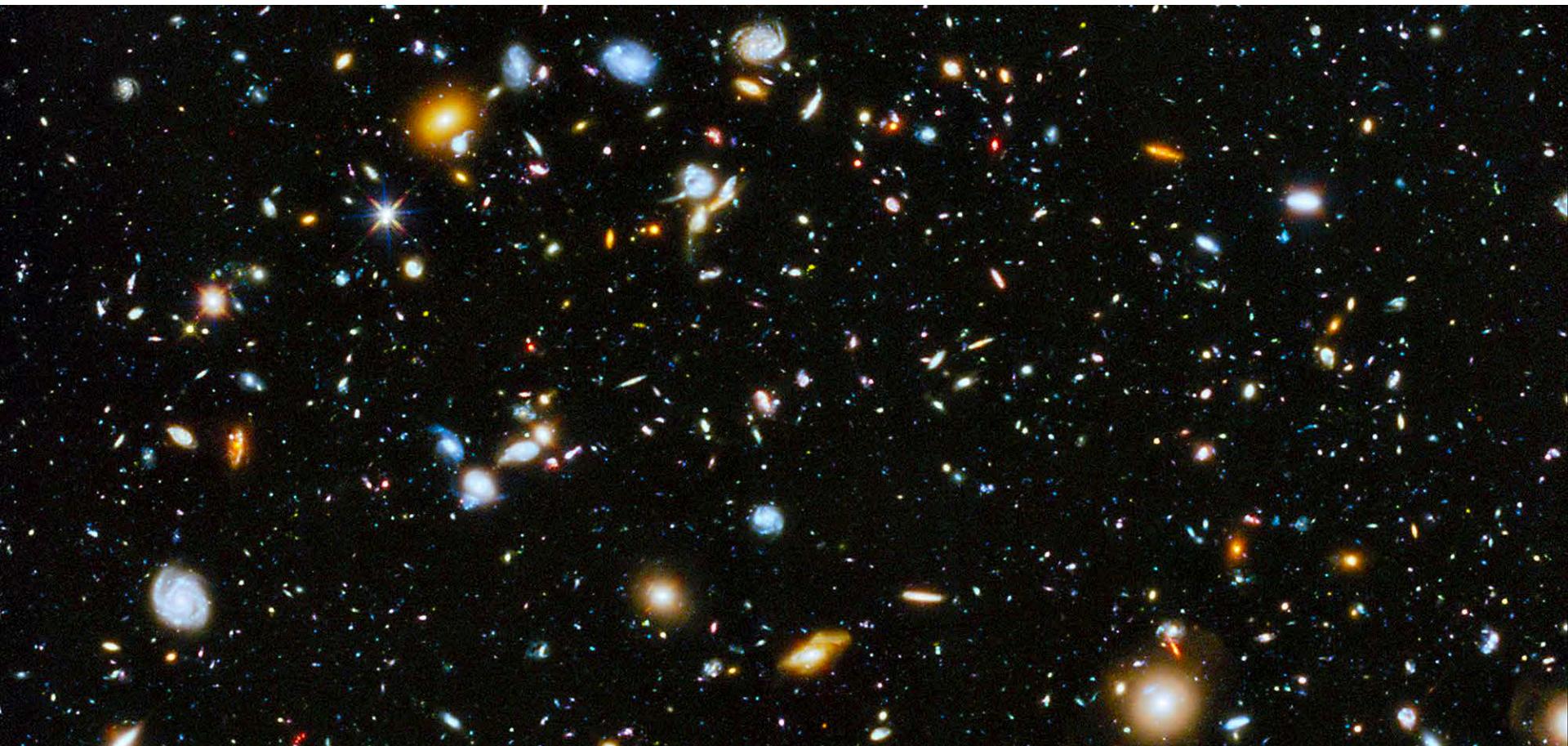


How do galaxies form and evolve?

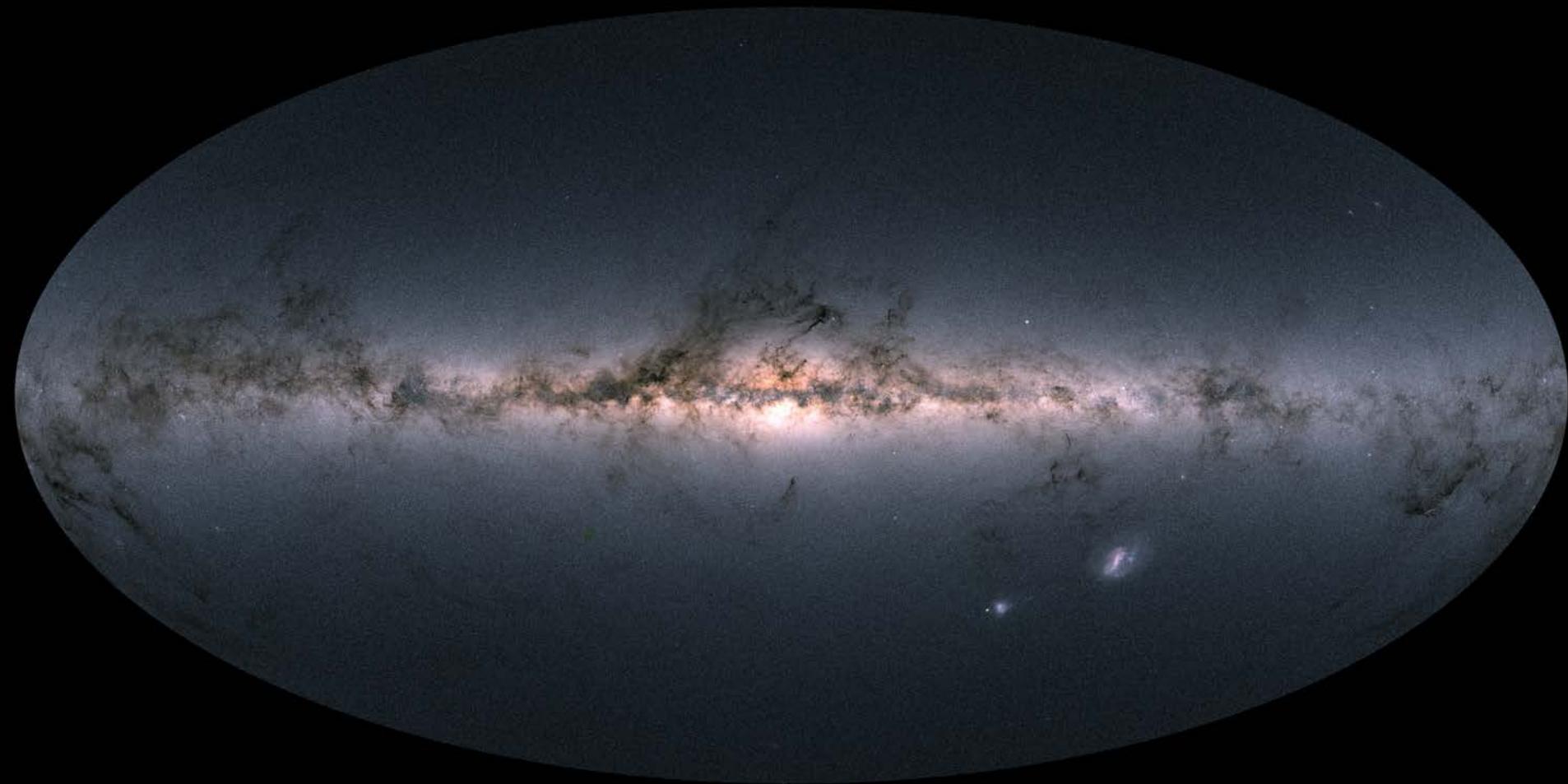
One of the key questions in modern astrophysics:

- A Science Vision for European Astronomy, ASTRONET, 2007
- Science Vision and Infrastructure Roadmap, ASTRONET, 2022 (*DRAFT*)

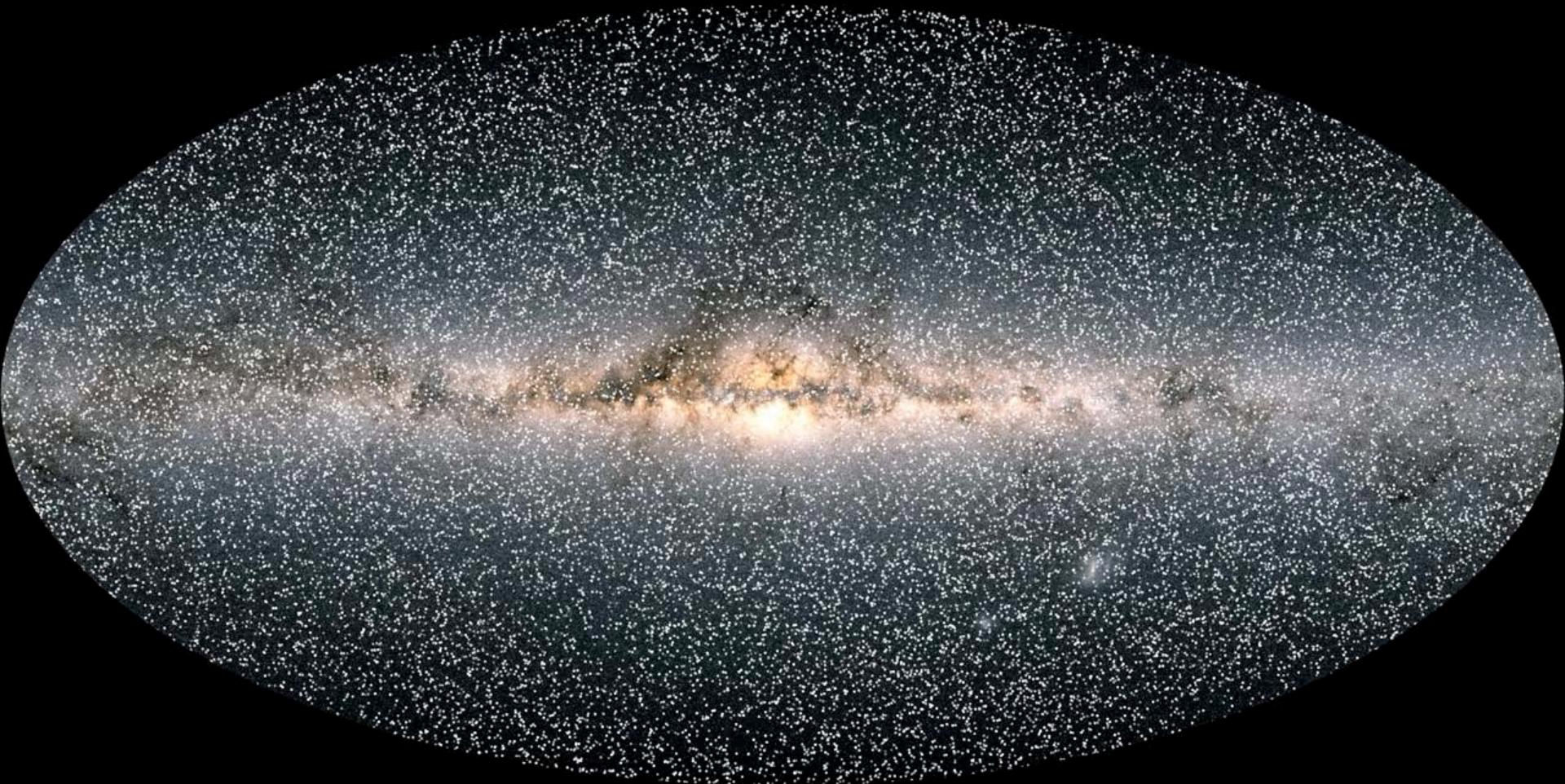
Hubble Ultra Deep Field



Gaia DR2

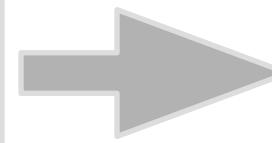
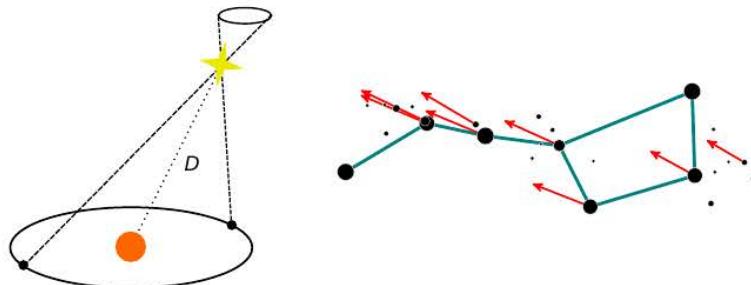


Gaia EDR3

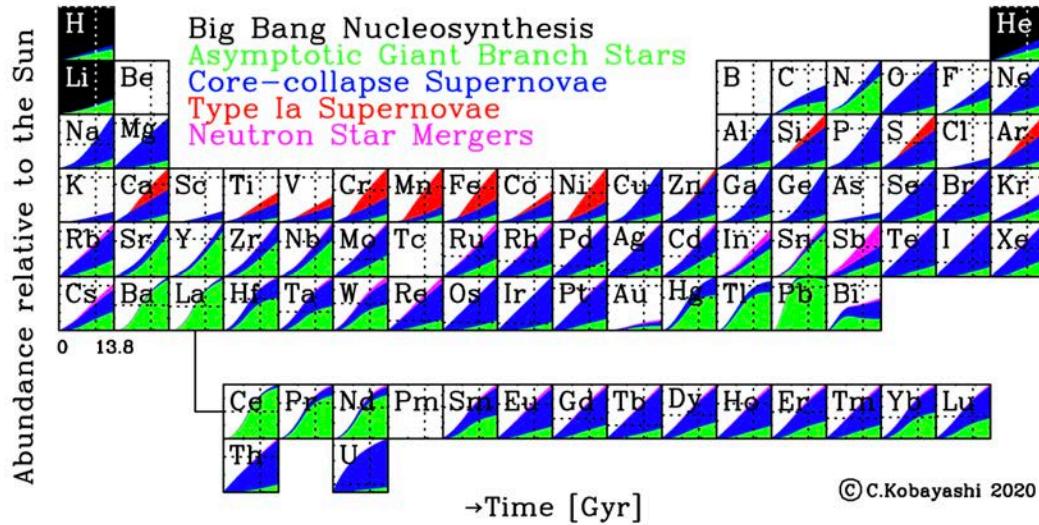


How did our galaxy and its components form?

Astronomical measurements in Galactic Astronomy



- Galaxy gravitational potential (mass distribution)
- History and evolution



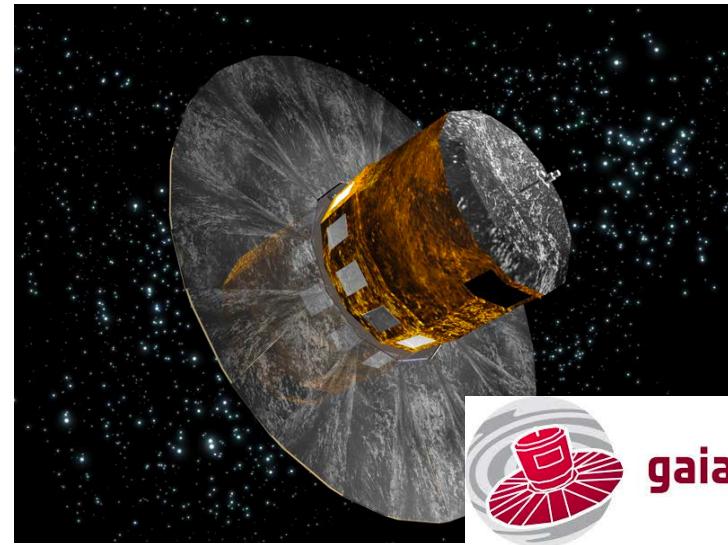
GALACTIC ASTRONOMY

1. Introduction CESCA, 13 set
 - 1.1. Galaxies and their role in the Universe
 - 1.2. Galactic astronomy history
 - 1.3. Global description of the Milky Way: our present knowledge
 2. Astronomical measurements CARME 14, 15, 19 set
 - 2.1. Astrometry
 - 2.2. Photometry
 - 2.3. Spectroscopy
 3. Statistical astronomy CESCA 20, 21, 22, 27 set
 - 3.1. Apparent distribution of stars
 - 3.2. Stellar statistics fundamental equation
 - 3.3. Stellar luminosity function
 - 3.4. Initial Mass Function and Star formation History
 - 3.5. Galactic models for star count predictions
 4. Galactic kinematics TERESA 28, 29 set, 3, 4 oct
 - 4.1. Galactocentric reference systems
 - 4.2. Kinematics of solar neighbourhood stars
 - 4.3. Large scale kinematics
 - 4.4. Rotation curve and Oort constants

+2h Exercises measurements CARME 5, 6 oct
 5. Galactic Dynamics I: basic concepts
 - 5.1. Gravitational potentials & Poisson equation TERESA 10, 11, 13 17 oct
 - 5.2. Orbits TERESA 18, 19, 20, 24 oct
 - 5.3. Collisionless dynamics MERCE 25, 26, 27 oct 2, 3 nov
 - 5.4. Collisions and encounters of stellar systems MARK 7, 8, 9 nov
 6. Galactic dynamics II: advanced
 - 6.1. Dynamics of spiral structure and bars MERCE 10, 14, 15, 16, 17 nov
 - 6.2. Galaxy interactions, non-axisymmetry, Gaia TERESA 21, 22 nov

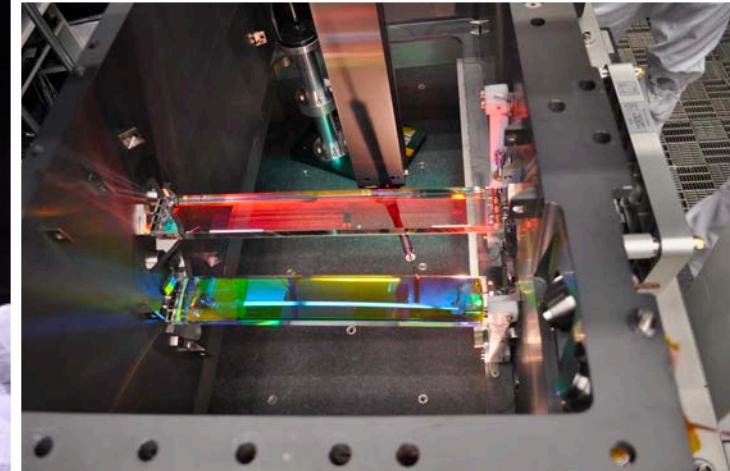
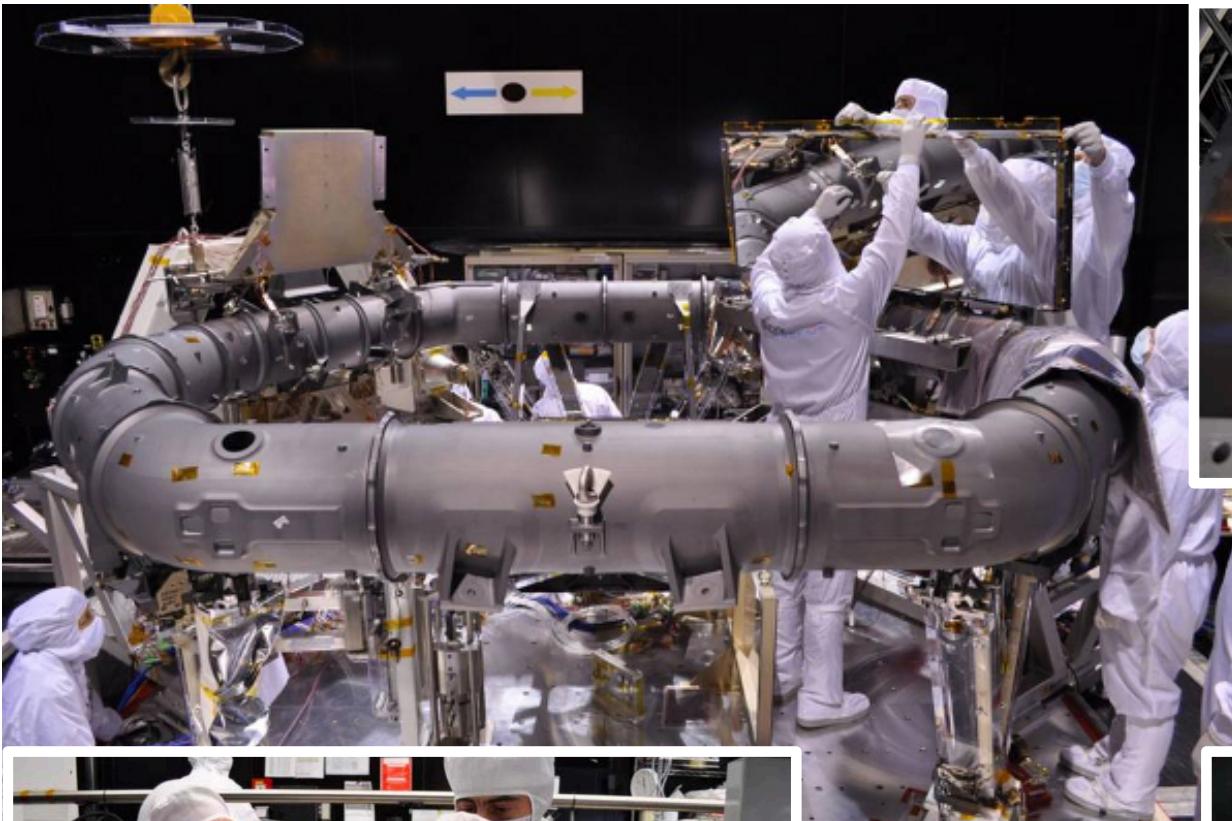
+ 2h hands-on kinematics TERESA 23, 24 nov
 7. Chemical evolution of the Milky Way FEDE 28, 29, 30 nov, 1, 12, 13, 14, 15 dec
 - 7.1. Observational evidence
 - 7.2. Surface gas density, supernova explosion rate and metal enrichment
 - 7.3. Basic elements of a model of chemical evolution
 - 7.4. Some simple models
- +2h hands-on orbits MERCE 19, 20 dec
- +1h Journal Club TERESA 21 dec

Measurements: Gaia mission

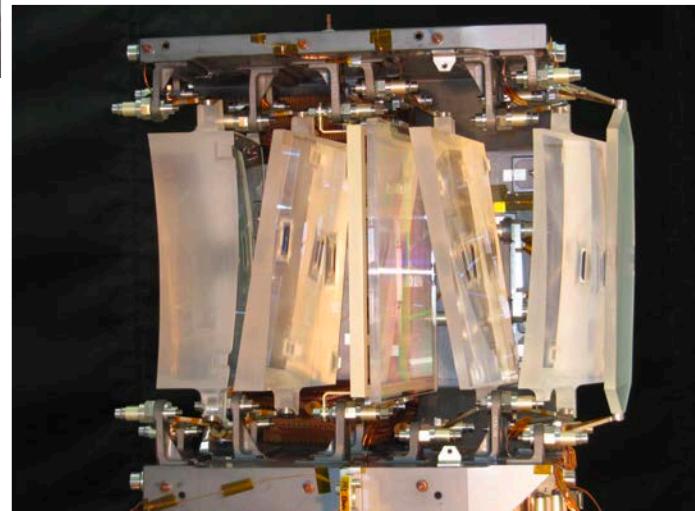


**December 19th, 2013
10:12 CET**

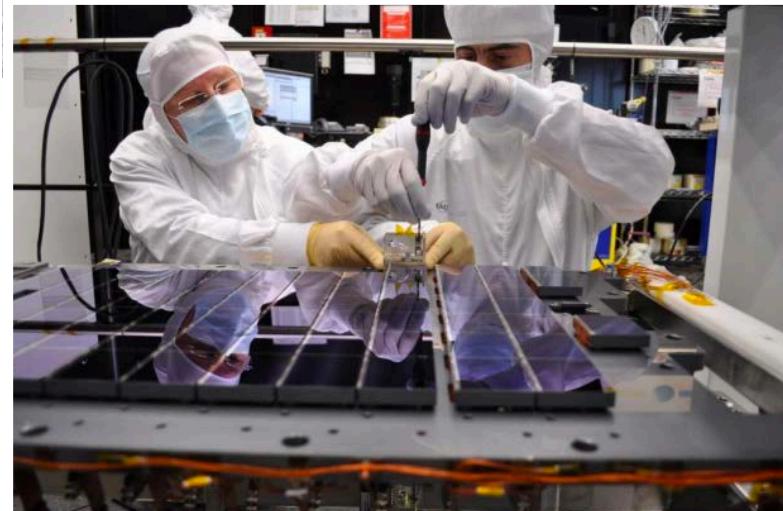
Measurements



Photometers



Spectrograph



CCDs
detectors

- astrometric
- photometric
- spectroscopic

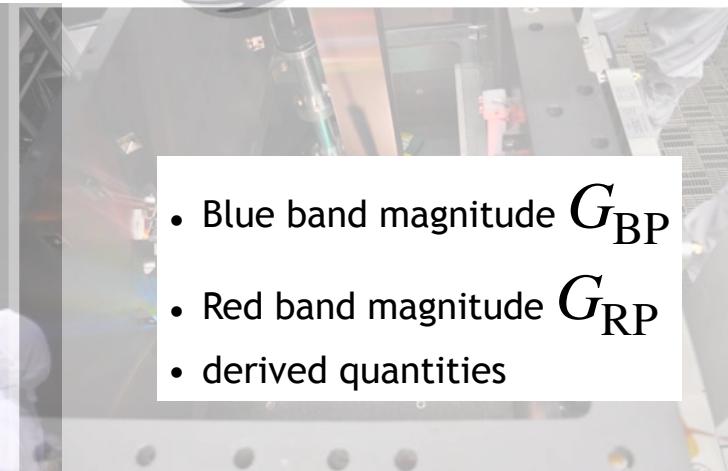
Instruments



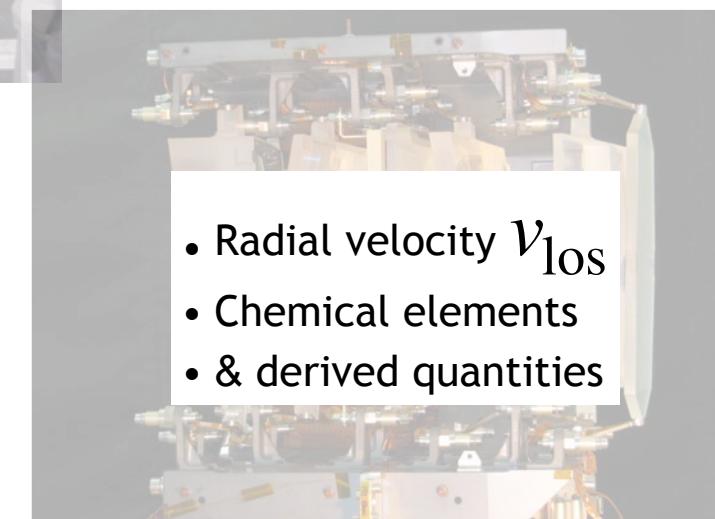
gaia



- Positions on the sky
 - $\alpha \delta$
- distance
 - parallax ϖ
- transverse velocities
 - Proper motions $\mu_\alpha^* \mu_\delta$
- Magnitude G

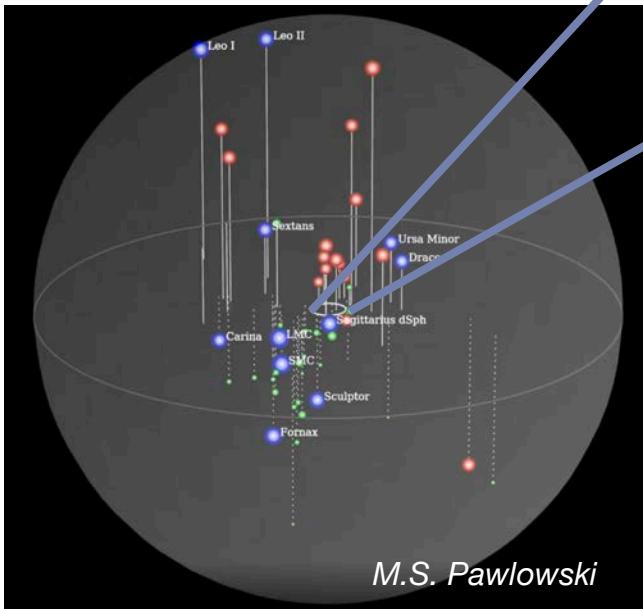
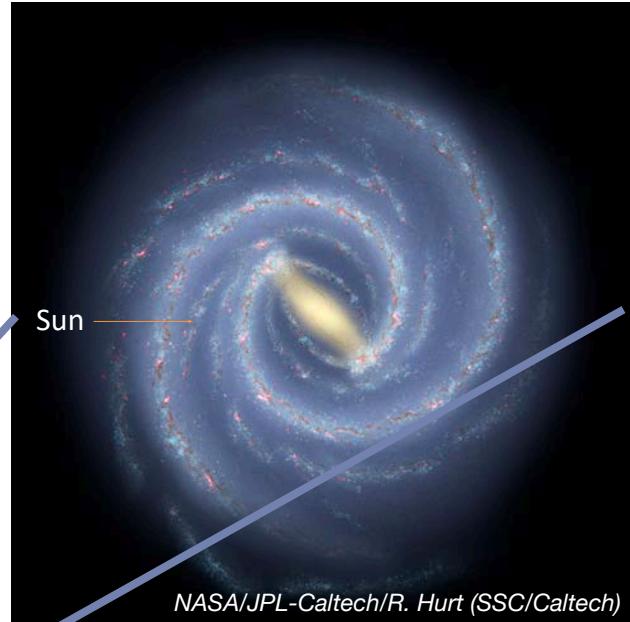
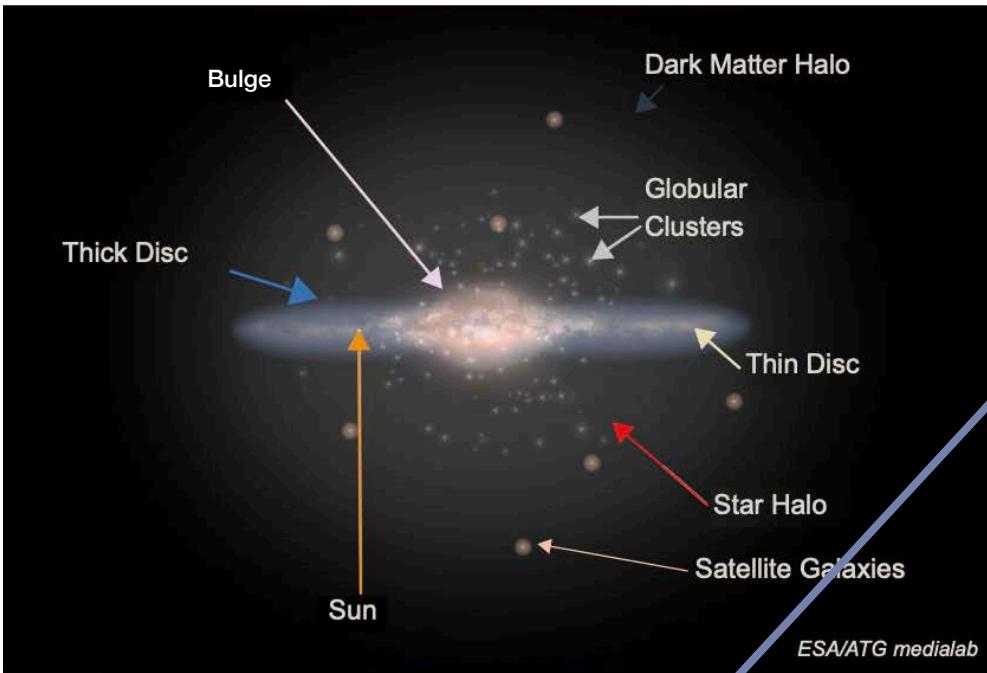


- Blue band magnitude G_{BP}
- Red band magnitude G_{RP}
- derived quantities

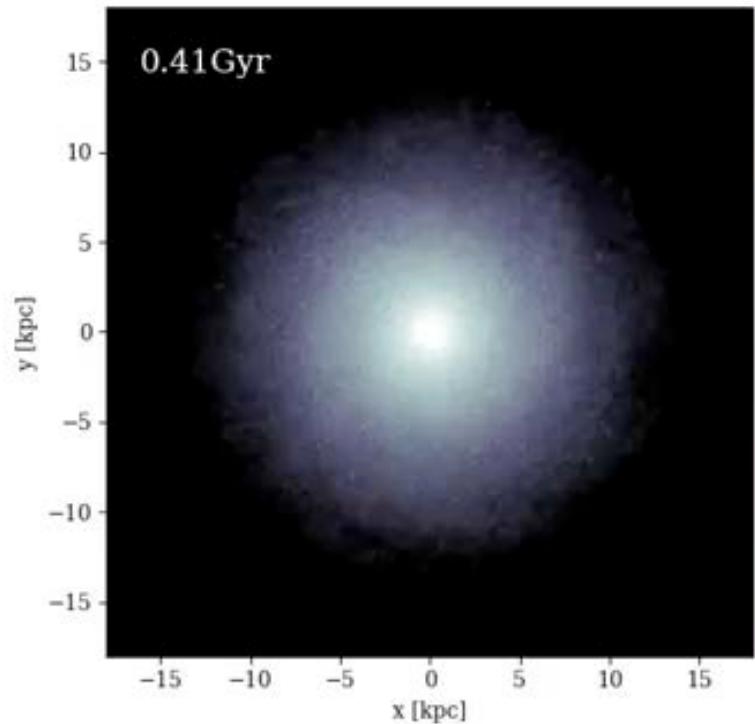
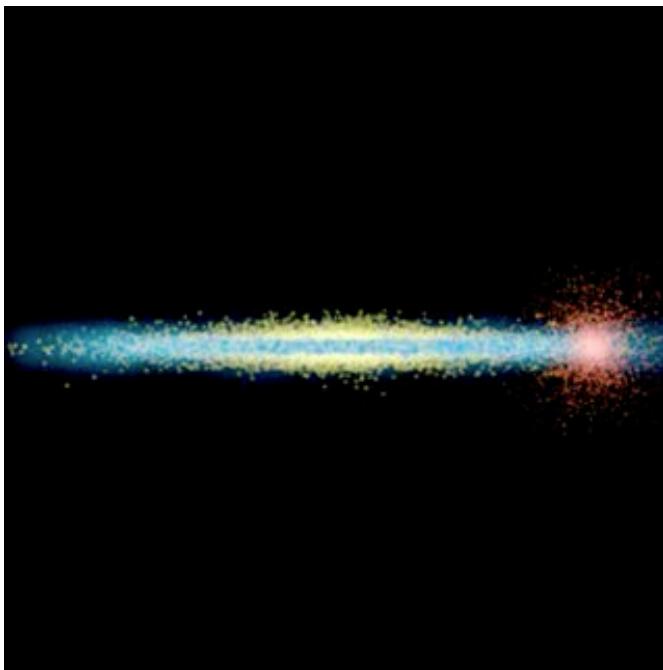
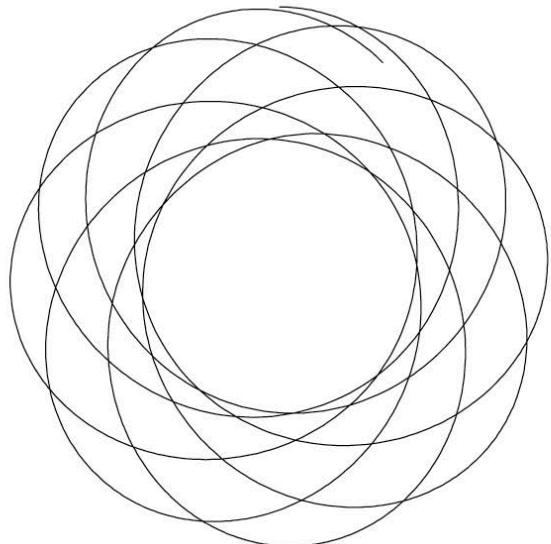


- Radial velocity v_{los}
- Chemical elements
- & derived quantities

What we think the MW looks like



Dynamics: Orbits & Milky Way potential

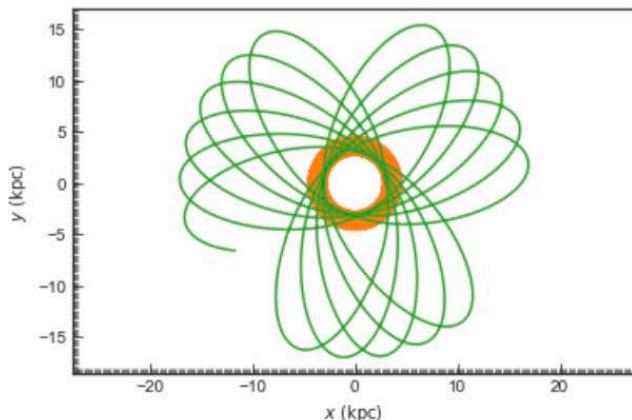


- Hand-on exercises

- Analysis of *Gaia* data
- Orbits in Galactic potentials

In [25]:

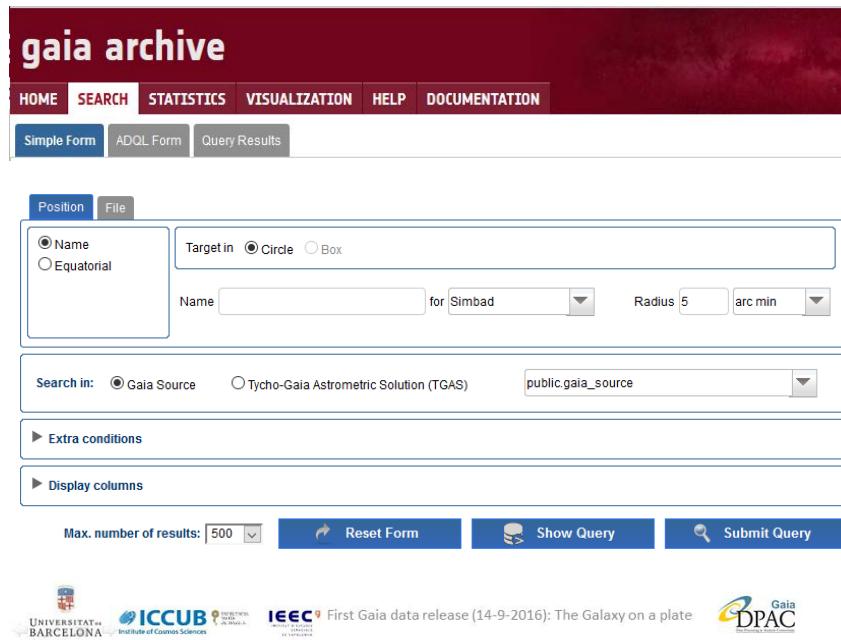
```
1 omw1.plot(d1='x',d2='y')
2 omw2.plot(d1='x',d2='y',overplot=True)
3 omw3.plot(d1='x',d2='y',overplot=True)
4
5 plt.axis('equal')
6 plt.show()
```



- Paper reading and discussion (journal club)

• Short tasks

1. Gaia Archive & Gaia measurements



The screenshot shows the Gaia Archive search interface. At the top, there is a dark red header bar with the text "gaia archive" in white. Below it is a navigation menu with links: HOME, SEARCH, STATISTICS, VISUALIZATION, HELP, and DOCUMENTATION. The "SEARCH" link is highlighted in red. Below the menu, there are three buttons: Simple Form (selected), ADQL Form, and Query Results. The main search form has two tabs: Position and File. The Position tab is selected. It contains fields for "Name" (radio button selected) and "Equatorial" (radio button). Under "Target in", there are radio buttons for "Circle" (selected) and "Box". A "Name" input field, a dropdown for "for" (set to "Simbad"), and a "Radius" input field (set to 5) with a dropdown for "arc min" are also present. Below this, there is a "Search in:" section with radio buttons for "Gaia Source" (selected) and "Tycho-Gaia Astrometric Solution (TGAS)". A dropdown menu next to "public.gaia_source" is open. There are also sections for "Extra conditions" and "Display columns". At the bottom, there is a "Max. number of results:" dropdown set to 500, and three buttons: "Reset Form", "Show Query", and "Submit Query".

HTTP://
ARCHIVES.ESA
C.ESA.INT/
GAIA/

2. Statistical astronomy, Besançon model

- Lectures from invited professors

Dr. Mark Gieles (ICCUB-ICREA)



47 Tucanae with ESO/VISTA telescope

Collisional dynamics

- Basic concepts for collisional systems: relaxation, core collapse, etc
- Dynamics of Globular Clusters

Nov 2022

Evaluation

Short tasks + presentations

Hands-on work

Participation

40%

Exam

5/10 required

Exam date: TBD with students

60%

Master's thesis

- Open clusters
 - Galactic Disk dynamics
 - Satellite galaxies
 - Stellar evolution
 - Population synthesis
 - White dwarfs
- Big Data and Machine learning
 - Galaxy formation and cosmology
 - Spectroscopic stellar surveys
 - Globular clusters
 - Light pollution
 - etc

*F. Anders, T. Antoja, L. Balaguer, J. M. Carrasco, F. Figueras, M. Gieles,
C. Jordi, X. Luri, E. Masana, J. Miralda, M. Romero-Gomez*

