Working with Gaia data

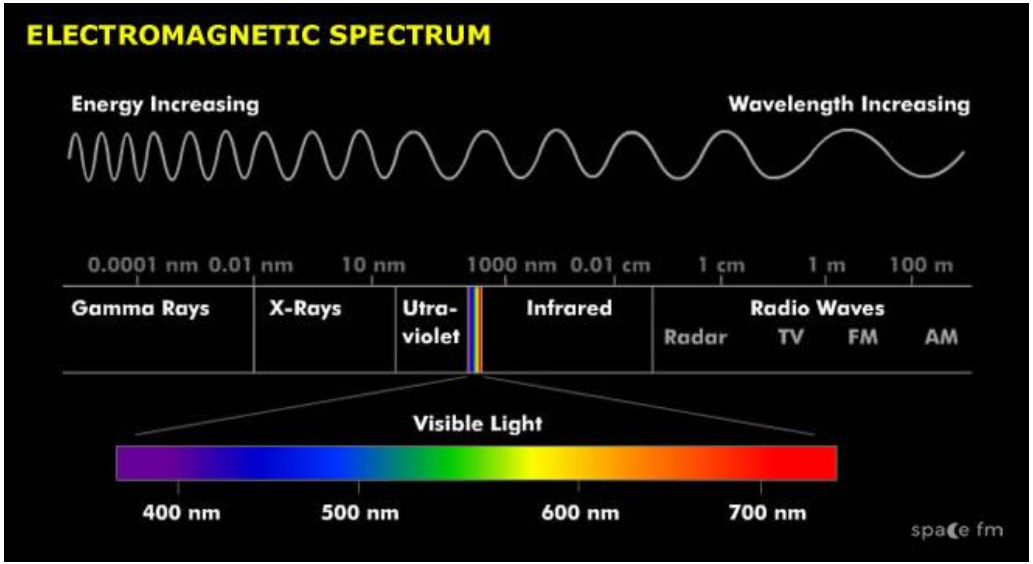
ASTR 2910 ⋆ Week 7

Astronomical data

The electromagnetic spectrum

Primary information source for astronomy: EM radiation (light)

EM radiation is characterized by energy and wavelength.



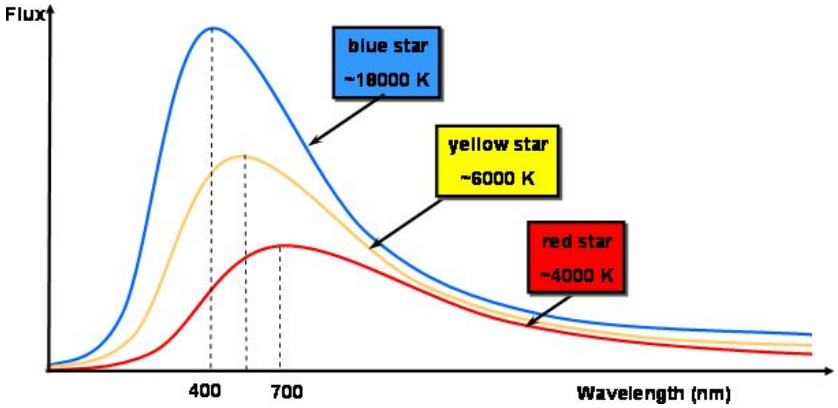

Radio
Microwave
Infrared
UV
X-Ray
Gamma Ray
Radio
60,000 nm
600 K
Infrared
1200-800 nm (10-3.6 um)
4,500 K
Optical
450-750 nm
6,000 K
Ultraviolet
400-200 nm
10,000 K
X-ray
100-10 nm
10,000,000 K
Multiwavelength Whirlpool Galaxy
COLD GAS: Radio waves reveal regions of gas cool enough for CO_2 molecules to exist.
COOL STARS: Infrared shows smaller cool red stars that make up most of the galaxy.
SOLAR STARS: Optical light comes from stars around the size of the Sun.
HOT STARS: Ultraviolet shows the larger hot blue stars that are less frequent in galaxies.
HOT GAS: X-rays are emitted from the hottest regions of gas where atoms are ionized.
COOL LOW ENERGY RADIATION
VISIBLE LIGHT
HOT HIGH ENERGY RADIATION

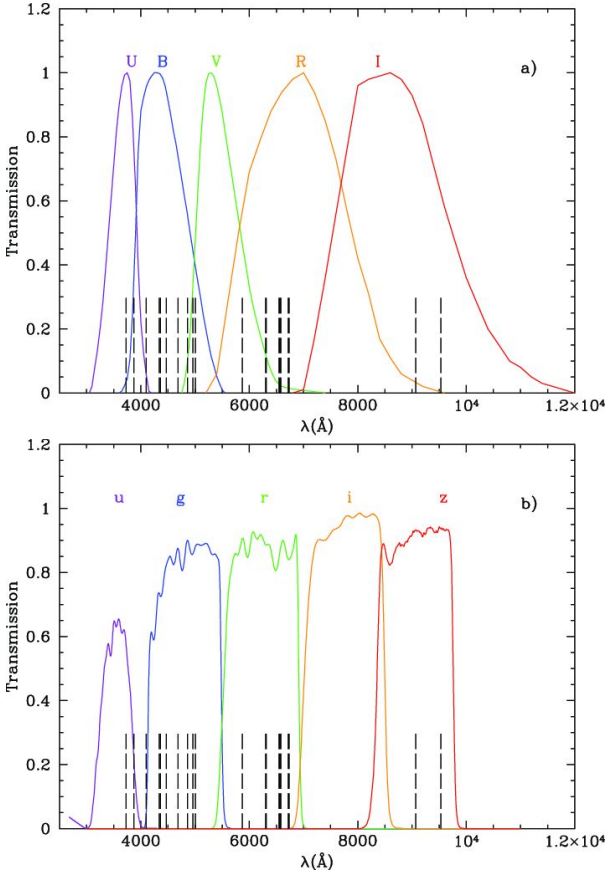
Photometry: Measuring light intensity

How bright is the object the telescope is pointing at?

Properties measured/derived:

1. Magnitude (brightness) in different filters
2. Color (difference of two magnitudes)



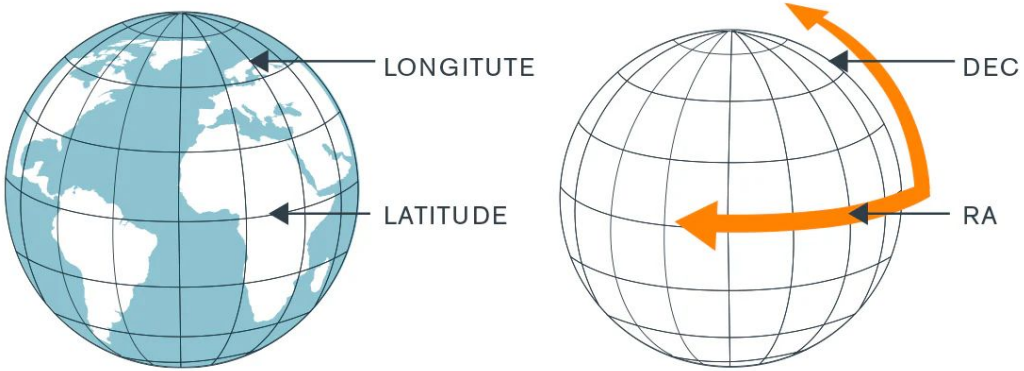


Astrometry: Measuring positions and motion

Each time the telescope points at a star, which pixel on the detector is hit?

Properties measured/derived:

1. On-sky position (e.g. right ascension and declination)



Typical units: degrees, arcminutes, arcseconds

RA can also be measured in hours, minutes, and seconds.

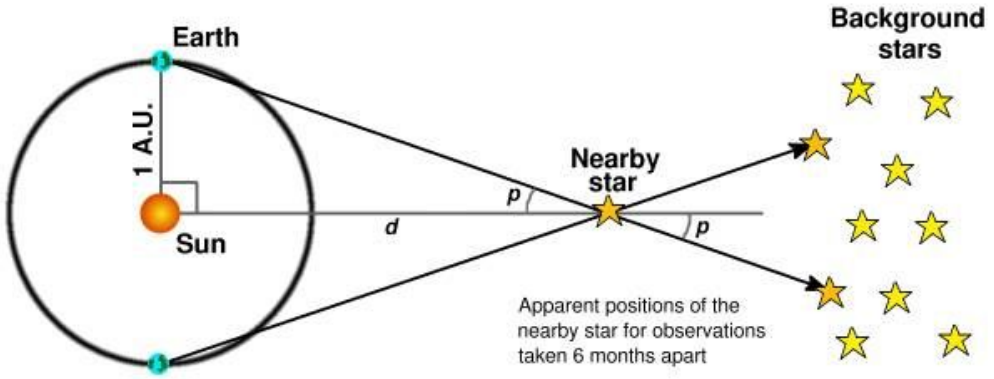
```
Right Ascension 101.287 degrees, Declination -16.716 degrees

Right Ascension 06:45:09, Declination -16:42:58
```

Astrometry: Measuring positions and motion

Each time the telescope points at a star, which pixel on the detector is hit?

Properties measured/derived:

1. On-sky position (e.g. right ascension and declination)
2. Distance (from parallax)



Astrometry: Measuring positions and motion

Each time the telescope points at a star, which pixel on the detector is hit?

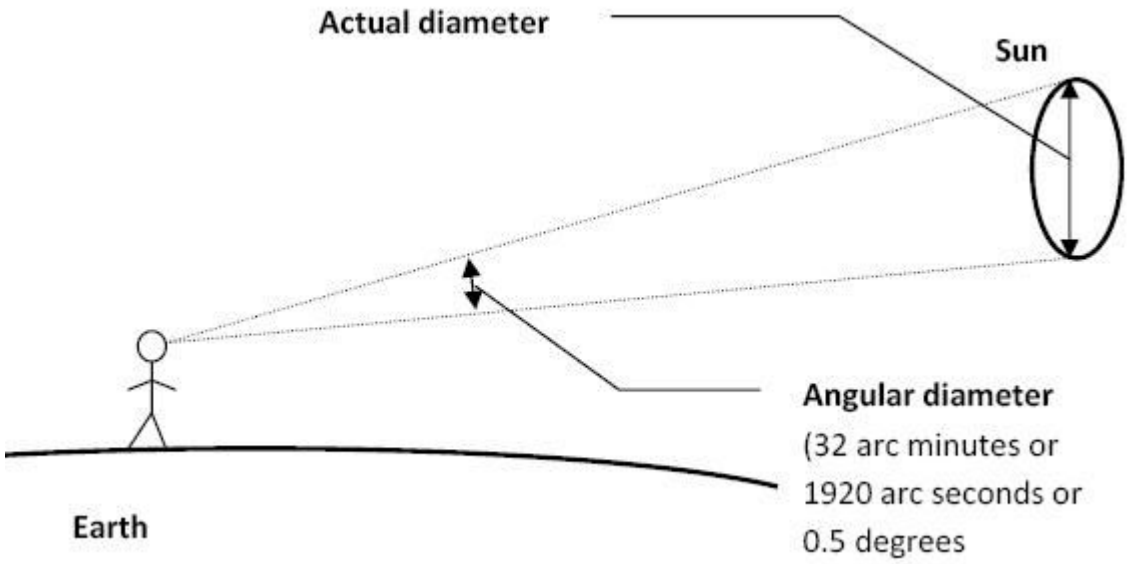
Properties measured/derived:

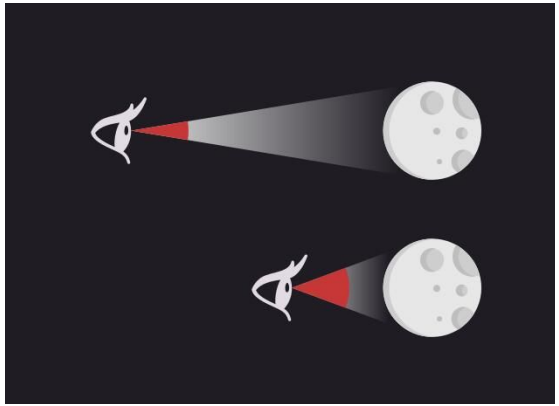
1. On-sky position (e.g. right ascension and declination)
2. Distance (from parallax)
3. Proper motion (velocities across 2D plane of sky)

What you DON’T get: radial velocity (the third dimension)!

Angular sizes

Astronomers usually use angular size to describe how big an object is. For distant objects, angular size ~ radius/distance.





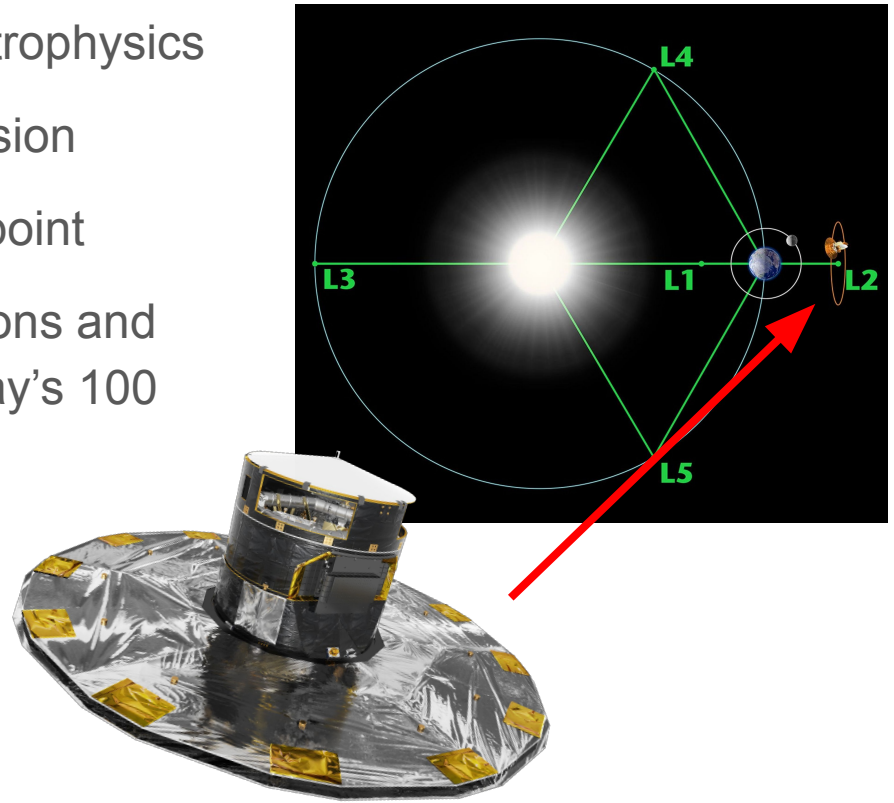
Halving the distance to an object doubles its angular size!

Gaia

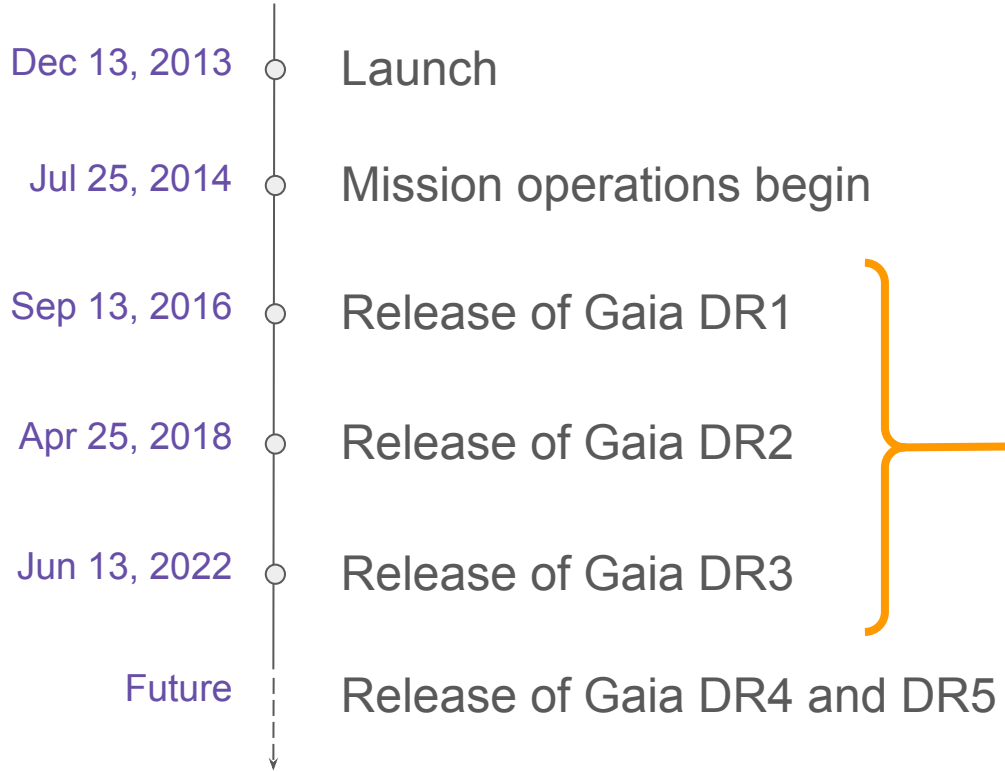
What is Gaia?

Global **A**strometric **I**nterferometer for **A**strophysics

- European Space Agency (ESA) mission
- Located at Sun-Earth L2 Lagrange point
- Goal: Accurately measure the positions and brightnesses of ~1% of the Milky Way's 100 billion stars
- Not the first astrometry mission! Precursor = Hipparcos



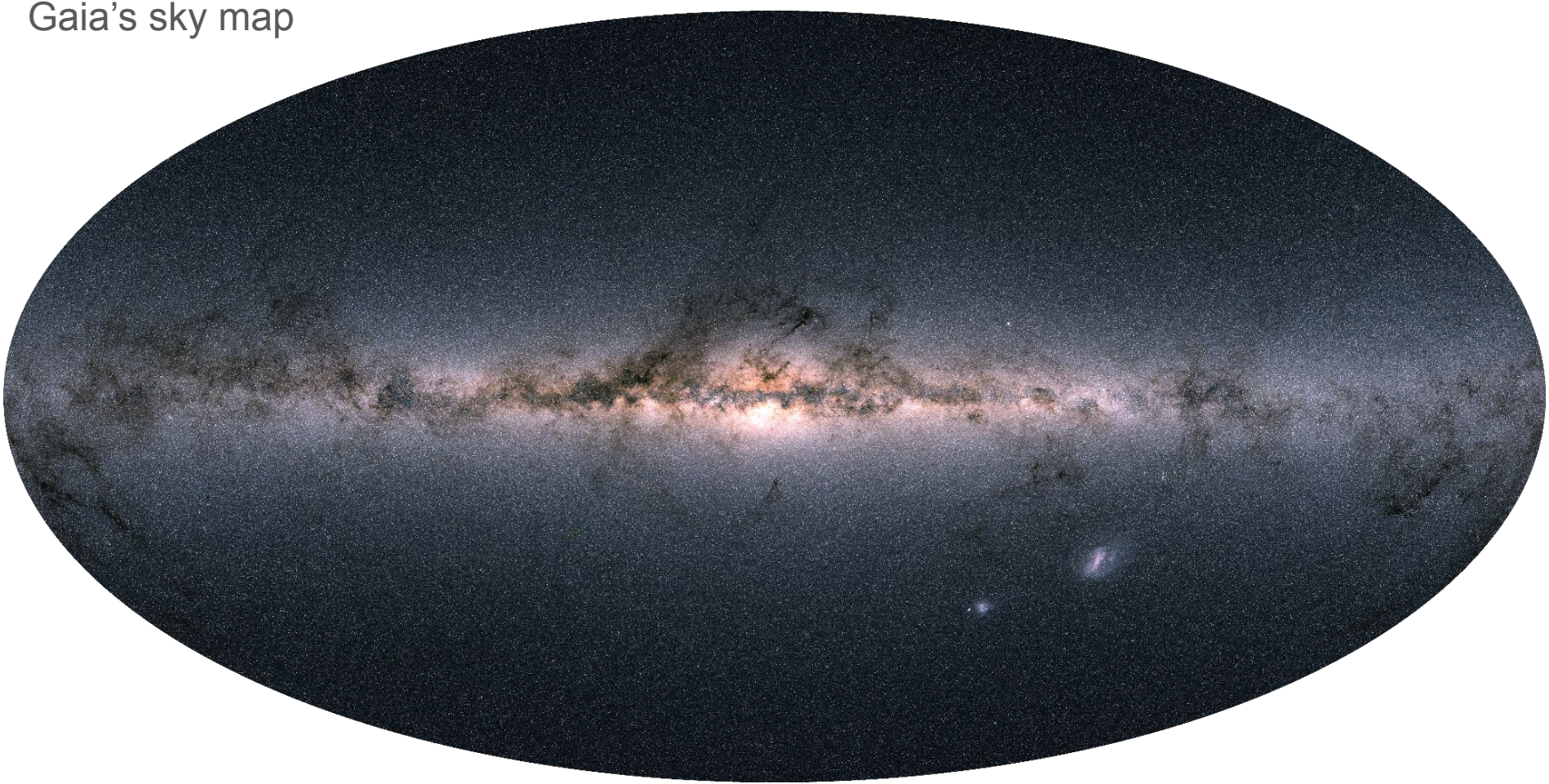
What is Gaia?



Each new data release has:

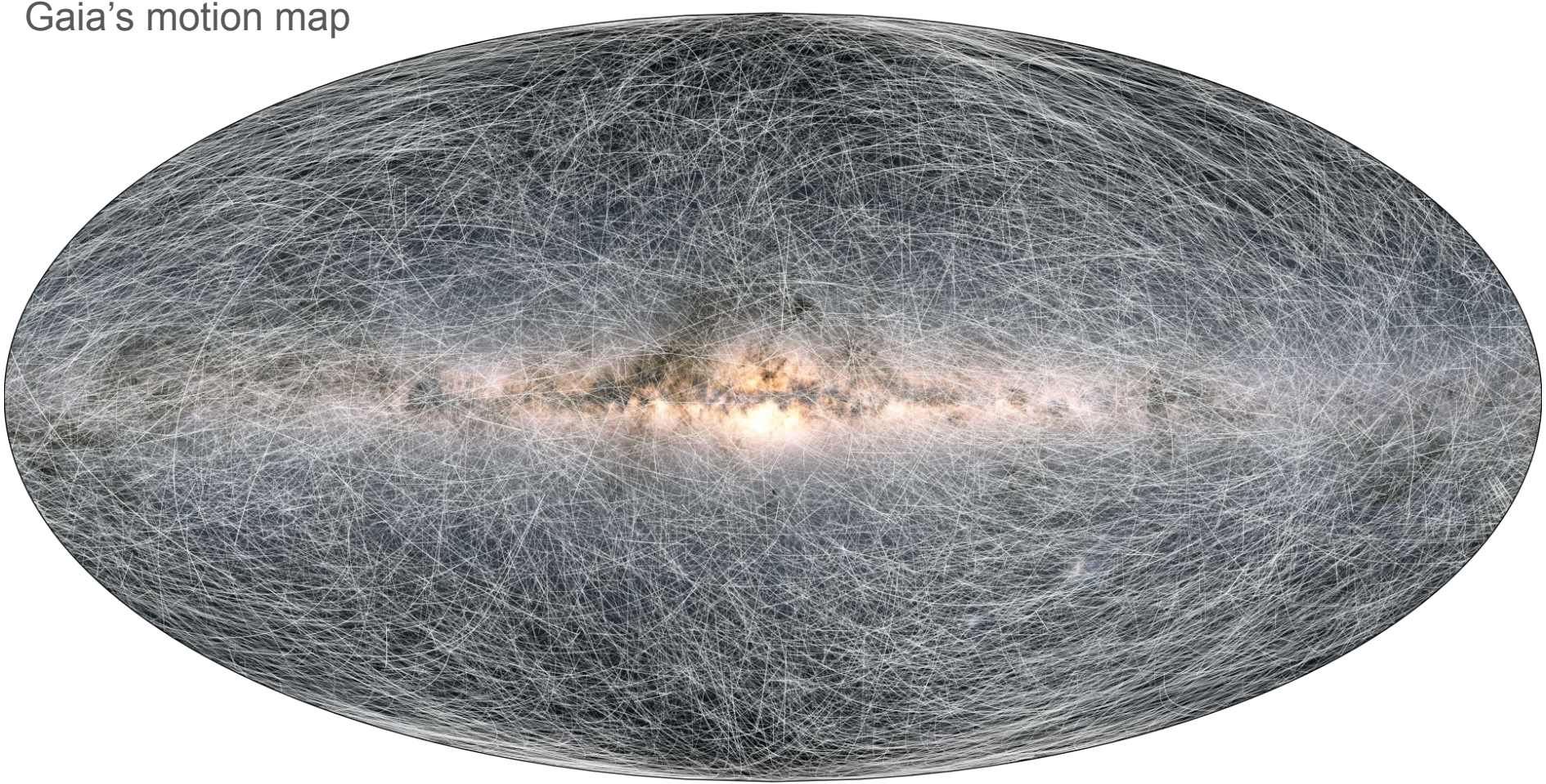
- More stars!
- Increased precision
- More advanced processing (e.g. looking for binaries)
- Additional data (RVs in DR2, variability info in DR3, etc)

Gaia’s sky map



Source: ESA

Gaia’s motion map



Source: ESA

SCIENCE & EXPLORATION

Last starlight for ground-breaking Gaia

15/01/2025 19755 VIEWS 72 LIKES

The European Space Agency's Milky Way-mapper Gaia has completed the sky-scanning phase of its mission, racking up more than three trillion observations of about two billion stars and other objects over the last decade to revolutionise the view of our home galaxy and cosmic neighbourhood.

SKY-SCANNING COMPLETE FOR ESA'S MILKY WAY MAPPER GAIA

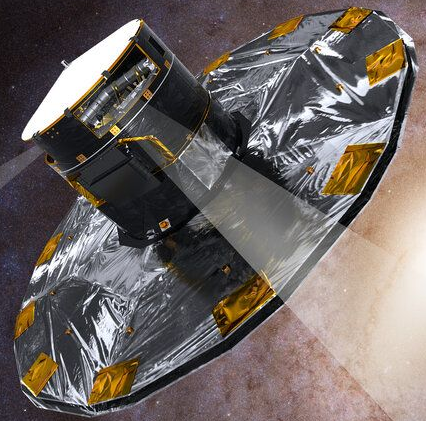
From 24 July 2014 to 15 January 2025, Gaia made more than three trillion observations of two billion stars and other objects, which revolutionised the view of our home galaxy and cosmic neighbourhood.

3 TRILLION
Observations

2 BILLION
Stars & other objects observed

938 MILLION
Camera pixels on board

15 300
Spacecraft 'pirouettes'



580 MILLION
Accesses of Gaia catalogue so far

13 000
Refereed scientific publications so far

2.8 MILLION
Commands sent to spacecraft

142 TB
Downlinked data (compressed)

500 TB
Volume of data release 4
(5.5 years of observations)

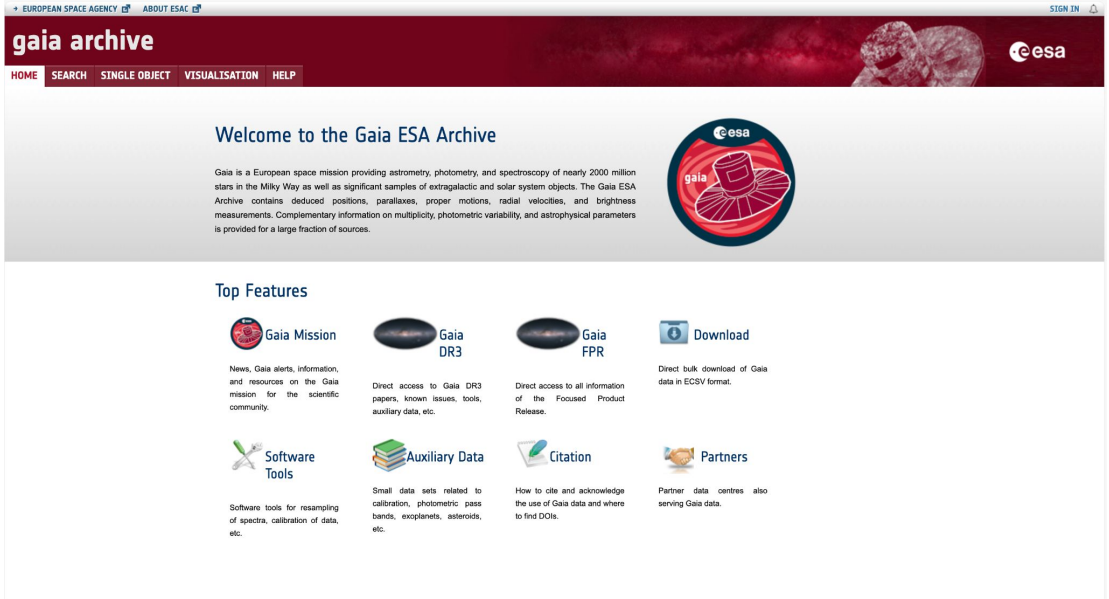
55 KG
Cold nitrogen gas consumed

3827
Days in science operations

50 000 HOURS
Ground station time used

Accessing Gaia data

Method 1: The Gaia ESA Archive (https://gea.esac.esa.int/archive/)



Method 2: Python with `astroquery` (documentation)