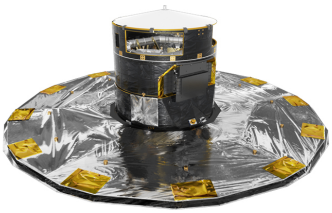
Gaia Information



Mission: Gaia is a space observatory of the European Space Agency (ESA), launched in 2013. The spacecraft is designed for astrometry: measuring the positions, distances and motions of stars with unprecedented precision, aiming to construct the largest and most precise 3D space catalog ever made, totaling approximately 1 billion astronomical objects.

Gaia was launched on 19 December 2013 and reached its designated orbit around the Sun-Earth L2 Lagrange point (a very similar orbit to JWST) on 8 January 2014. On March 27, 2025, scientists at the ESA switched off Gaia after more than a decade of service, sending it into orbit around the sun.

Data Releases

- Data Release 3 (DR3) is the current release and the one we will use in class.
- Data Release 4 (DR4) will be the full data release for the five-year nominal mission and is expected to be released no earlier than mid-2026.
- Data Release 5 (DR5) will be the final release and will consist of all data collected during the lifespan of the mission. It will be published no earlier than the end of 2030

Detectors: Gaia has the largest camera ever to be launched into space. It is 104 x 42 cm in size and contains 1 billion pixels divided among 106 CCDs. Each star that Gaia detects will be observed and measured approximately 70 times. Data is collected using 2 telescopes that focus and direct incoming light onto Gaia's 3 scientific instruments.

Scientific Instruments

- Astrometric Instrument (ASTRO): Determines the position, parallax, and proper motion of stars.
- The Photometric Instrument (BP/RP): A low-resolution spectrometer with a wavelength band of 330-1050 nm.
- Radial Velocity Spectrometer (RVS): Measures the velocity of stars along Gaia's line of sight by calculating the Doppler Shift of calcium lines.

In this class we will mostly be using the parallax data from ASTRO and the spectra from the Photometric Instrument.

Gaia Parallax: Gaia precisely determines the parallax of all stars brighter than magnitude 20 by measuring their angular position over the five-year mission.

Gaia reports the parallax of stars in milliarcseconds (mas).

$$\text{Distance in pc } (d_{\text{pc}}) \approx \frac{1}{\text{p (mas)}/1000}$$

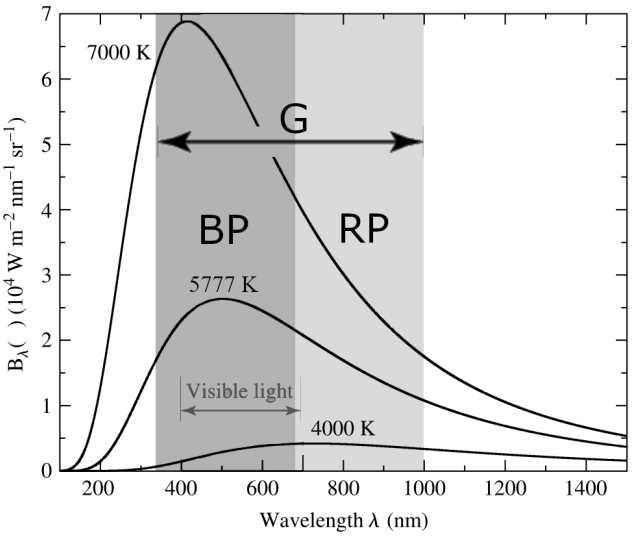
Gaia Photometry: The flux of an object observed over the entire Gaia bandpass (330-1050 nm) is refereed to as the G Magnitude.

Absolute G magnitude (M_G) is related to apparent G magnitude (m_G) via:

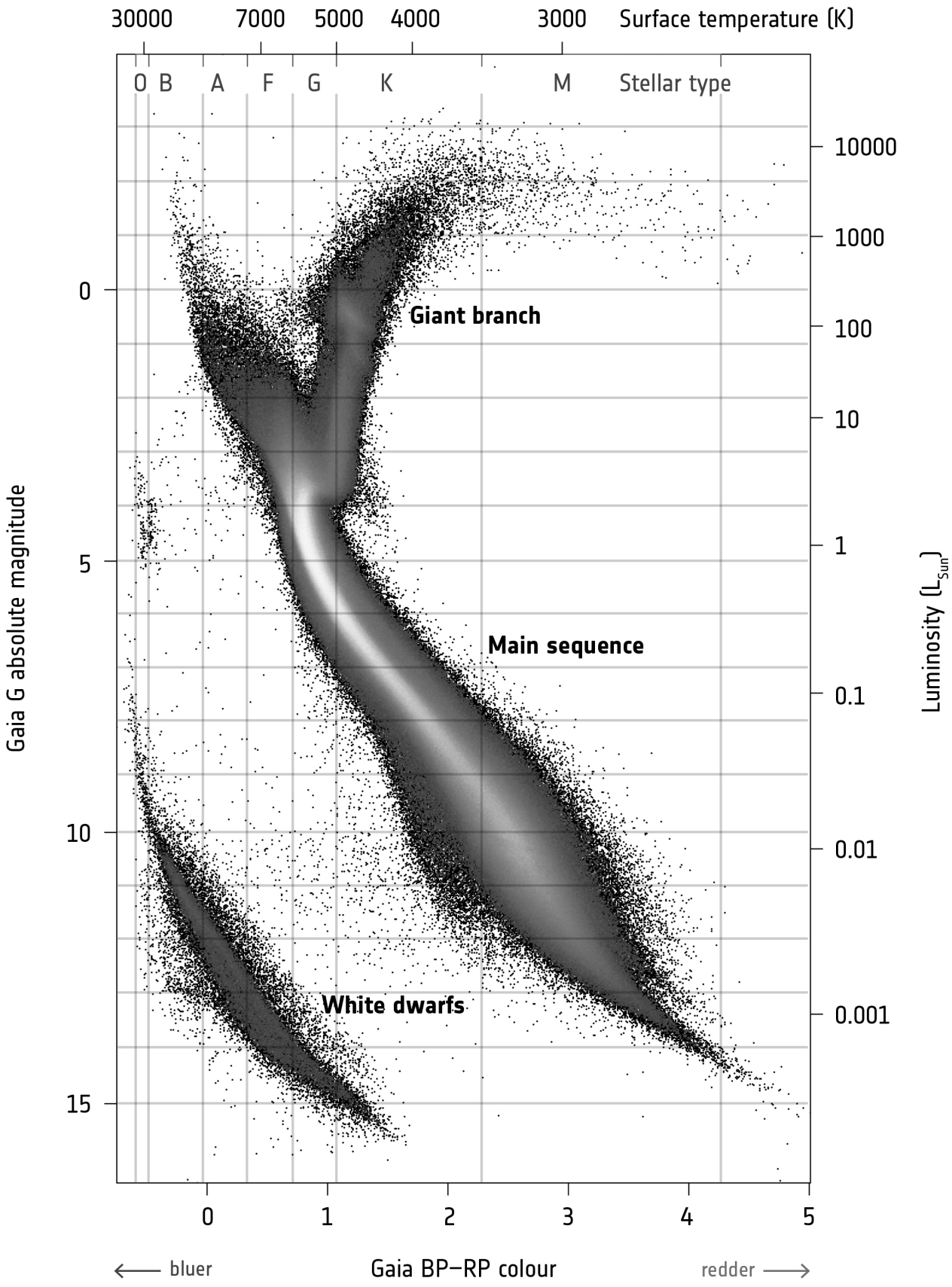
$$M_G = m_G - 5\log_{10}\left(\frac{d_{\text{pc}}}{10\,\text{pc}}\right)$$

Gaia color index (G_{CI}) The G bandpass is divided into two bandpasses - The Blue Photometer (BP 330–680 nm) and the Red Photometer (RP 640–1050 nm).

$$G_{CI} = BP - RP$$



Gaia color magnitude diagram: The Gaia CMD is shown on the next page.


30000
7000
5000
4000
3000
Surface temperature (K)
O
B
A
F
G
K
M
Stellar type
Giant branch
Main sequence
White dwarfs
Gaia G absolute magnitude
0
5
10
15
10000
1000
100
10
1
0.1
0.01
0.001
Luminosity (L_sun)
0
1
2
3
4
5
← bluer
Gaia BP–RP colour
redder →