

AA 652: Astronomy Laboratory-III

Constellations with Gaia

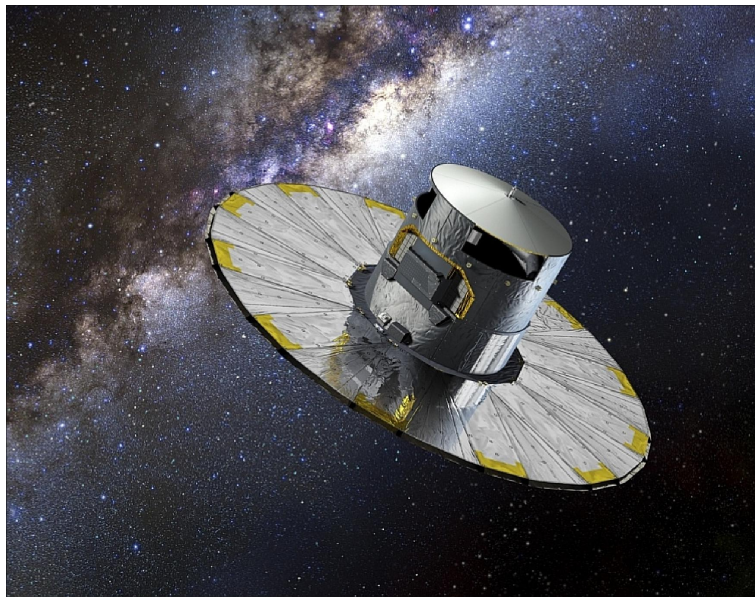
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1 Introduction

1.1 GAIA:

Gaia is a space observatory of the European Space Agency (ESA), launched in 2013 and expected to operate until c. 2022. The spacecraft is designed for astrometry: measuring the positions, distances and motions of stars with unprecedented precision. The mission aims to construct by far the largest and most precise 3D space catalog ever made, totalling approximately 1 billion astronomical objects, mainly stars, but also planets, comets, asteroids and quasars, among others.



The spacecraft monitored each of its target objects about 70 times over the first five years of the mission to study the precise position and motion of each target, and will keep doing so. The spacecraft has enough micro-propulsion fuel to operate until about November 2024. As its detectors are not degrading as fast as initially expected, the mission could therefore be extended. Gaia targets objects brighter than magnitude 20 in a broad photometric band that covers most of the visual range; such objects represent approximately 1% of the Milky Way population. Additionally, Gaia is expected to detect thousands to tens of thousands of Jupiter-sized exoplanets beyond the Solar System, 500,000 quasars outside our galaxy and tens of thousands of new asteroids and comets within the Solar System.

During the mapping, Gaia will detect and very accurately measure the motion of each star in its orbit around the centre of the Galaxy. Much of this motion was imparted upon each star during its birth; studying this motion allows astronomers to peer back in time, to when the Galaxy was first forming. By constructing a detailed map of the stars, Gaia will provide a crucial tool to study the formation of our Galaxy, the Milky Way.

1.2 Cepheus Constellation:

The constellation Cepheus, the king, is visible all year in the northern hemisphere. It can be seen between latitudes of 90 degrees and -10 degrees. It is a medium-sized constellation with a total area of 588 square degrees. This makes it the 27th largest constellation in the night sky. It is bordered by the constellations Camelopardalis, Cassiopeia, Cygnus, Draco, Lacerta, and Ursa Minor.

Cepheus is one of the 48 constellations identified by the Greek astronomer Ptolemy in the second century. It was named after the king of Ethiopia. Cepheus was the husband of Cassiopeia and the father of Andromeda. All three are immortalized in the night sky as constellations. It is said that Zeus placed him among the stars after his death because he was descended from the nymph Io, who was one of Zeus' favorites. Cepheus is usually depicted as a robed king with a crown of stars. He stands with his left foot placed over the pole and his scepter extended towards his queen, Cassiopeia.

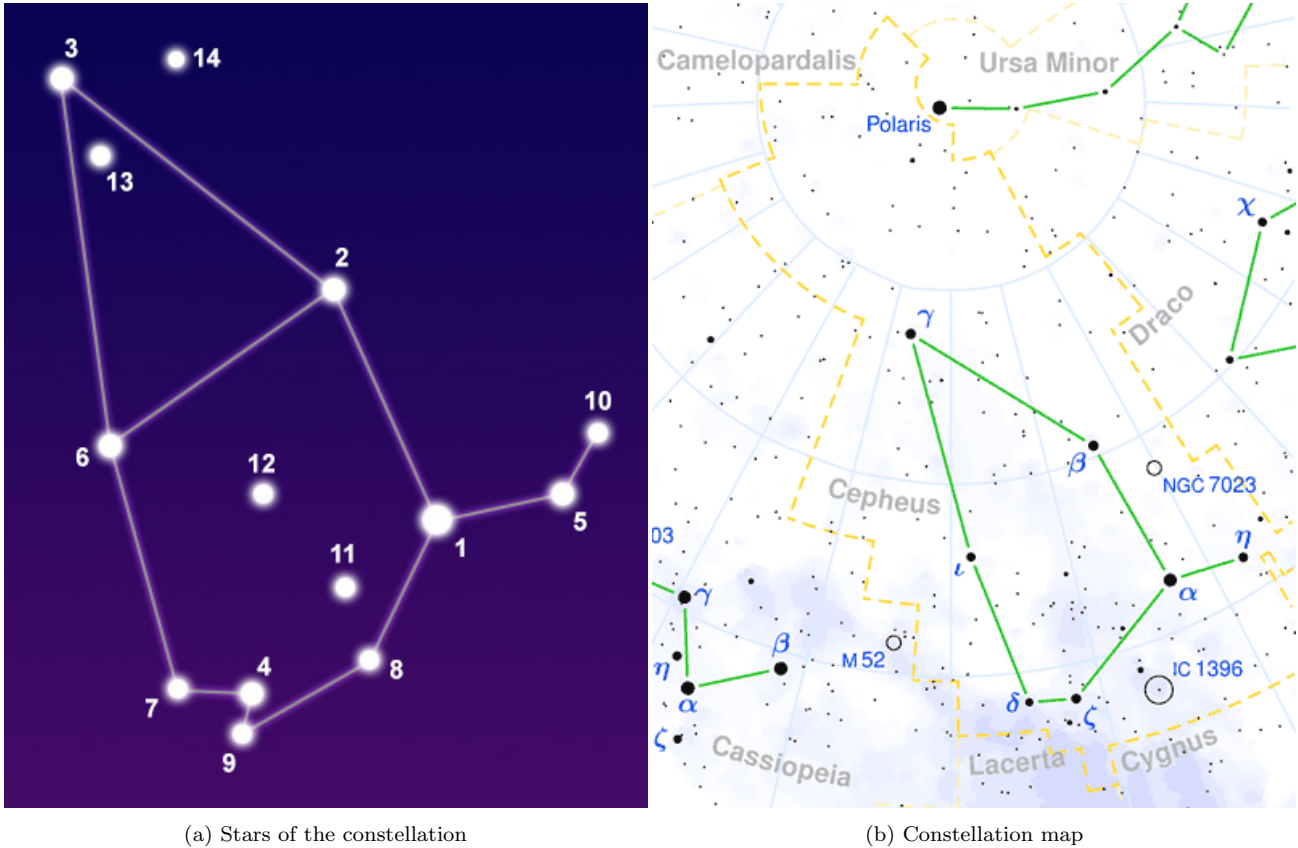


Figure 1: Cepheus constellation

Cepheus contains three stars brighter than magnitude 4. Alderamin is the brightest with a visual magnitude of 2.44. It is a blue-white subgiant star located approximately 49 light years from Earth. Alfirk is the second brightest, with a magnitude of 3.15. Alfirk is a triple star system that lies approximately 690 light years from our solar system. Alrai is a binary star system. At magnitude 3.0, it is the third brightest star in this constellation.

Cepheus contains no Messier objects but does contain several dim deep-sky objects that can only be seen in large telescopes. NGC 6946, the Fireworks Galaxy, is a spiral galaxy in which nine supernovae have been observed. This is more than any other galaxy. Other notable objects in Cepheus include the Cave Nebula, the Iris Nebula (NGC 7023), and the Wizard nebula (NGC 7380). These objects are extremely faint and can only be seen with large telescopes.

1.2.1 List of main stars making the Cepheus Constellation

Table 1: Recorded and calculated data

Designation	Name / Meaning	Object Type	Visual Mag
Alderamin	"The Right Arm"	Blue-White Subgiant Star	2.44
Alfirk	"The Flock"	Triple Star System	3.15
Alrai	"The Shepherd"	Binary Star System	3.22
Zeta Cephei		Orange Subgiant Star	3.35
Eta Cephei		Orange Giant Star	3.43
Iota Cephei		Orange Giant Star	3.50
Delta Cephei		Quadruple Star System	4.07
Herschel's Garnet Star	Named for Red Color	Red Supergiant Star	4.08
Epsilon Cephei		Yellow-White Dwarf Star	4.18
Theta Cephei		Binary Star System	4.21
Nu Cephei		Blue Supergiant Star	4.29
Alkurhah	"The Ape"	Binary Star System	4.29
Pi Cephei		Trinary Star System	4.42
Al Kalb al Rai	"The Shepherd's Dog"	Blue Subgiant Star	5.50

2 Observations

2.1 Observation table:

Table 2: Coordinates for stars from Cepheus constellation using GAIA

Name	RA	Dec	parallax	parallax err	pmra	pmdec
Theta Cephei	307.395779	62.994049	23.481038	0.689382	34.797919	-13.903874
Eta Cephei	311.323206	61.842419	69.597554	0.127860	85.993441	818.451125
Alderamin	319.646337	62.585796				
Alfirk	322.165053	70.560719				
Herschel's Garnet Star	325.876944	58.780028	0.119024	0.263686	3.439341	-4.108340
Nu Cephei	326.362155	61.120797	0.932088	0.086511	-3.545024	-2.024904
Zeta Cephei	332.713770	58.201285	3.297198	0.145636	13.358976	5.274815
Epsilon Cephei	333.762613	57.043803	38.159770	0.243227	423.158506	52.691098
Delta Cephei	337.292885	58.415208	3.555064	0.147539	14.559643	3.237520
Rho-2 Cephei/ Al kalb al rai	337.470823	78.824194	13.603749	0.054390	3.543434	-20.840265
Iota Cephei	342.419347	66.199850	27.286898	0.130935	-65.946568	-124.967063
Pi Cephei	346.974507	75.387361	12.145783	0.568886	2.463138	-33.829431
Gamma Cephei/ Alrai/Errai	354.835781	77.633125	72.516692	0.146989	-64.860178	171.158603

In the above table,

RA: Right Ascension Dec: Declination pmra: right ascension accounting for proper motion pmdec: declination accounting for proper motion app mag: apparent magnitude

Table 3: Apparent magnitudes of stars and their distances

Name	App Mag	Distance (Ly)
Theta Cephei	4.1649013	136.47
Eta Cephei	3.1779127	46.53
Alderamin	2.428267	49.05
Alfirk	3.19459	685.22
Herschel's Garnet Star	2.450726	5930.24
Nu Cephei	4.121482	6795.07
Zeta Cephei	2.8701382	836.32
Epsilon Cephei	4.1220145	85.45
Delta Cephei	3.8505998	883.91
Rho-2 Cephei/ Al kalb al rai	5.442163	245.05
Iota Cephei	3.222498	115.29
Pi Cephei	4.2604837	246.72
Gamma Cephei/ Alrai/Errai	2.9429574	46

3 Inferences

1. Although the stars are in the same constellation, that does not mean they are moving together.
2. As seen above, all stars in a constellation are moving with very different velocities and in very different directions compared to each other. As a result, after a period of time, the constellation won't even look the same.
3. Even if the stars are of the same constellation, it does not mean that they are in the same locality in space. It's just that they look to be in the same plane of our vision and thus we associate them as a group.
4. The stars of a constellation need not be of the same type as well. As seen above, from the example of the Cepheus constellation, it is clearly observed that the stars of a constellation are of very different types.

4 Acknowledgement

We thank the European Space agency for making the GAIA data archives public for us to use and enable us to learn more about how satellites collect data, and how it's used to understand things. We would also like to thank the various contributors to the open source SciLab tool which has been used to plot and generate a straight line fit for the observed data.