University of Science and Technology at Zewail City

Report II

Observational Astrophysics Laboratory (PEU-327)

Lab 2

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Contents

Experiment (III)):
Observations of the Milky Way Galaxy and Stellarium Laboratory

1.1 Task (I): Exploring the Milky Way

1.1.1 Constellations

1. Big Dipper:

Figure 1: The star at the end of the handle

- **Name:** Alkaid
- **Magnitude:**[1] 1.85
- **Distance:** 103.94 ± 0.79 ly
- **Bayer designation:**[2] η

2. Northern Sky:

Figure 2: The Northern sky

- **Note:** All the stars in the northern sky appear to rotate around fixed star.
- **Name**: Polaris
- **Bayer designation:** α

[1] **Magnitude:** A measure of a celestial object's brightness as seen from Earth. It includes apparent magnitude (observed brightness) and absolute magnitude (intrinsic brightness at 10 parsecs).

[2] **Bayer designation:** A system of naming stars using Greek letters followed by the constellation name, introduced by Johann Bayer in 1603.

3. Southern Sky:

Figure 3: The Southern sky

- **Constellation 1:** Pavo
- **Constellation 2:** Indus
- **Constellation 3:** Octans

1.1.2 Nebulae

1. The Great Nebula in Orion

Figure 4: The Great Nebula in Orion

- **Constellation:** Orion
- **Magnitude:** 4
- **Distance:** 0.412 ± 0.018 kpc
- **Description:** an enormous glowing cloud of gas and dust.

2. The Crab Nebula

Figure 5: The Crab Nebula

- **Constellation:** Tau
- **Magnitude:** 8.4
- **Distance:** 2000 ± 0.500 kpc
- **Description:** Looks like an ellipse contacting upon itself with red glowing strings.

1.1.3 Star Clusters

1. M45

Figure 6: Pleiades

- **Constellation:** Taurus
- **Magnitude:** 1.2
- **Distance:** 0.136 ± 0.001 kpc
- **Name:** Pleiades (Seven Sisters - Subaru)
- **Description:** Blue colored butterfly.

2. M79

Figure 7: M79

- **Constellation:** Lepus
- **Magnitude:** 7.2
- **Distance:** 13,000 kpc
- **Name:** M79 - NGC 1904 - Mel 342
- **Description:** Intermediate concentration of stars.

1.1.4 The Sun and Sky

Figure 8: Sun

- **Description:** During the day, the sky appears mostly empty, with only the Sun and occasionally the Moon visible. The absence of stars and deep-sky objects highlights the vast openness of the daytime sky.
- **Constellation:** Aquarius
- **Today's Zodiac Sign:** Pisces
- **Agreement with Today's Zodiac Sign:** No, it does not agree.
- **Visible Planets:** Mercury and Saturn

1.1.5 Eclipse 2017

Figure 9: Eclipse I

Figure 10: Eclipse II

- **Start Time of Totality:** 21:10
- **End Time of Totality:** 21:30 PM
- **The Star to the Left of the Sun:** Regulus
- **The Planet to the Right of the Sun:** Mars

1.2 Task (II): Simulating Telescope Observations using Stellarium

1.2.1 The Full Moon

Figure 11: The Full Moon

1.2.2 Jupiter and its moons

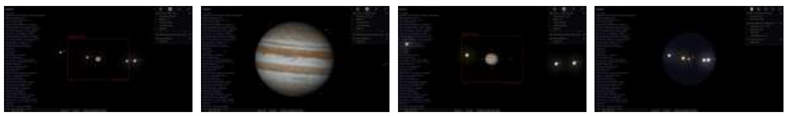

Figure 12: Jupiter and its Moons

1.2.3 Saturn and its moons

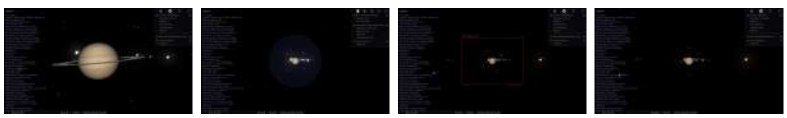

Figure 13: Saturn and its Moons

1.2.4 Orion (M42) and Horsehead (Barnard 33) nebulae, and the Pleiades cluster (M45)

Figure 14: Orion

Figure 15: Horsehead nebulae

Figure 16: Pleiades cluster

Experiment (IV): Angular Size: Ring, Dumbbell, Orion, and Owl Nebula

2.1 2.1 Task A

1. A) 1 m 30 s

2.2 2.2 Task B

1. C) 5 m 30 s
2. C) Angular Size

2.3 2.3 Task C

1. C) 48 m 6 s
2. A) Colors (red and blue) / C) A visible central star.

2.4 2.4 Task D

1. B) 2 m 45 s
2. A) Angular size / B) Colors in their spectra (red and blue)
3. A) The Great Nebula in Orion

Experiment (V): The Proper Motion of Barnard's Star.

3.1 Part (I): Reproducing E. E. Barnard's Observational Discovery using Stellarium

3.1.1 Procedure and Assumptions:

We will take screenshots of the proper motion of Barnard's star with respect to a neighboring star. We assume that the neighboring star is stationary, hence why we measure the changes in the position of Barnard's star with respect to the neighboring star. However, this assumption may be slightly off and be a source of error due to the proper motion of the star we choose, however from observing the star, its proper motion is negligible. We will also use the (J2000) epoch for the observation. This is to factor out effects like the precession of the Earth. We take the readings from Stellarium and table them in OriginPro.

3.1.2 Results:

We plot the difference in the declination between Barnard's star and the neighboring star against years. The plot is shown below:

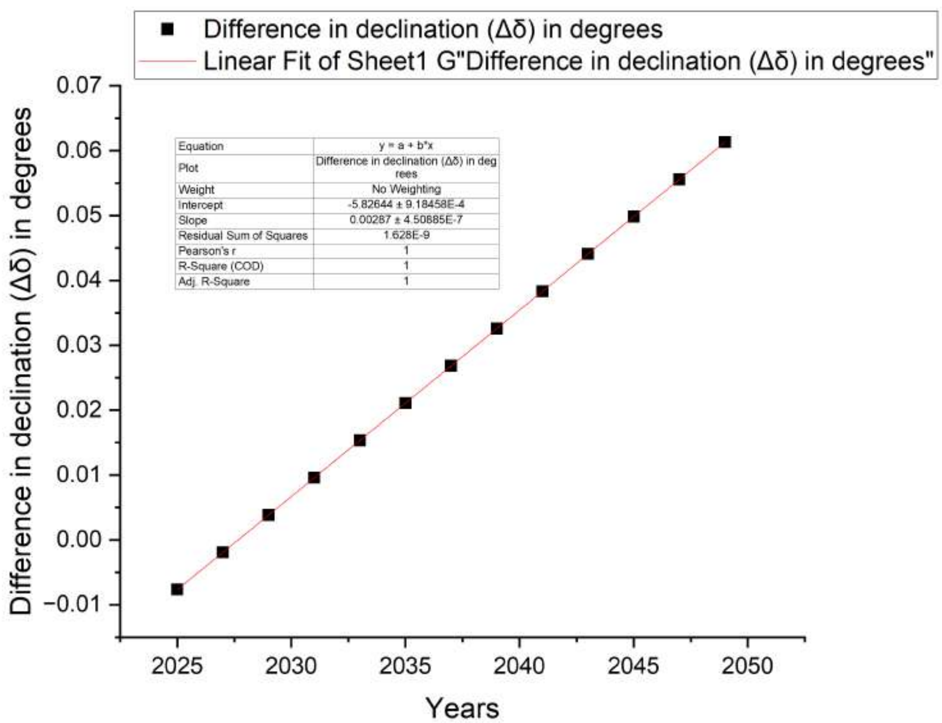

Figure 17: Change in Dec against time (Stellarium).

We see that the proper motion along the declination is the slope, $\mu_\delta = 0.00287 \pm 5 \times 10^{-7}$ degrees/year $= 10332 \pm 2$ mas/year. This is close to the recorded value of 10326.93 mas/year.

We now plot $\Delta\alpha \cos(\delta)$ against $\Delta\delta$ to get the angle of the proper motion of Barnard's star. The plot is shown below:

Since both values are negative,

$$\theta = 360 - \tan^{-1}(|\text{slope}|) = 360 - \tan^{-1}(0.06982) \approx 356.0°.$$

This is as expected.

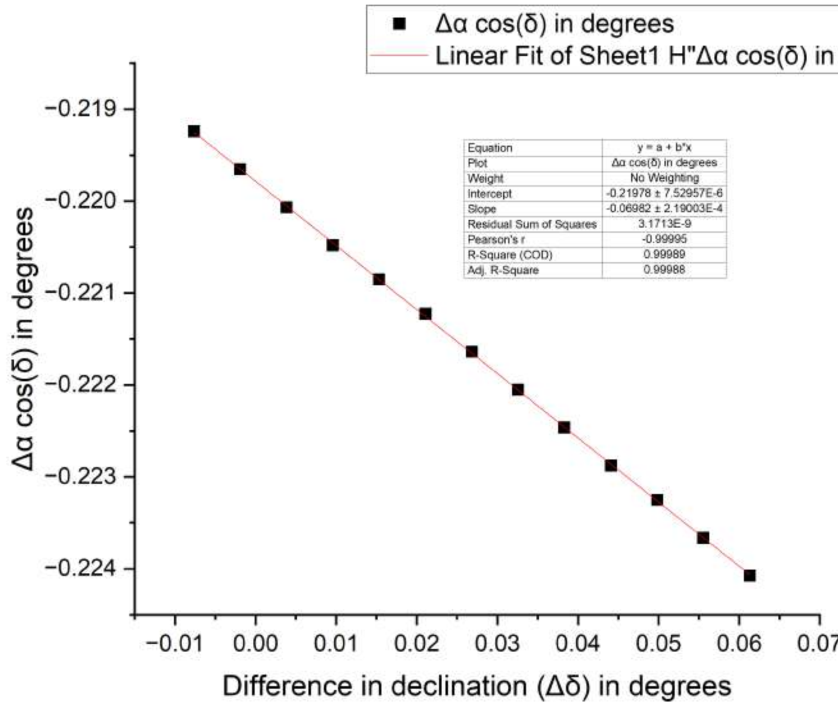

Figure 18: $\Delta\alpha\cos(\delta)$ against $\Delta\delta$ (Stellarium).

The proper motion along the right ascension is given by:

$$\frac{\sin(\theta)\mu_\delta}{\cos(\theta)}.$$

This is equal to the product of the two slopes:

$$10332 \times (-0.06982) \approx -721 \text{ mas/year}.$$

This is slightly off from the recorded value of -797.84 mas/year, which could be due to rounding errors.

3.2 Part (II): Exporting the Position of Barnard's Star Using Python

We will follow the same procedure as in Part (I) but using data obtained from Skyfield.

3.2.1 Results:

We plot the difference in the declination between Barnard's star and the neighboring star against years. The plot is shown below:

We see that the proper motion along the declination is the slope, $\mu_\delta = 0.00287 \pm 9 \times 10^{-7}$ degrees/year $= 10332 \pm 3$ mas/year. This result is the same as the one obtained using Stellarium, except with a slightly higher error. This is still close to the recorded value of 10326.93 mas/year.

We now plot $\Delta\alpha\cos(\delta)$ against $\Delta\delta$ to determine the angle of the proper motion of Barnard's star. The plot is shown below:

Since both values are negative,

$$\theta = 360 - \tan^{-1}(|\text{slope}|) = 360 - \tan^{-1}(0.07736) \approx 355.6°.$$

This is as expected.

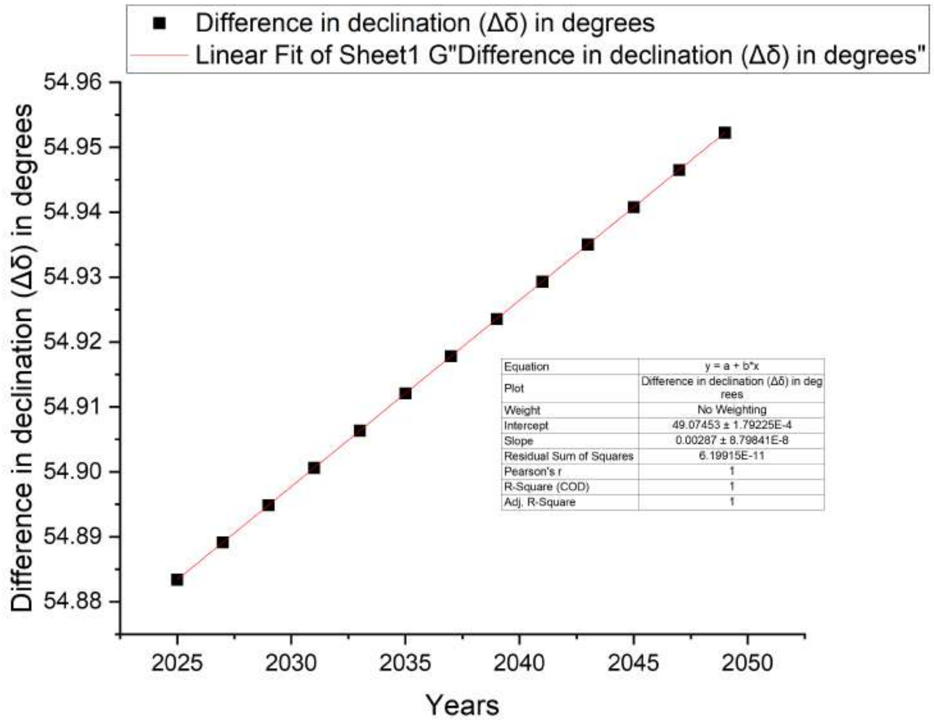

Figure 19: Change in Dec against time (Skyfield).

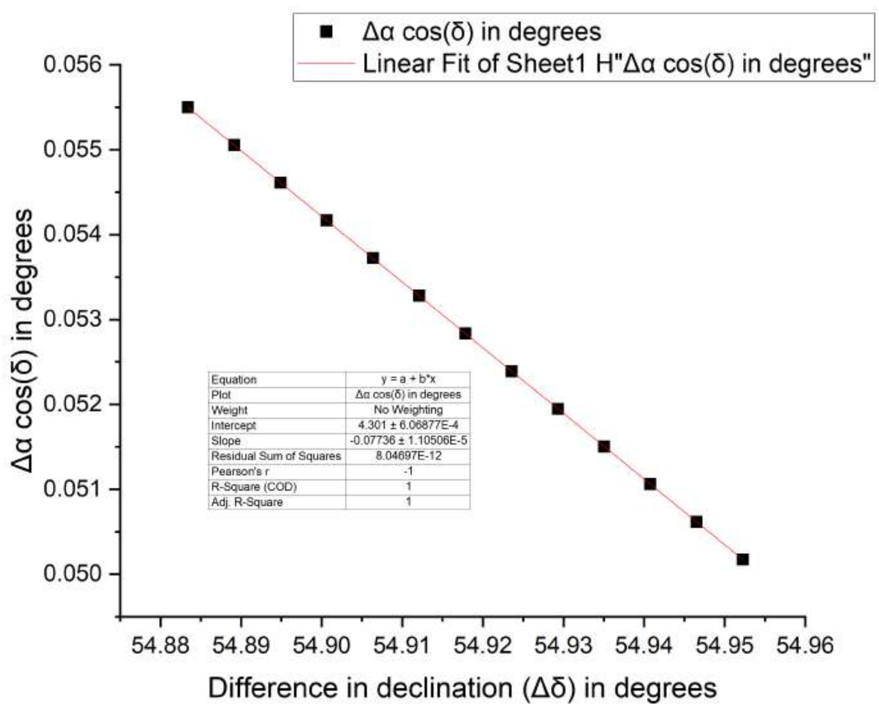

Figure 20: $\Delta\alpha\cos(\delta)$ against $\Delta\delta$ (Skyfield).

The proper motion along the right ascension is given by:

$$\frac{\sin(\theta)\mu_\delta}{\cos(\theta)}.$$

This is equal to the product of the two slopes:

$$10332 \times (-0.07736) \approx -799 \text{ mas/year}.$$

This result is much closer to the recorded value of -797.84 mas/year compared to the result obtained using Stellarium.