Coordinates: 03h 47m 24s, +24° 07′ 00″

Pleiades

The **Pleiades** (/ˈplaɪ.ədiːz, ˈpliːə-/), also known as the **Seven Sisters** and **Messier 45**, are an open star cluster containing middle-aged, hot B-type stars located in the constellation of Taurus. It is among the nearest star clusters to Earth and is the cluster most obvious to the naked eye in the night sky.

The cluster is dominated by hot blue and luminous stars that have formed within the last 100 million years. Reflection nebulae around the brightest stars were once thought to be left over material from the formation of the cluster, but are now considered likely to be an unrelated dust cloud in the interstellar medium through which the stars are currently passing.[7]

Computer simulations have shown that the Pleiades were probably formed from a compact configuration that resembled the Orion Nebula.[8] Astronomers estimate that the cluster will survive for about another 250 million years, after which it will disperse due to gravitational interactions with its galactic neighborhood.[9]

Pleiades

A color-composite image of the Pleiades from the Digitized Sky Survey
Credit: NASA/ESA/AURA/Caltech

Observation data (J2000 epoch)	
Constellation	Taurus
Right ascension	03h 47m 24s[1]
Declination	+24° 07′ 00″[1]
Distance	444 ly on average (136.2±1.2 pc[2][3][4][5])
Apparent magnitude (V)	1.6[6]
Apparent dimensions (V)	110' (arcmin)[6]
Physical characteristics	
Other designations	M45,[1] Seven Sisters,[1] Melotte 22[1]

Contents

Origin of name

The name of the Pleiades comes from Ancient Greek. It probably derives from *plein* ("to sail") because of the cluster's importance in delimiting the sailing season in the Mediterranean Sea: "the season of navigation began with their heliacal rising".[10] However, in mythology the name was used for the Pleiades, seven divine sisters, the name supposedly deriving from that of their

mother Pleione and effectively meaning "daughters of Pleione". In reality, the name of the star cluster almost certainly came first, and Pleione was invented to explain it.[11]

Folklore and mythology

The Pleiades are a prominent sight in winter in the Northern Hemisphere, and are easily visible out to mid-Southern latitudes. They have been known since antiquity to cultures all around the world,[12] including the Celts, Hawaiians (who call them *Makali'i*[13]), Māori (who call them *Matariki*), Aboriginal Australians (from several traditions), the Persians, the Arabs (who called them *Thurayya*[14]), the Chinese (昴 *mǎo*), the Quechua, the Japanese, the Maya, the Aztec, the Sioux, the Kiowa,[15][16] and the Cherokee. In Hinduism, the Pleiades are known as Krittika and are associated with the war-god Kartikeya. They are also mentioned three times in the Bible.[17][18]

The Nebra sky disk, dated circa 1600 BC. The cluster of dots in the upper right portion of the disk is believed to be the Pleiades.

The earliest-known depiction of the Pleiades is likely a Northern German bronze age artifact known as the Nebra sky disk, dated to approximately 1600 BC.[19] The Babylonian star catalogues name the Pleiades ^{MUL}MUL (), meaning "stars" (literally "star star"), and they head the list of stars along the ecliptic, reflecting the fact that they were close to the point of vernal equinox around the 23rd century BC. The Ancient Egyptians may have used the names "Followers" and "Ennead" in the prognosis texts of the Calendar of Lucky and Unlucky Days of papyrus Cairo 86637.[20] Some Greek astronomers considered them to be a distinct constellation, and they are mentioned by Hesiod's *Works and Days*,[21] Homer's *Iliad* and *Odyssey*,[22] and the *Geoponica*.[23] Some scholars of Islam suggested that the Pleiades (ath-thurayya) are the "star" mentioned in Sura An-Najm ("The Star") of the Quran.[24]

Galileo's drawings of the Pleiades star cluster from *Sidereus Nuncius*. *Image courtesy of the History of Science Collections, University of Oklahoma Libraries.*

Subaru

In Japan, the constellation is mentioned under the name Mutsuraboshi ("six stars") in the 8th-century *Kojiki*.[25] The constellation is now known in Japan as Subaru ("to unite"). It was chosen as the brand name of Subaru automobiles to reflect the origins of the firm as the joining of five companies, and is depicted in the firm's six-star logo.[26]

Observational history

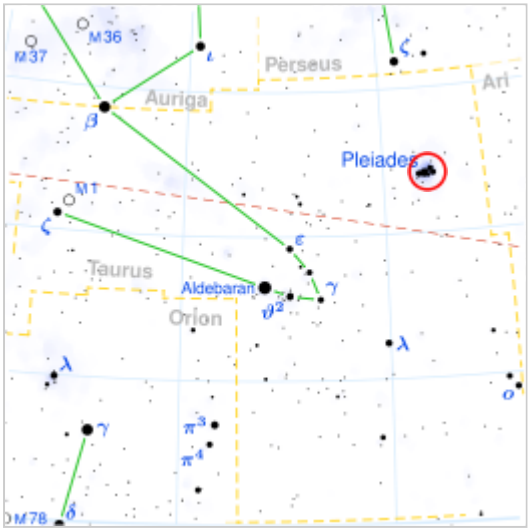
Galileo Galilei was the first astronomer to view the Pleiades through a telescope. He thereby discovered that the cluster contains many stars too dim to be seen with the naked eye. He published his observations, including a sketch of the Pleiades showing 36 stars, in his treatise *Sidereus Nuncius* in March 1610.

The Pleiades have long been known to be a physically related group of stars rather than any chance alignment. John Michell calculated in 1767 that the probability of a chance alignment of so many bright stars was only 1 in 500,000, and so surmised that the Pleiades and many other clusters of stars must be physically related.[27] When studies were first made of the stars' proper motions, it was found that they are all moving in the same direction across the sky, at the same rate, further demonstrating that they were related.

Charles Messier measured the position of the cluster and included it as M45 in his catalogue of comet-like objects, published in 1771. Along with the Orion Nebula and the Praesepe cluster, Messier's inclusion of the Pleiades has been noted as curious, as most of Messier's objects were much fainter and more easily confused with comets—something that seems scarcely possible for the Pleiades. One possibility is that Messier simply wanted to have a larger catalogue than his scientific rival Lacaille, whose 1755 catalogue contained 42 objects, and so he added some bright, well-known objects to boost his list.[28]

Edme-Sébastien Jeaurat then drew in 1782 a map of 64 stars of the Pleiades from his observations in 1779, which he published in 1786.[29][30][31]

Distance



Location of Pleiades (circled)

The distance to the Pleiades can be used as an important first step to calibrate the cosmic distance ladder. As the cluster is so close to the Earth, its distance is relatively easy to measure and has been estimated by many methods. Accurate knowledge of the distance allows astronomers to plot a Hertzsprung–Russell diagram for the cluster, which, when compared to those plotted for clusters whose distance is not known, allows their distances to be estimated. Other methods can then extend the distance scale from open clusters to galaxies and clusters of galaxies, and a cosmic distance ladder can be constructed. Ultimately astronomers' understanding of the age and future evolution of the universe is influenced by their knowledge of the distance to the Pleiades. Yet some authors argue that the controversy over the distance to the Pleiades discussed below is a red herring, since the cosmic distance ladder can (presently) rely on a suite of other nearby clusters where consensus exists regarding the distances as established by the *Hipparcos* satellite and independent means (e.g., the Hyades, Coma Berenices cluster, etc.).[3]

Measurements of the distance have elicited much controversy. Results prior to the launch of the *Hipparcos* satellite generally found that the Pleiades were about 135 parsecs (pc) away from Earth. Data from *Hipparcos* yielded a surprising result, namely a distance of only 118 pc by measuring the parallax of stars in the cluster—a technique that should yield the most direct and accurate results. Later work consistently argued that the *Hipparcos* distance measurement for the Pleiades was erroneous.[3][4][5][32][33][34] In particular, distances derived to the cluster via the Hubble Space Telescope and infrared color-magnitude diagram fitting (so-called "spectroscopic parallax") favor a distance between 135 and 140 pc;[3][32] a dynamical distance from optical interferometric observations of the Pleiad double Atlas favors a distance of 133 to 137 pc.[34] However, the author of the 2007–2009 catalog of revised *Hipparcos* parallaxes reasserted that the distance to the Pleiades is ~120 pc and challenged the dissenting evidence.[2] Recently, Francis and Anderson[35] proposed that a systematic effect on *Hipparcos* parallax errors for stars in clusters biases calculation using the weighted mean and gave a *Hipparcos* parallax distance of 126 pc and photometric distance 132 pc based on stars in the AB Doradus, Tucana-Horologium, and Beta Pictoris moving groups, which are all similar in age and composition to the Pleiades. Those authors note that the difference between these results can be attributed to random error. More recent results using very-long-baseline interferometry (VLBI) (August 2014) and preliminary solutions using Gaia Data Release 1 (September 2016) and Gaia Data Release 2 (August 2018), determine distances of 136.2 ± 1.2 pc,[36] 134 ± 6 pc[37] and 136.2 ± 5.0 pc,[38] respectively. Although the Gaia Data Release 1 team was cautious about their result, the VLBI authors assert "that the *Hipparcos*-measured distance to the Pleiades cluster is in error".

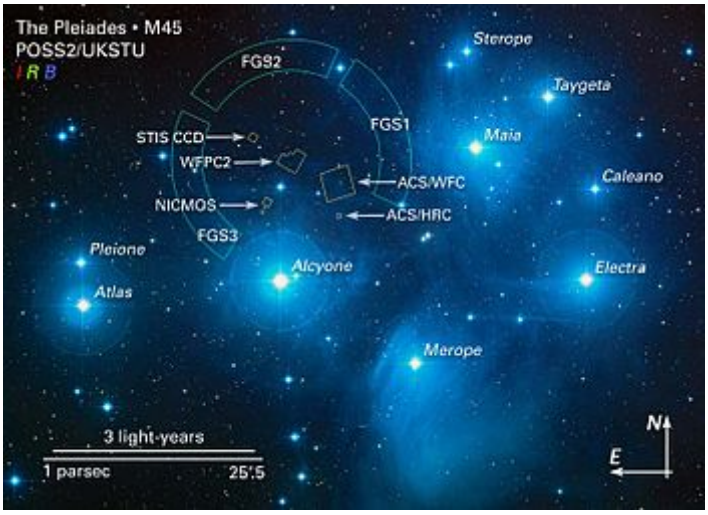
Selected distance estimates to the Pleiades

Year	Distance (pc)	Notes
1999	125	*Hipparcos*[39]
2004	134.6 ± 3.1	Hubble Fine Guidance Sensor[32]
2009	120.2 ± 1.9	Revised *Hipparcos*[2]
2014	136.2 ± 1.2	Very-long-baseline interferometry[36]
2016	134 ± 6	Gaia Data Release 1[37]
2018	136.2 ± 5	Gaia Data Release 2[38]

For another distance debate see Polaris#Distance, also with a different measurement from *Hipparcos*, although this time it suggested a farther distance.

Composition

The cluster core radius is about 8 light-years and tidal radius is about 43 light-years. The cluster contains over 1,000 statistically confirmed members, although this figure excludes unresolved binary stars.[40] Its light is dominated by young, hot blue stars, up to 14 of which can be seen with the naked eye depending on local observing conditions. The arrangement of the brightest stars is somewhat similar to Ursa Major and Ursa Minor. The total mass contained in the cluster is estimated to be about 800 solar masses and is dominated by fainter and redder stars.[40]



A map of the Pleiades

The cluster contains many brown dwarfs, which are objects with less than about 8% of the Sun's mass, not heavy enough for nuclear fusion reactions to start in their cores and become proper stars. They may constitute up to 25% of the total population of the cluster, although they contribute less than 2% of the total mass.[41] Astronomers have made great efforts to find and analyse brown dwarfs in the Pleiades and other young clusters, because they are still relatively bright and observable, while brown dwarfs in older clusters have faded and are much more difficult to study.

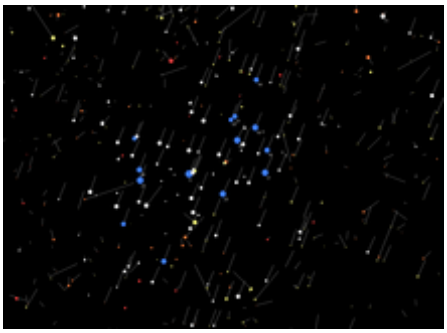
Brightest stars

The nine brightest stars of the Pleiades are named for the Seven Sisters of Greek mythology: Sterope, Merope, Electra, Maia, Taygeta, Celaeno, and Alcyone, along with their parents Atlas and Pleione. As daughters of Atlas, the Hyades were sisters of the Pleiades. The English name of the cluster itself is of Greek origin (Πλειάδες), though of uncertain etymology. Suggested derivations include: from πλεῖν *plein*, "to sail", making the Pleiades the "sailing ones"; from πλέος *pleos*, "full, many"; or from πελειάδες *peleiades*, "flock of doves". The following table gives details of the brightest stars in the cluster:

Pleiades bright stars

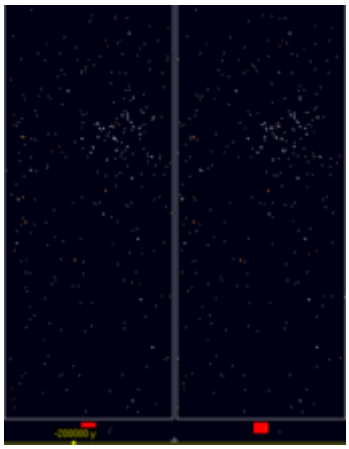
Name	Pronunciation (IPA & respelling)	Designation	Apparent magnitude	Stellar classification	Distance (ly)[42]
Alcyone	/æl'saɪ.əni/ *al-SY-ə-nee*	Eta (25) Tauri	2.86	B7IIIe	409 ±50
Atlas	/'ætləs/ *AT-ləs*	27 Tauri	3.62	B8III	387 ±26
Electra	/ɪ'lɛktrə/ *i-LEK-trə*	17 Tauri	3.70	B6IIIe	375 ±23
Maia	/'meɪ.ə, 'maɪ.ə/ *M(A)Y-ə*	20 Tauri	3.86	B7III	344 ±25
Merope	/'mɛrəpi/ *MERR-ə-pee*	23 Tauri	4.17	B6IVev	344 ±16
Taygeta	/teɪ'ɪdʒɪtə/ *tay-IJ-i-tə*	19 Tauri	4.29	B6V	364 ±16
Pleione	/'plaɪ.əni/ *PLY-ə-nee*	28 (BU) Tauri	5.09 (var.)	B8IVpe	422 ±11
Celaeno	/sɪ'liːnoʊ/ *si-LEE-noh*	16 Tauri	5.44	B7IV	434 ±10
Sterope, Asterope	/(ə)'stɛrəpi/ *(ə)-STERR-ə-pee*	21 and 22 Tauri	5.64;6.41	B8Ve/B9V	431.1 ±7.5
—	—	18 Tauri	5.66	B8V	444.3 ±7.5

Age and future evolution



Stars of Pleiades with color and 10,000-year backwards proper motion shown

Ages for star clusters can be estimated by comparing the Hertzsprung–Russell diagram for the cluster with theoretical models of stellar evolution. Using this technique, ages for the Pleiades of between 75 and 150 million years have been estimated. The wide spread in estimated ages is a result of uncertainties in stellar evolution models, which include factors such as convective overshoot, in which a convective zone within a star penetrates an otherwise non-convective zone, resulting in higher apparent ages.



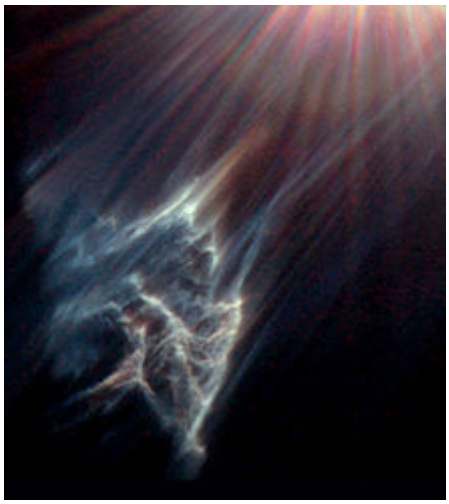
Animation of proper motion in 400,000 years—cross-eyed viewing ⧖ (click for viewing guide)

Another way of estimating the age of the cluster is by looking at the lowest-mass objects. In normal main-sequence stars, lithium is rapidly destroyed in nuclear fusion reactions. Brown dwarfs can retain their lithium, however. Due to lithium's very low ignition temperature of 2.5×10^6 K, the highest-mass brown dwarfs will burn it eventually, and so determining the highest mass of brown dwarfs still containing lithium in the cluster can give an idea of its age. Applying this technique to the Pleiades gives an age of about 115 million years.[43][44]

The cluster is slowly moving in the direction of the feet of what is currently the constellation of Orion. Like most open clusters, the Pleiades will not stay gravitationally bound forever. Some component stars will be ejected after close encounters with other stars; others will be stripped by tidal gravitational fields. Calculations suggest that the cluster will take about 250 million years to disperse, with gravitational interactions with giant molecular clouds and the spiral arms of our galaxy also hastening its demise.[45]

Reflection nebulosity

With larger amateur telescopes, the nebulosity around some of the stars can be easily seen; especially when long-exposure photographs are taken. Under ideal observing conditions, some hint of nebulosity around the cluster may even be seen with small telescopes or average binoculars. It is a reflection nebula, caused by dust reflecting the blue light of the hot, young stars.



Hubble Space Telescope image of reflection nebulosity near Merope (IC 349)

It was formerly thought that the dust was left over from the formation of the cluster, but at the age of about 100 million years generally accepted for the cluster, almost all the dust originally present would have been dispersed by radiation pressure. Instead, it seems that the cluster is simply passing through a particularly dusty region of the interstellar medium.

Studies show that the dust responsible for the nebulosity is not uniformly distributed, but is concentrated mainly in two layers along the line of sight to the cluster. These layers may have been formed by deceleration due to radiation pressure as the dust has moved towards the stars.[46]

Possible planets

Analyzing deep-infrared images obtained by the Spitzer Space Telescope and Gemini North telescope, astronomers discovered that one of the cluster's stars—HD 23514, which has a mass and luminosity a bit greater than that of the Sun, is surrounded by an extraordinary number of hot dust particles. This could be evidence for planet formation around HD 23514.[47]

See also

- White Tiger (China) § Seven mansions of White Tiger
- Australian Aboriginal astronomy § Pleiades
- Stozhary
- Subaru

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External links

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- The Pleiades on WikiSky: DSS2 (http://www.wikisky.org/?object=Pleiades&img_source=DSS2), SDSS (http://www.wikisky.org/?object=Pleiades&img_source=SDSS), GALEX (http://www.wikisky.org/?object=Pleiades&img_source=GALEX), IRAS (http://www.wikisky.org/?object=Pleiades&img_source=IRAS), Hydrogen α (http://www.wikisky.org/?object=Pleiades&img_source=HALPHA), X-Ray (http://www.wikisky.org/?object=Pleiades&img_source=RASS), Astrophoto (http://www.wikisky.org/?object=Pleiades&img_source=IMG_all), Sky Map (http://www.wikisky.org/?object=Pleiades), Articles and images (http://www.wikisky.org/starview?object=Pleiades)
- The Pleiades (M45) At the astro-photography site of T. Yoshida. (http://ryutao.main.jp/english/stl_m45.html)
- Photos and information on the Pleiades from the University of Calgary (https://web.archive.org/web/19981203050941/http://www.ras.ucalgary.ca/~gibson/pleiades/)
- Information on the Pleiades from SEDS (http://messier.seds.org/m/m045.html)
- Information and images from the Anglo-Australian Observatory (https://web.archive.org/web/20050715104031/http://www.aao.gov.au/images.html/captions/uks018.html)
- NightSkyInfo.com: The Pleiades (http://www.nightskyinfo.com/archive/pleiades/)
- Maya Astronomy (https://web.archive.org/web/20070606210812/http://www.authenticmaya.com/maya_astronomy.htm)
- Doppler Imaging: Results (http://www.aip.de/groups/activity/DI/results.html) first Doppler image of a Pleiades solar-type G dwarf – HII314, Strassmeier & Rice 2001, A&A 377, 264
- Dark Atmospheres Photography (deep nebulosity exposure) (http://www.darkatmospheres.com/astro/gallery/nebulae/enlarge.php?fileBase=nebulae_1)
- WEBDA open cluster database webpage on Pleiades cluster (http://www.univie.ac.at/webda/cgi-bin/ocl_page.cgi?dirname=mel022) – E. Pauzen (Univ. Vienna)

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- The Pleiades (M45) at Constellation Guide (http://www.constellation-guide.com/pleiades-the-seven-sisters-messier-45/)
- Warburg Institute Iconographic Database (over 50 medieval and early modern images of the Pleiades) (http://warburg.sas.ac.uk/vpc/VPC_search/subcats.php?cat_1=9&cat_2=71&cat_3=32&cat_4=40&cat_5=851)
