

I. Introduction

The Pleiades are an open cluster of hot, B-type stars located at approximately $(RA, DEC)_{2000} = (3h47m, +24^\circ03')$ and about 136.2 ± 5 [pc] from the Earth [1]. The goal of this assignment is to use observations from Hipparcos [2] to estimate the distance to the Pleiades using stellar parallax measurements, by recalling,

$$d[pc] = \frac{1}{\text{parallax}[arcsec]} \quad (1)$$

Thus, if we accurately retrieve the parallaxes of Pleiades cluster members, we can constrain some estimate of the distance. Some parameters about the Pleiades are tabulated in Table I.

Parameter	Value
Distance	136.2 ± 5 [pc]
RA(2000)	$\approx 3h47m$
DEC(2000)	$\approx +24^\circ03'$
μ_α	≈ 20 [mas/yr]
μ_δ	≈ -45 [mas/yr]
Angular radius	$\approx 2^\circ$

Table I. Some useful parameters about the Pleiades cluster utilized in this assignment.

II. Data

The data for the Pleiades is retrieved from the Hipparcos catalog on Vizier¹ using the astroquery library². Using the built-in functionality of Vizier, the data was extracted from by querying a region centered at the Pleiades (see Table I), with a search radius of 2° . Within this search region, 47 stars are extracted, histograms of their Parallax, μ_α , and μ_δ are visualized in Fig. 1.

III. Outline of Analyses & Results

As seen in Fig. 1, there is a strong suspicion that the sample is contaminated by the influence of foreground (or background) stars. Specifically, there exists clear outlier stars which have a drastically different parallax and proper motion than the rest of the sample. The average parallax is 0.0090 ± 0.0037 [arcsec], which implies an average distance of 111.47 ± 46.67 [pc]—which is a very large error. Thus, to retrieve an accurate estimate of the distance, those outlier stars must be removed from the sample.

As a first order approximation, extraneous samples are removed from the sample by conducting an aggressive $\pm 1\sigma$ -clipping on the proper motions. Additionally, a $\pm 1\sigma$ -clipping is used on the parallax measurements. Visualizing this procedure in a color-magnitude diagram is seen in Fig. 2

After removing those identified stars, the average parallax is 0.0083 ± 0.0009 [arcsec]. Which corresponds to an average distance of 119.13 ± 12.99 [pc]³.

¹ <http://cdsarc.u-strasbg.fr/viz-bin/VizieR-3?-source=I/311/hip2>

² An astropy affiliated package which can be used to access online astronomical data <https://astroquery.readthedocs.io/>

³ Where the errors were propagated using the errors provided by the catalog, and the standard error propagation technique.

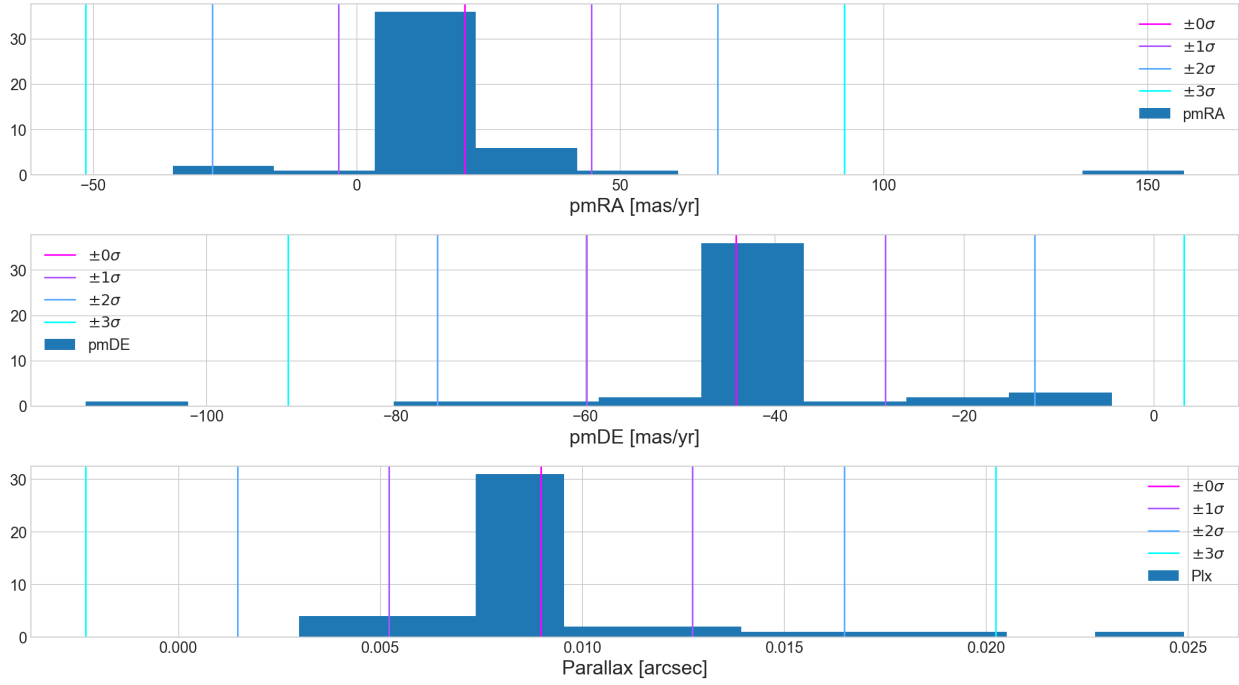


Figure 1. Histograms of the μ_α (top), μ_δ (middle), and Parallax (bottom) with the mean and $\pm 1\sigma$, $\pm 2\sigma$, and $\pm 3\sigma$ ranges indicated by vertical bars. The average parallax is 0.0090 ± 0.0037 [arcsec].

IV. Discussion & Conclusion

In the end, after performing σ clipping, we are able to arrive at a more accurate estimate of the cluster distance. Specifically, before the data reduction, the average distance is 111.47 ± 46.67 [pc] with a z-score of 0.09, however after the sample constraints, the average distance is 119.13 ± 12.99 [pc] with a z-score of 0.02. Additionally, the corresponding distance modulus ($m - M = -5 + 5 \cdot \log_{10}(d)$) is 5.38 ± 0.24 . Results are summarized in Table II.

Before removing stars from the sample	
Number of stars in the sample:	47
Average Distance:	111.47 ± 46.67 [pc]
Z-score:	0.09
Distance Modulus:	5.2 ± 0.9
After removing stars from the sample	
Number of stars in the sample:	37
Average Distance:	119.13 ± 12.99 [pc]
Z-score:	0.02
Distance Modulus:	5.38 ± 0.24

Table II. Summary of Results

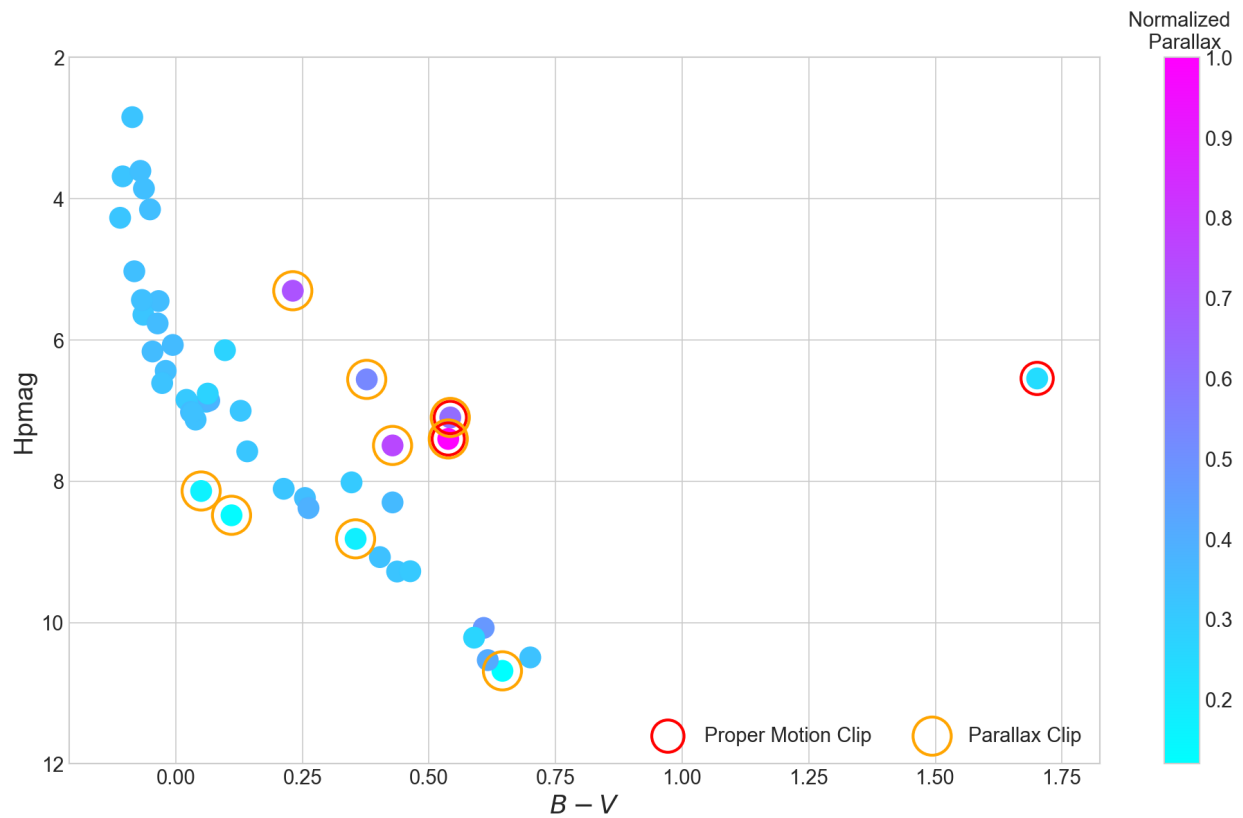


Figure 2. Color-Magnitude Diagram of all 47 stars in the sample. Visualized by the color bar is the normalized parallax. Additionally, the stars which were identified by the proper motion σ clipping are circled in red, while those identified by parallax σ clipping are noted in orange.

-
- [1] Guillermo Abramson. The Distance to the Pleiades According to Gaia DR2. *Research Notes of the American Astronomical Society*, 2:150, August 2018. doi:10.3847/2515-5172/aada8b.
- [2] F. van Leeuwen. Validation of the new Hipparcos reduction. , 474:653–664, November 2007. doi:10.1051/0004-6361:20078357.