Galactic Astronomy

2022-2023

ICCUB Institute of Cosmos Sciences

EXCELENCIA MARÍA DE MAEZTU

UNIVERSITAT DE BARCELONA

Gaia

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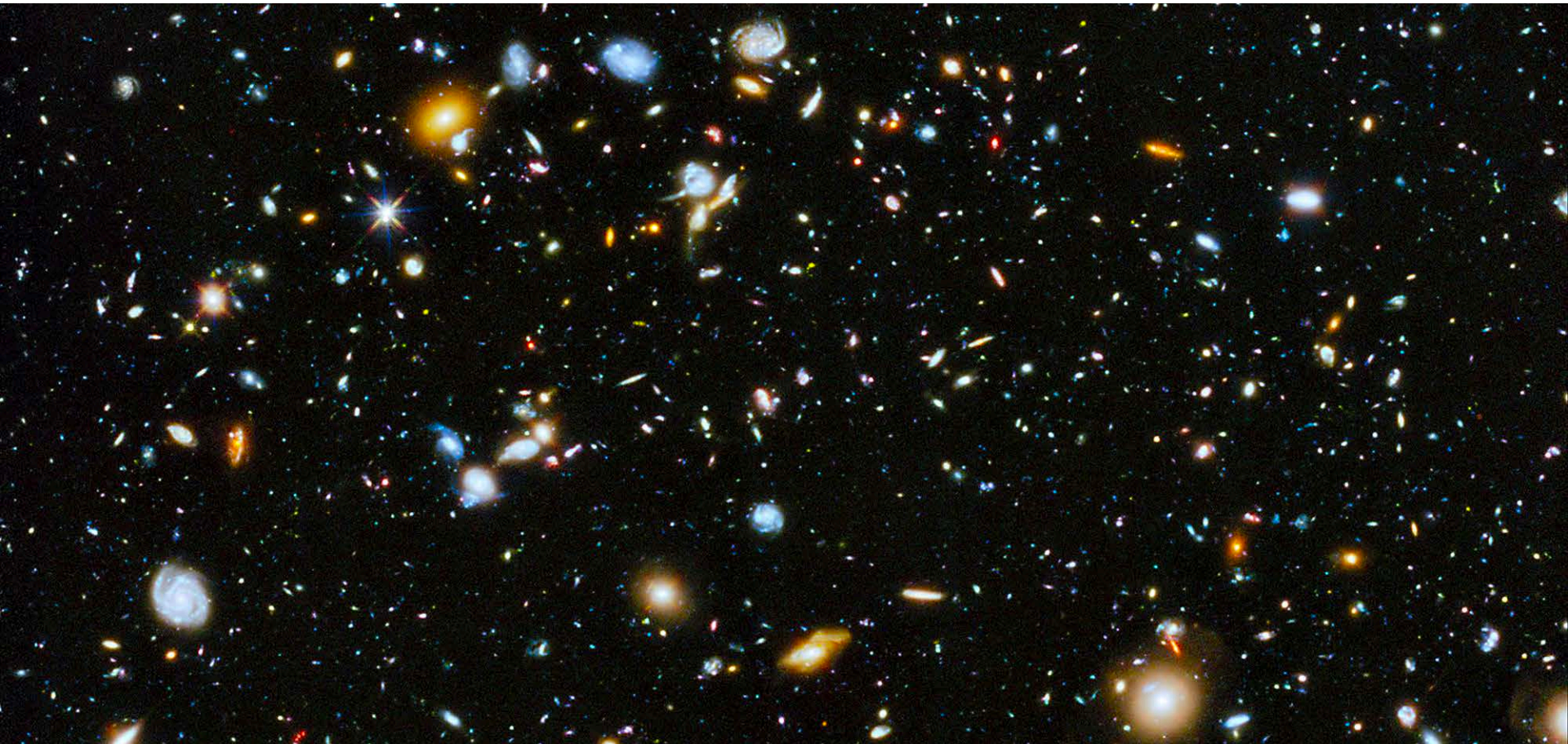
How do galaxies form and evolve?

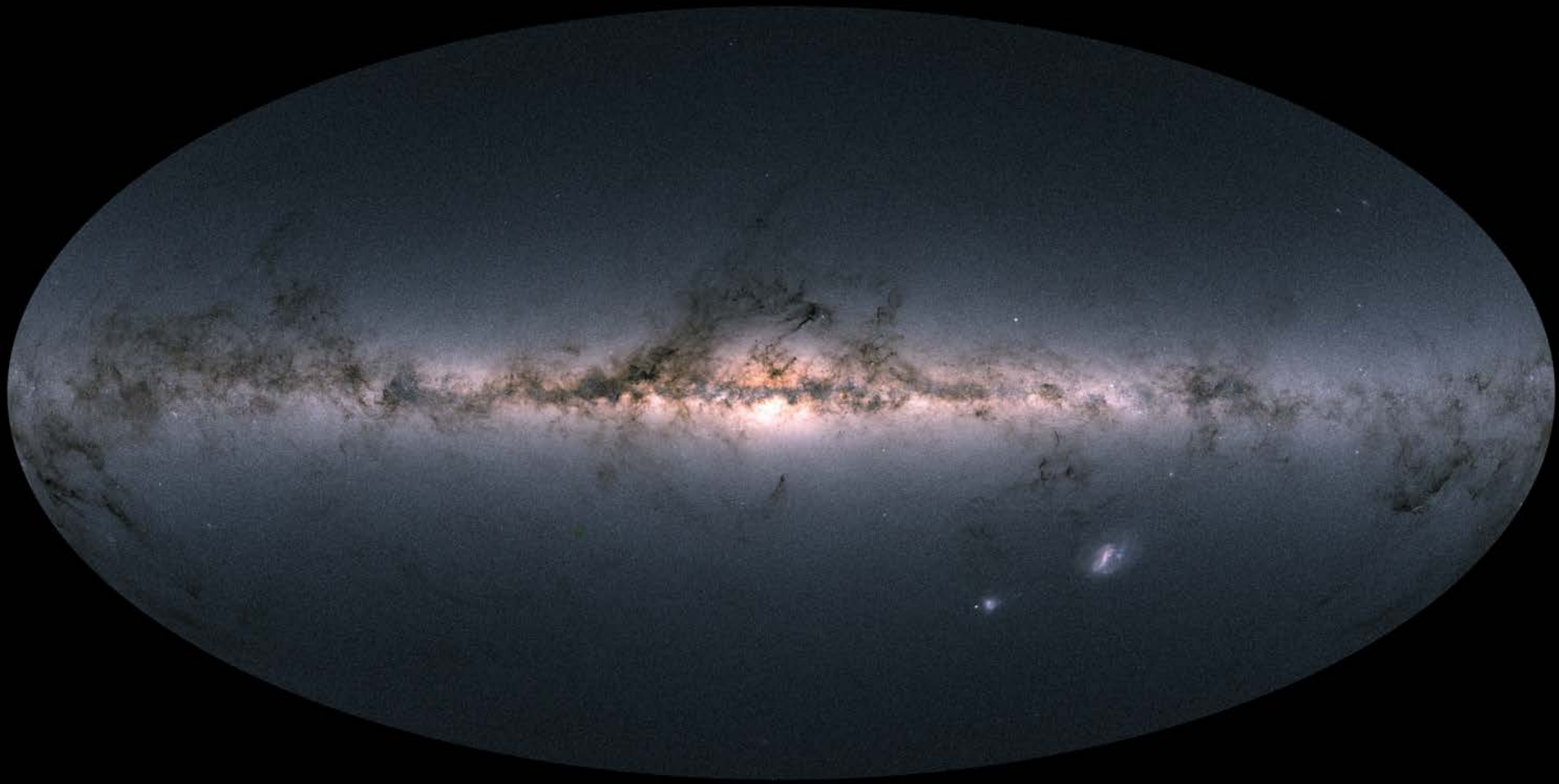
One of the key questions in modern astrophysics:

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

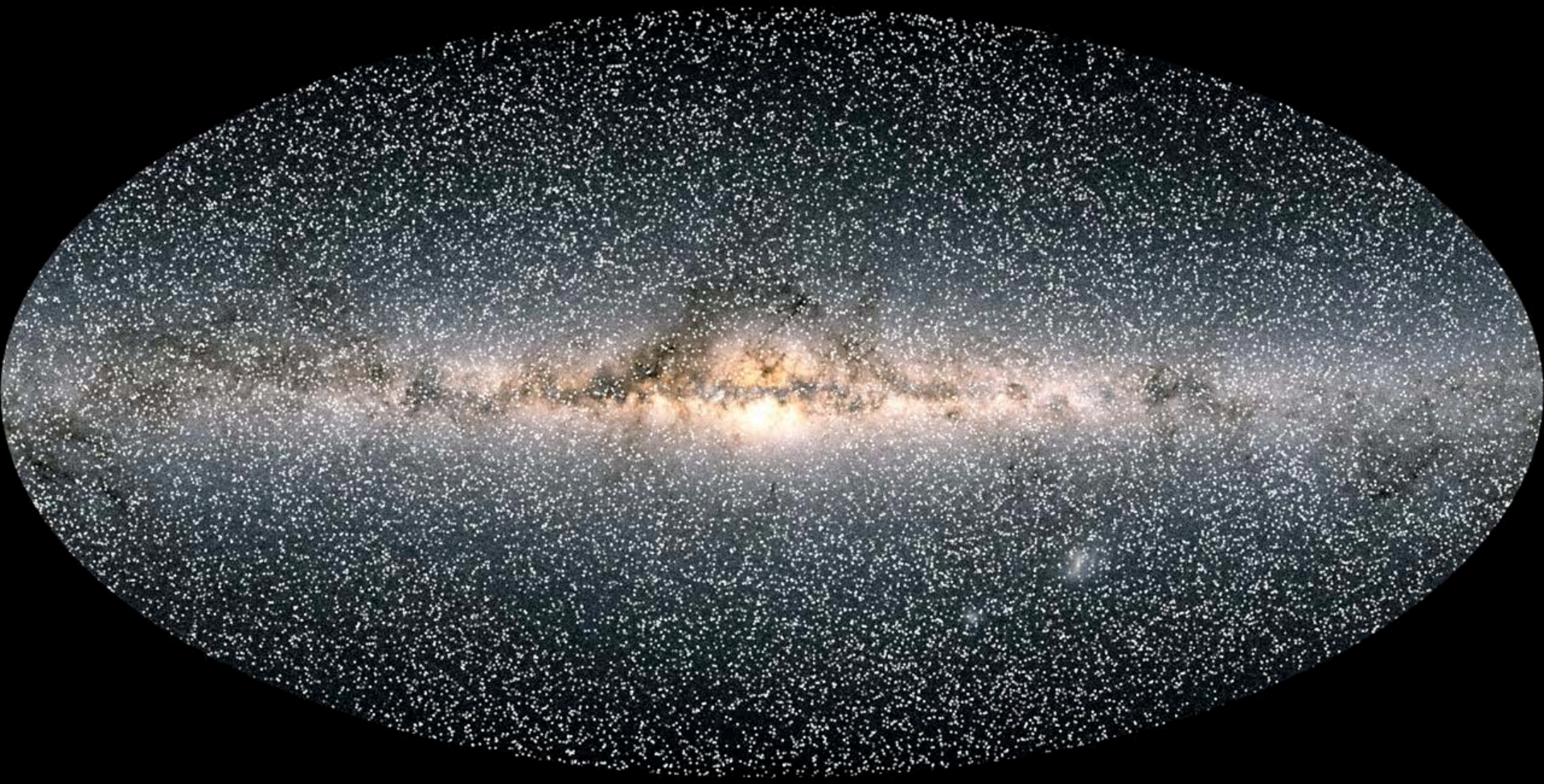
Hubble Ultra Deep Field



Gaia DR2

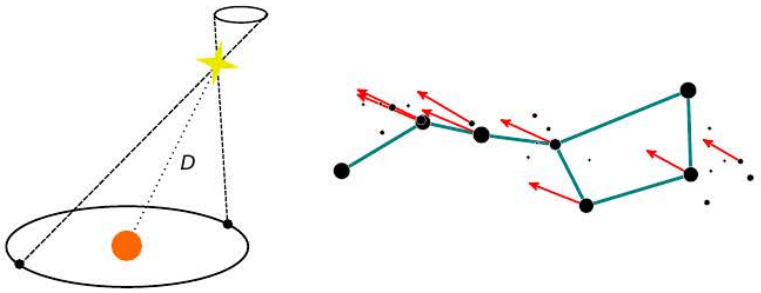


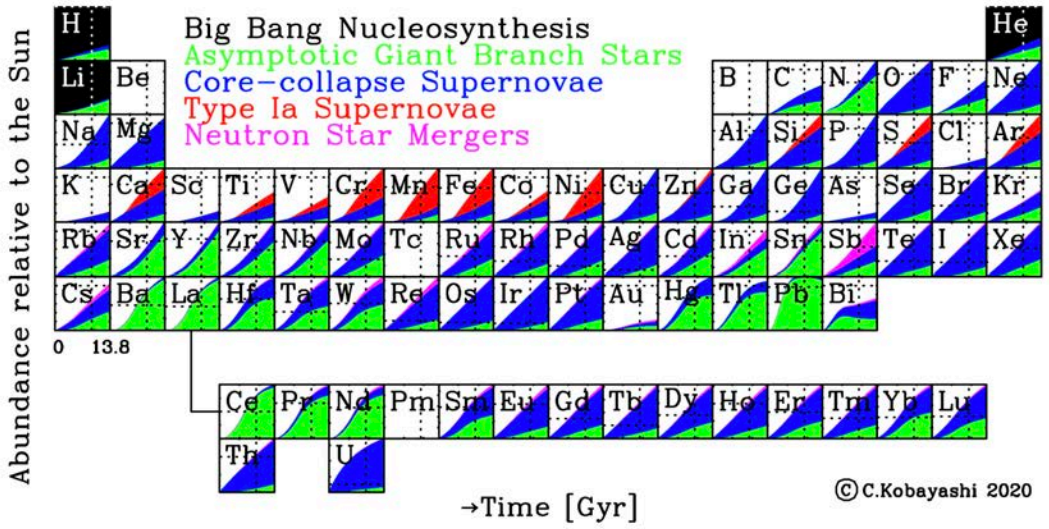
Gaia EDR3



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*

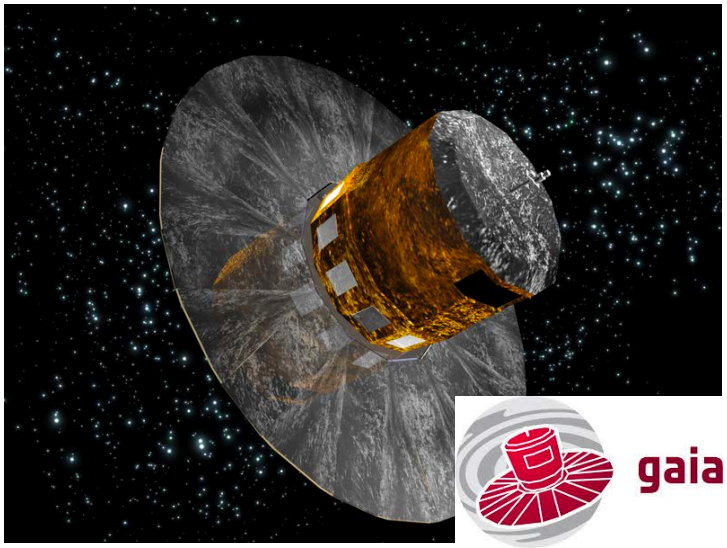
+ 2h hands-on kinematics TERESA *23, 24 nov*

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*

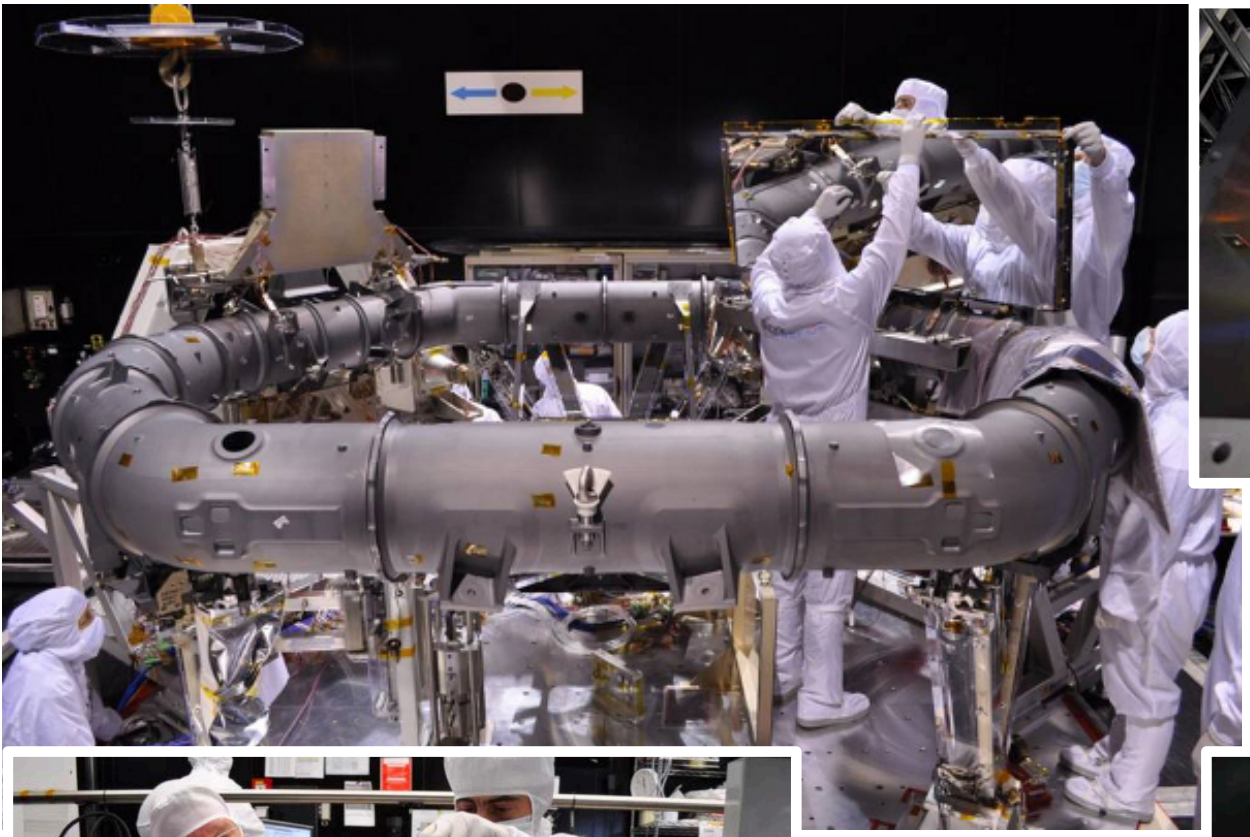
+1h Journal Club TERESA *21 dec*

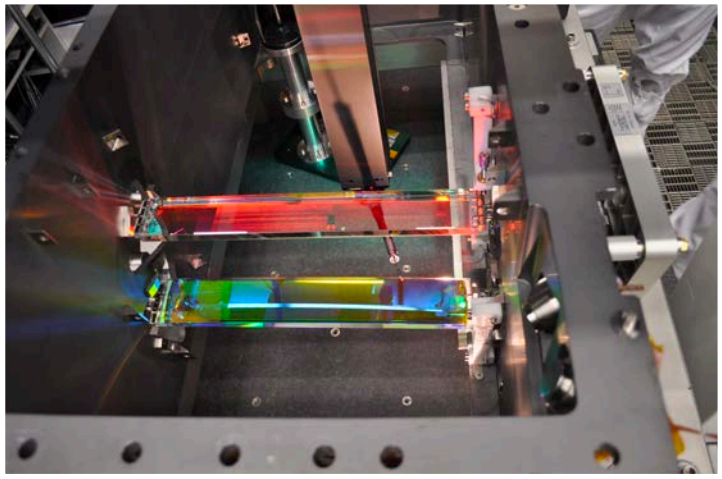
Measurements: Gaia mission



December 19th, 2013
10:12 CET

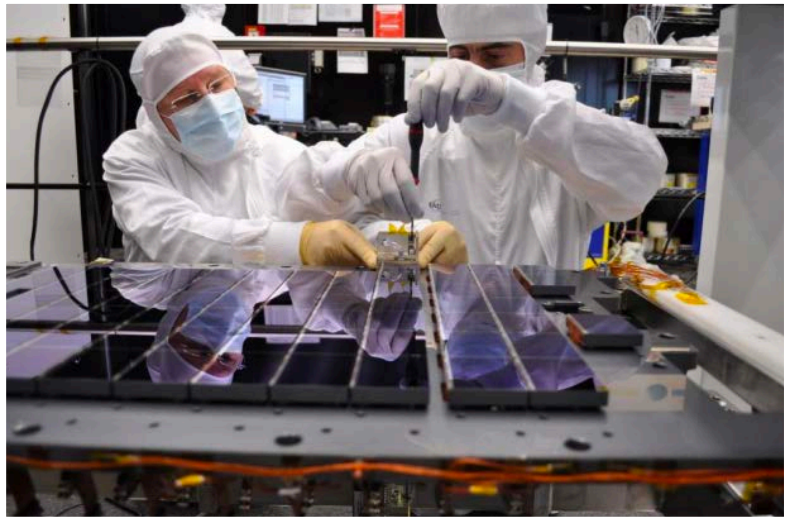
Measurements



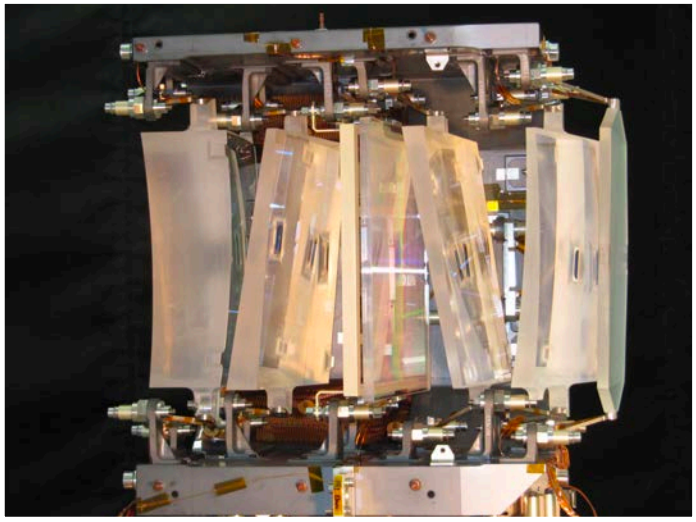


Photometers

Spectrograph

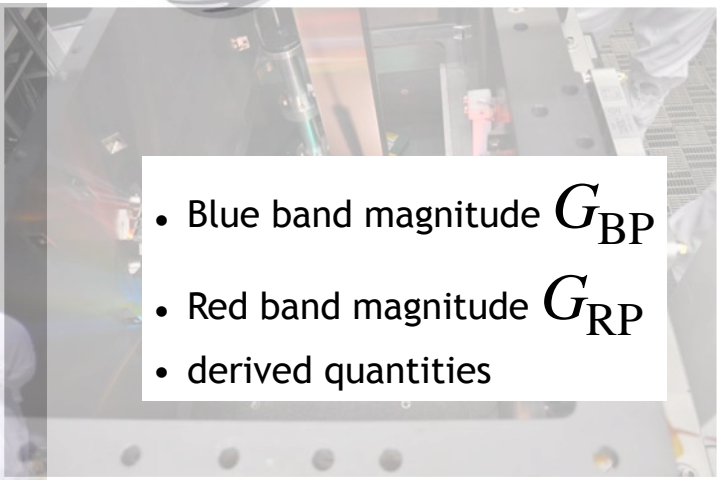


CCDs
detectors
- astrometric
- photometric
- spectroscopic

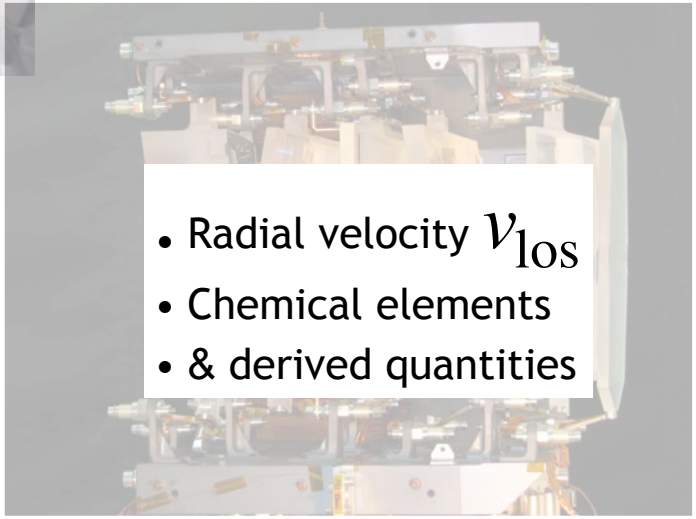


Instruments

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

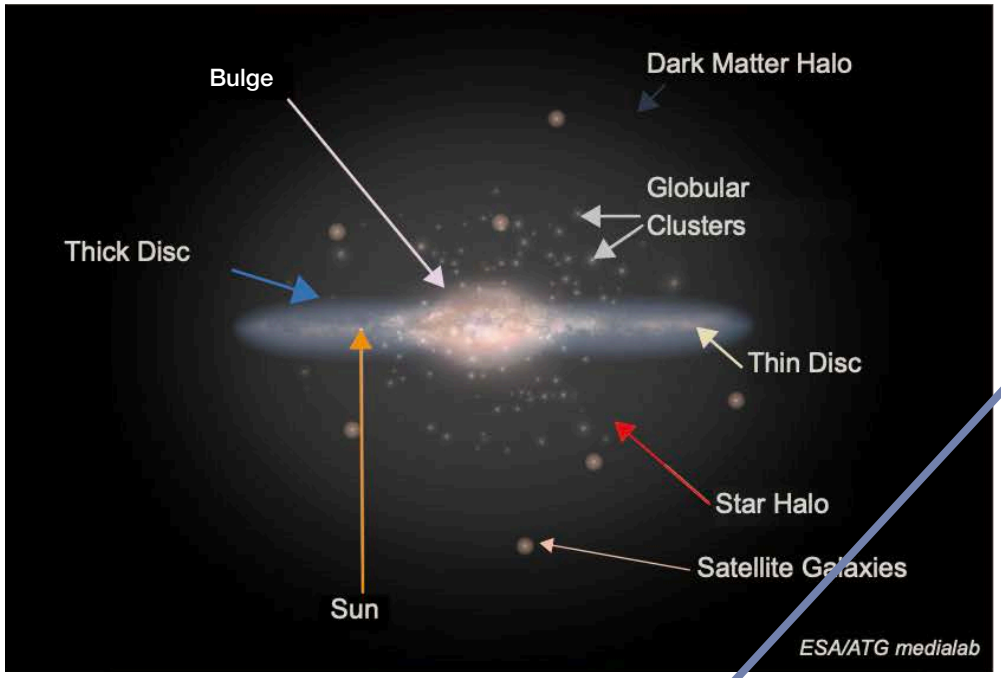


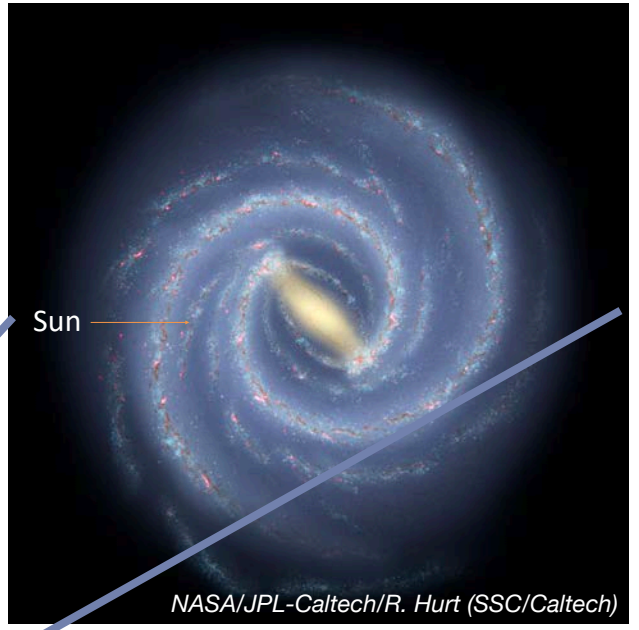
- Blue band magnitude G_{BP}
- Red band magnitude G_{RP}
- derived quantities

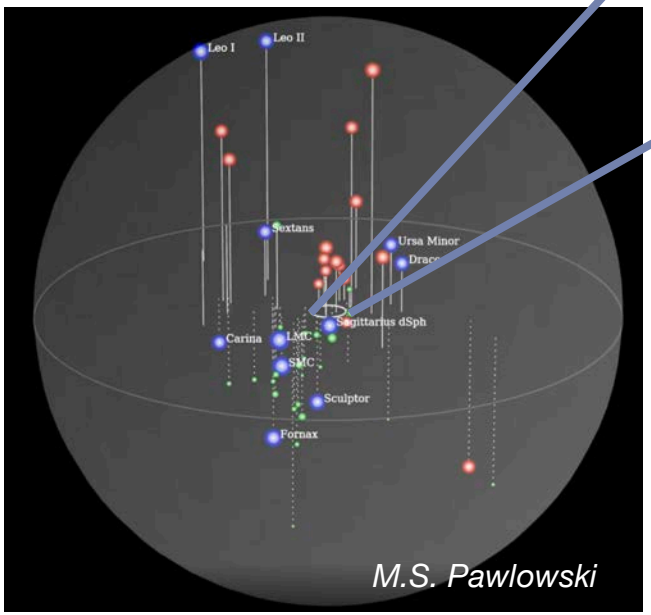


- Radial velocity v_{los}
- Chemical elements
- & derived quantities

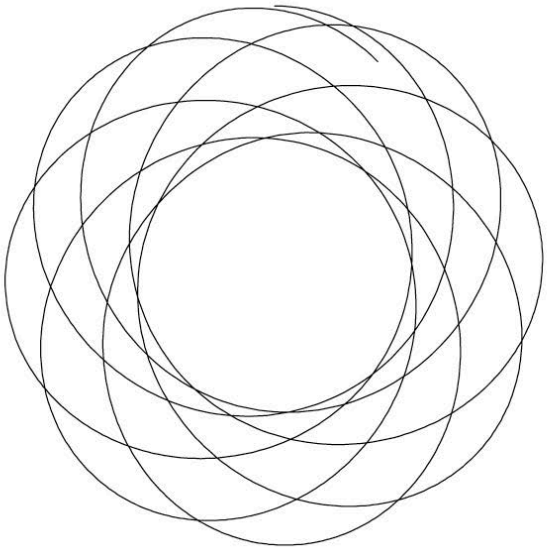
What we think the MW looks like

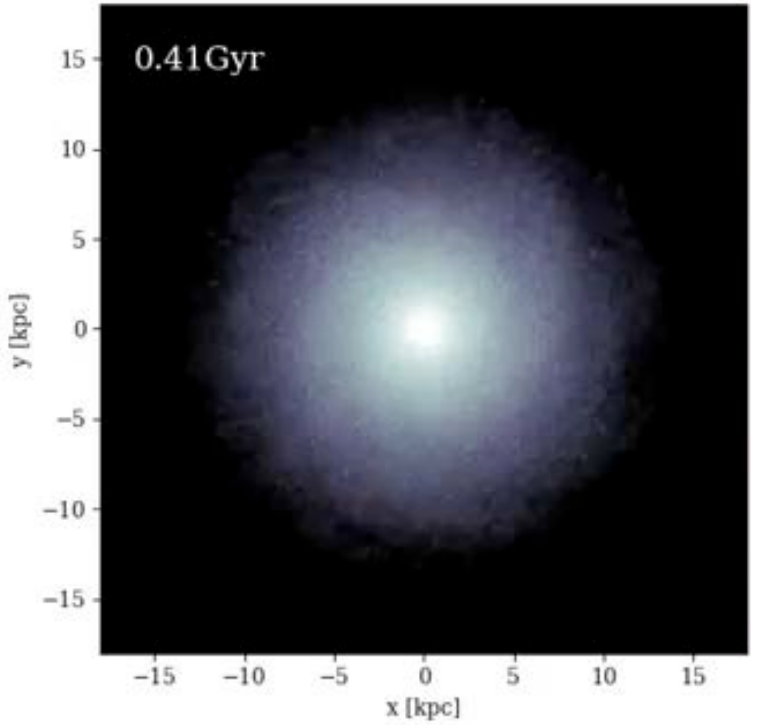


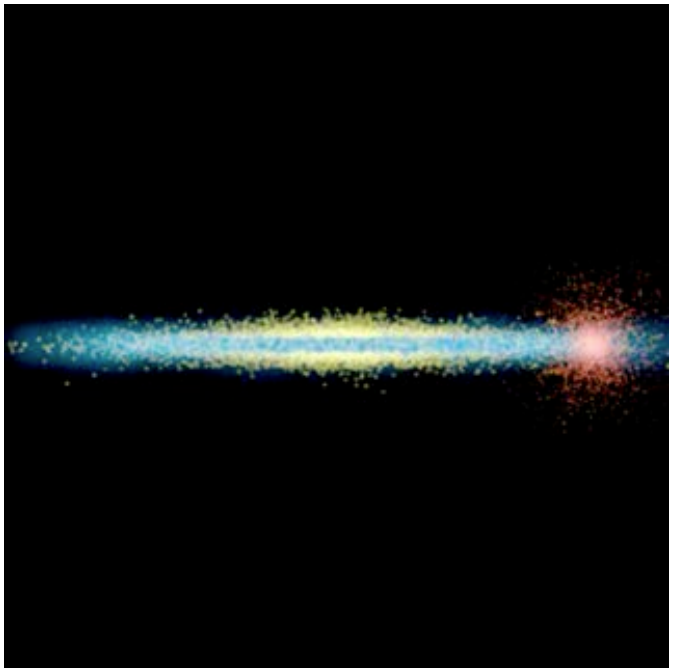




Dynamics: Orbits & Milky Way potential







- **Hand-on exercises**
  - Analysis of *Gaia* data
  - Orbits in Galactic potentials

In [25]:
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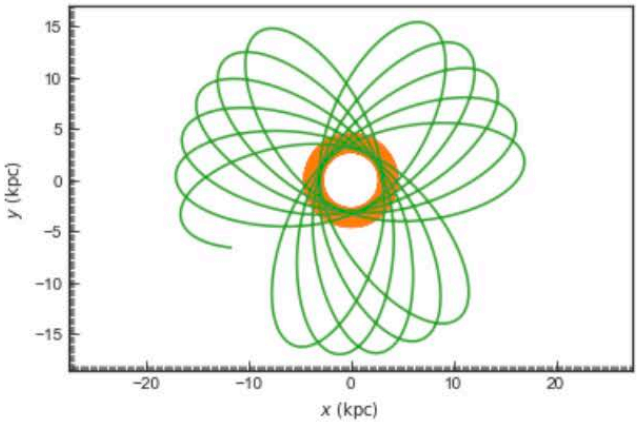
omw2.plot(d1='x',d2='y',overplot=True)
omw3.plot(d1='x',d2='y',overplot=True)

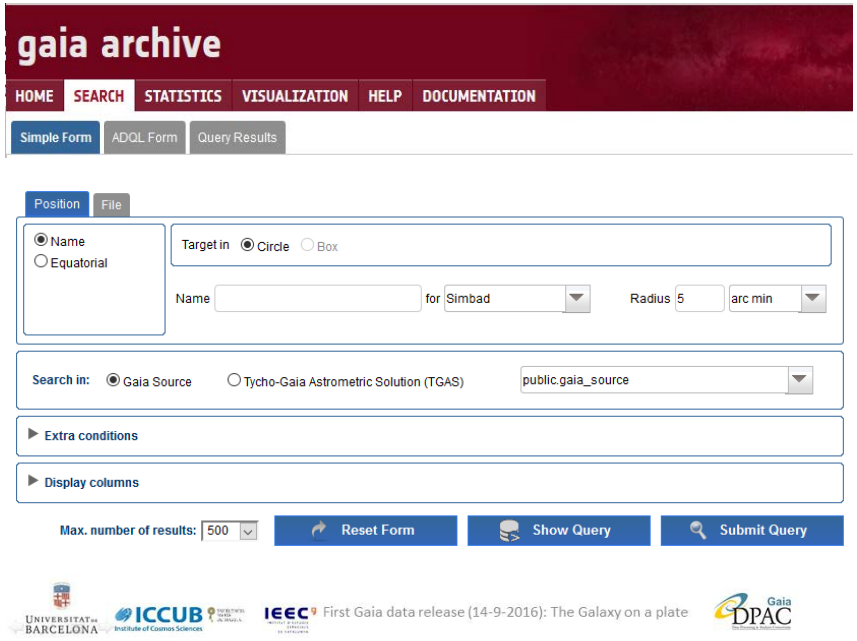
plt.axis('equal')
plt.show()
```



- **Paper reading and discussion (journal club)**

- **Short tasks**

1. Gaia Archive & Gaia measurements

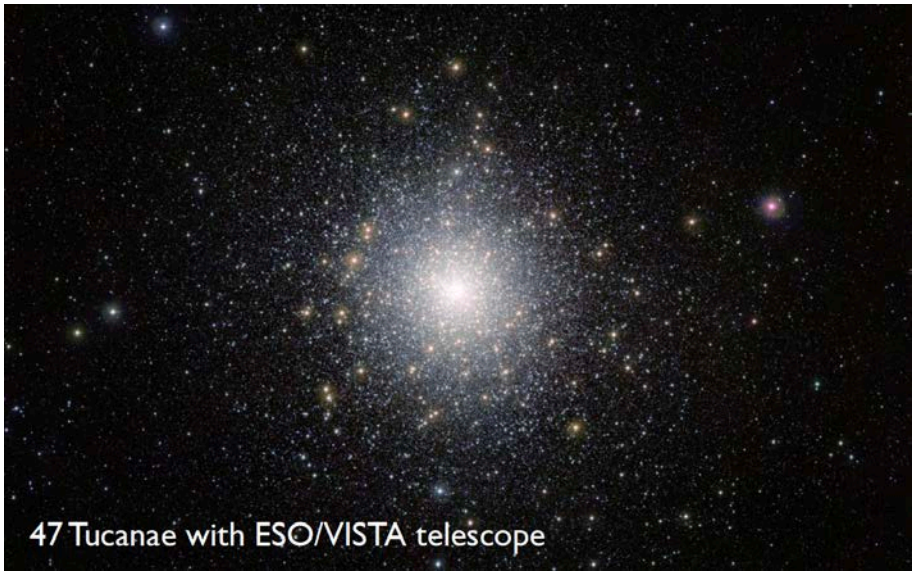


HTTP://
ARCHIVES.ESA
C.ESA.INT/
GAIA/

2. Statistical astronomy, Besançon model

- **Lectures from invited professors**

Dr. Mark Gieles
(ICCUB-ICREA)



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