Searching for the Seventh Sister: Cultural Records of Astronomical Phenomena in the Pleiades Cluster

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What is the Pleiades Cluster?

The Pleiades is the name assigned to a star cluster (M45) in the Taurus constellation. It is one of the most frequently observed and written about features of the night sky, both now and in antiquity. In fact, this is how the cluster got its name; Pleiades refers to a group of seven sisters in Greek mythology that eventually become the seven stars in the cluster. Scientifically, the cluster is categorized as an open star cluster, containing mostly B-type stars. These stars are considered "young" on an astronomical scale, in fact, dinosaurs were alive before the stars of the Pleiades were born. The seven brightest stars are named (in descending magnitude): Alcyone, Atlas, Electra, Maia, Merope, Taygeta, and Pleione. Today, most people can only see six of the stars, but some can see many more given ideal observing conditions.

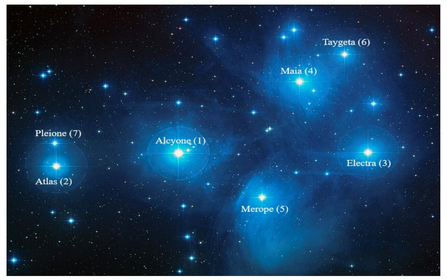

Figure 1: The Pleiades star cluster with the seven brightest stars labelled (NASA)

Motivation

- The Pleiades cluster has great cultural significance due to the timing of its appearance in the sky coinciding with important agricultural seasons
  - Noted by authors such as Hesiod (*Works and Days*) and Aratus (*Phaenomena*)
- The importance to humans' survival led to increased observation of the cluster and eventually myths to explain these observations **providing a type of observational record of the cluster's past**
- Each photon, a particle of light, can be observed only once and is a unique observation
  - Most astrophysical processes leave traces behind that can be observed today, but issues arise when theory and observation disagree
- **Cultural records provide data points that can be used to reconstruct the evolution of the Pleiades star cluster**

Methodology

- We gathered and analyzed myths about the Pleiades' origins from different cultures
- Identified key elements in these stories that describe the observed phenomena in the cluster
  - These were: the disappearance of one of the stars, the spatial layout of the stars, an explanation for the relative brightness of the stars (outliers)
- Constructed a chronology for the different sources
- Compared changes in the appearance of the cluster over time as recorded through cultural objects and stories to astrophysical theories to explain the observed evolution of the cluster

Results: Cultural Accounts

Source/Culture	Number of Objects	Disappearance (True/False)	Outlier (True/False)	Type of Outlier	Geographic Region
Lascaux Aurochs	7	F	F	NA	France
Nebra Disc	7	F	F	NA	Europe (Germany)
Aratus	7	T	F	NA	Mediterranean
Hyginus' *Fabulae*	7	T	F	NA	Mediterranean
Hyginus' *Astronomica*	7	T	F	NA	Mediterranean
Ovid's *Fasti*	7	T	F	NA	Mediterranean
Egyptian	7	T	F	NA	Mediterranean
Cherokee	7	T	F	NA	North America (Southeast U.S.)
Australian	7	T	F	NA	Australia
Nez Pearce	7	T	F	NA	North America (Great Plains)
Monache	7	F	T	Age	North America (Southwestern Sierra Nevadas)
Tachi Yokuts	6	F	T	Gender	North America (San Joaquin Valley, CA)
Navajo	7	F	T	Age	North America (Southwest U.S.)
Skidi (Pawnee)	7	F	T	Gender	North America (NE, U.S.)
Assibiniboin	7	F	T	Age	North America (Lake Superior/Northern Plains)
Chumash	8	T	F	NA	North America (Southern CA coast)
Luiseno	7	F	F	NA	North America (Southern CA coast)
Danish	7	F	T	Gender	Europe

Table 1: Yellow entries indicate accounts in which one of the stars disappears; blue entries account for one star appearing dimmer than the rest. Entries are arranged from earliest known date to most recent.

Figure 2: Auroch 18 from the Hall of the Bulls in the Lascaux Caves, France. The theorized Pleiades representation is circled to the upper right of the auroch (Wikimedia Commons)

Figure 3: The Nebra Sky Disc discovered in Germany where it was buried around 1600 B.C.E. The Pleiades cluster is located between the large circle and crescent (circled) (Frank Vincentz)

Astrophysics of the Pleiades Cluster

- **The Physics of Observation**
  - Human eyes are logarithmic detectors; only brightness differences large enough can be detected with the unaided eye
  - Pupils are relatively small observational instruments; two sources must be adequately separated in the sky for us to differentiate them
- **Open Clusters**
  - Groups of stars approximately the same age that are weakly gravitationally bound in a system
  - Over time the system will "relax" and expand to the point that the elements are no longer bound together
- **Variable Stars**
  - Stars that increase and decrease in the magnitude of their brightness over a specified interval due to internal processes
  - Alcyone, Electra, Merope, and Pleione are classified as Be variables; Taygeta, Atlas, and Maia vary due to other physical properties

What Happened to the Seventh Sister?

- The expansion of the cluster resulted in Pleione (5.19 mag) appearing to have moved slightly closer to Atlas (3.84 mag)
- Their difference in magnitude increased the difficulty of differentiating the two objects
  - The long period (34.5 yrs) of decreased luminosity due to Pleione's variability and the sudden drop in brightness during the transition from Be to shell phases means the star may have suddenly become significantly dimmer and remained that way for the course of an individual's entire life
- These processes in conjunction led to increased observational difficulties and the perceived "disappearance" of one of the stars

Future Work

In the future, data releases from newer observational instruments can strengthen our understanding of the processes occurring in the Pleiades cluster. Additional examination of cultural records not available in English as well as archaeological records such as the Tal-Qadi Sky Tablet can provide further evidence of past observations.

References

Key references are listed below, follow the QR code for a complete list:
[2] Anthony Aveni. 2019. Star Stories: Constellations and People. New Haven: Yale University Press.
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[18] White, T. R., et al., "Beyond the Kepler/K2 bright limit: variability in the seven brightest members of the Pleiades", Monthly Notices of the Royal Astronomical Society, vol. 471, no. 3, OUP, pp. 2882–2901, 2017.