Merak time lag

Sahar Nikkhah

Time lag

- In VERITAS we look at the stars with 4 telescopes and then create a time correlation for each pair of them. Since the data is very big and also there are some noises such as cloud happening while data taking, we make correlation for every 1 second of data and then add them all together. The time lag that the light of star could reach to each of these telescopes depending on which one is closer to star, can shift the correlation and when we sum all those one seconds they cancel up with each other. In this project I would like to calculate that time lag so we can use that in shift correction. I will be working specifically with Merak which was the most recent star that we took data from.

Location of the telescopes

- The location of the telescopes are given as
- T1: [135.48, -8.61, 12.23]
- T2: [44.1, -47.7, 4.4]
- T3: [29.4, 60.1, 9.8]
- T4: [-35.9, 11.3, 7.0]
- The origin is (31.675,-110.952) on the e

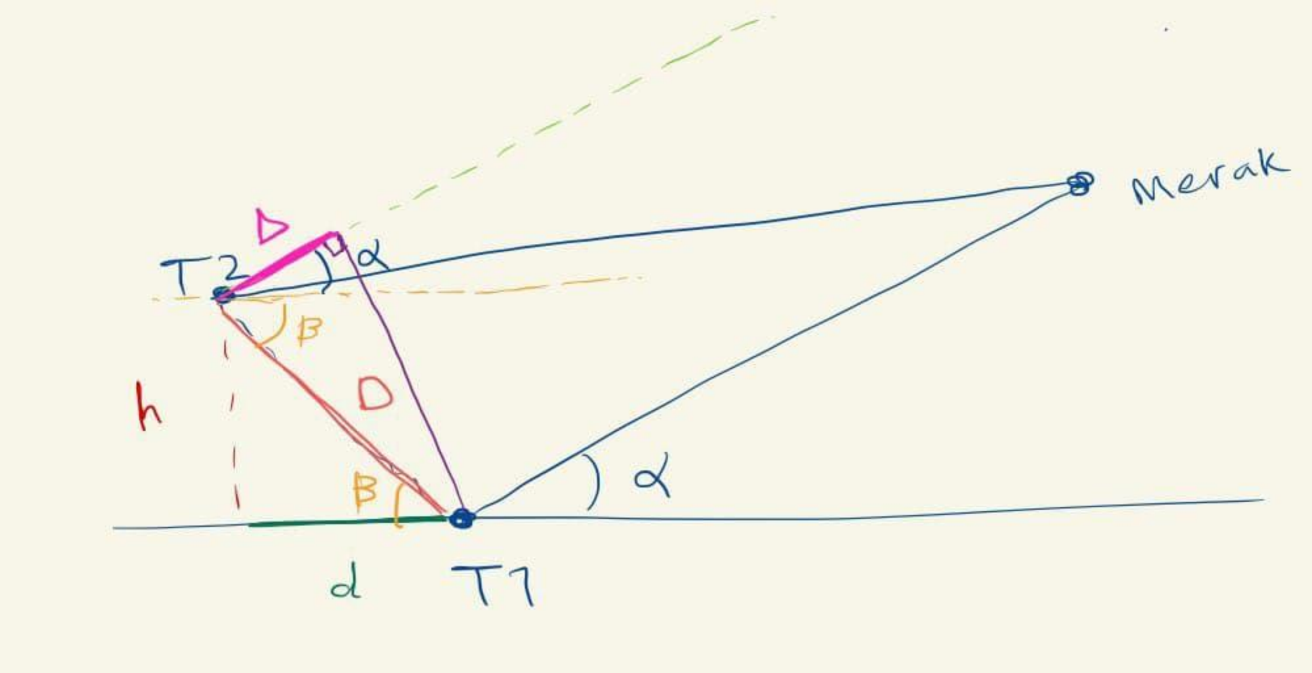
Calculating time difference

- By approximating that the lights are parallel, We have x, y, and h which are the positions of telescopes. But we will need alpha and beta.

$$\Delta = D\cos(\alpha+\beta)$$

$$D = \sqrt{d^2+h^2} \qquad d = \sqrt{x^2+y^2}$$

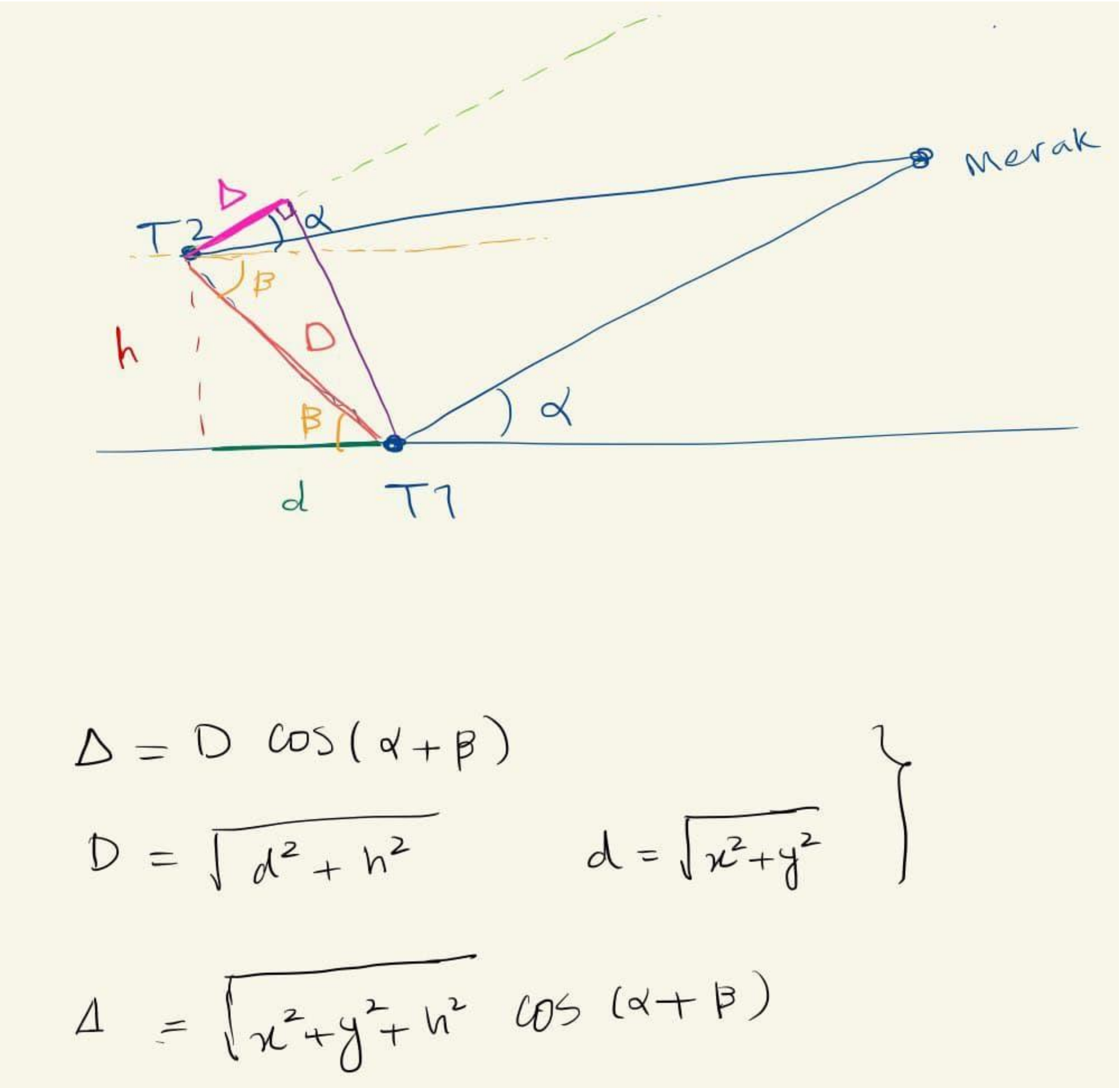
$$\Delta = \sqrt{x^2+y^2+h^2}\,\cos(\alpha+\beta)$$



Calculating beta

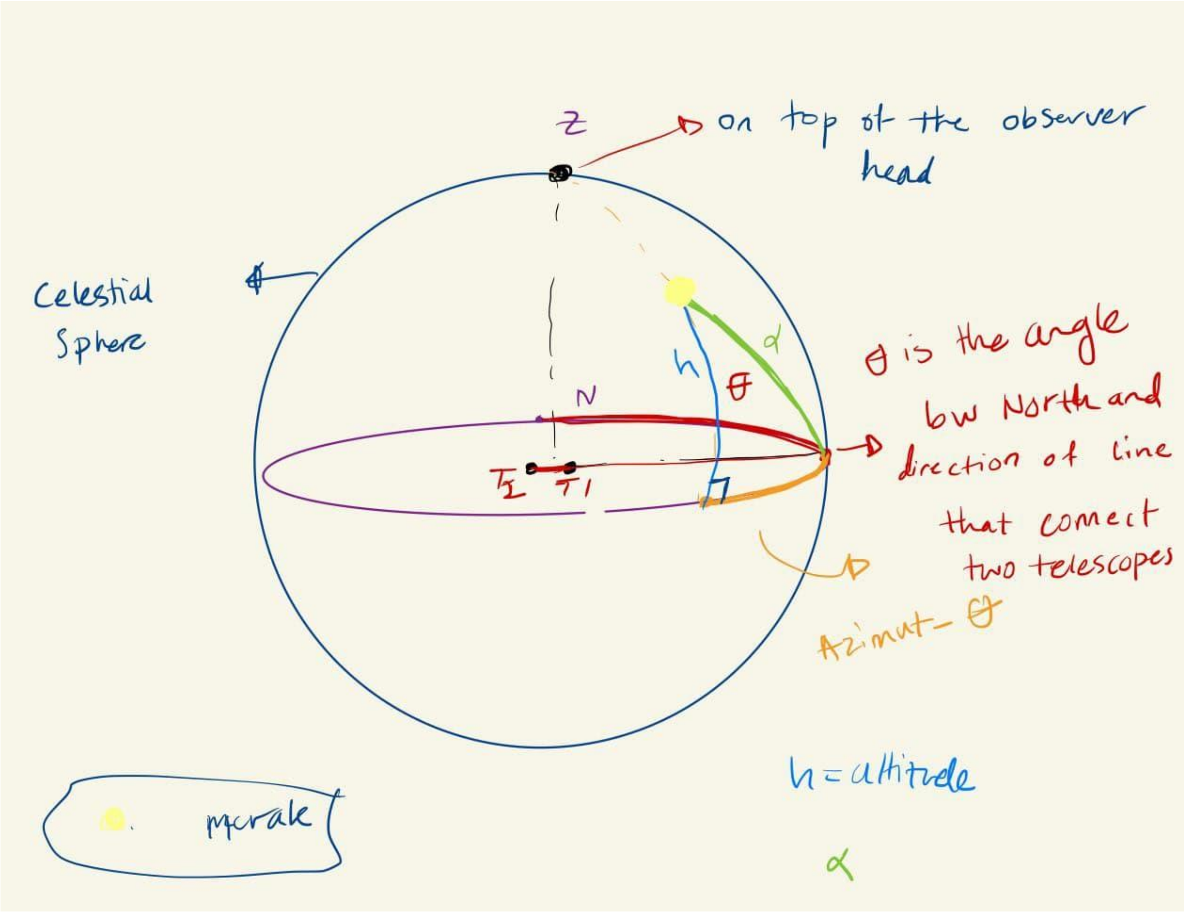
- Beta can be found as

Beta= Arcos(d/sqrt(h^2+d^2)



Calculating alpha

- Calculating alpha was a bit harder cause it depends on the location of star relative to the location of Telescopes. I needed to read about spherical trigonometry which I will explain by shape. Consider the celestial sphere.



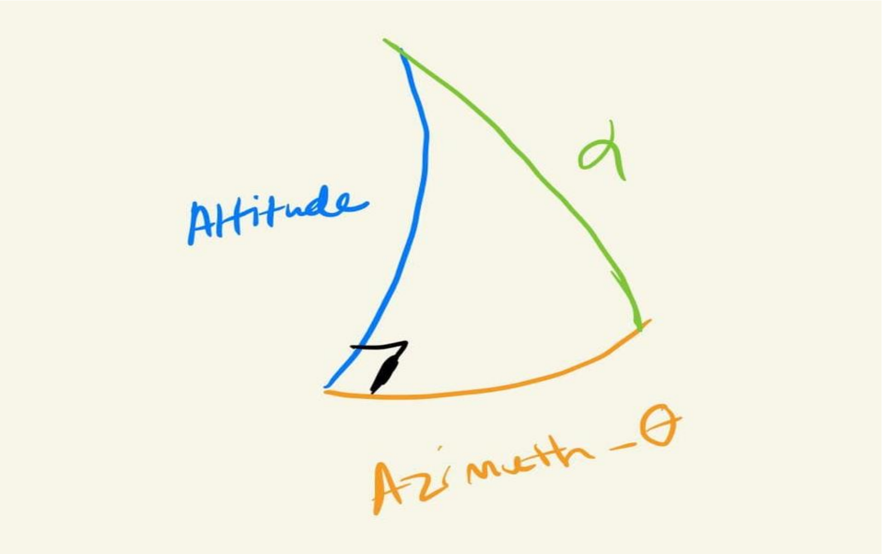
Calculating alpha

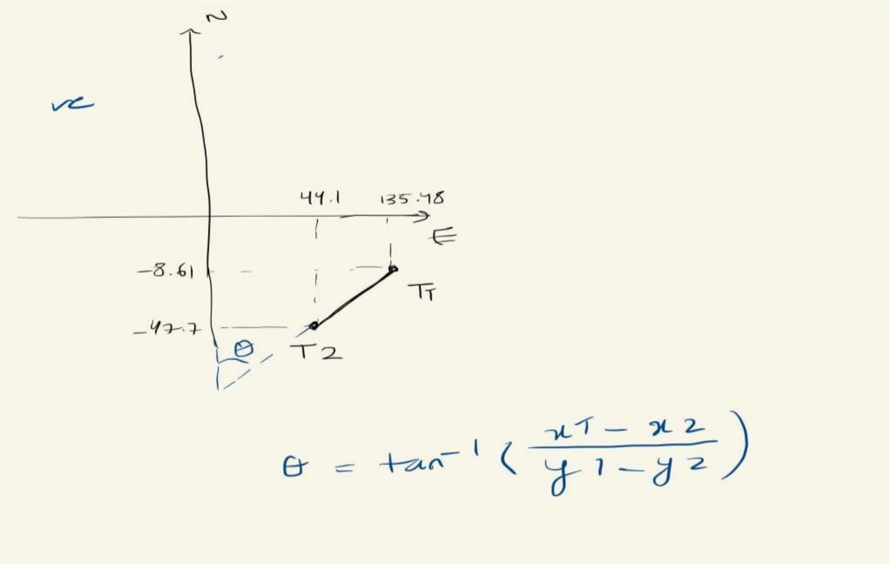
- Solving the triangle from last page

Cos(alpha)=Cos(Azimuth-theta)Cos(altitude)

Tan(theta) = (X1-X2)/ (Y1-Y2)

*Please note that azimuth and altitude of the star depends on the location on earth and the time of observation. And theta is the angle between the line that connects the two telescopes and North pole.





Now that we have all

- Now we can write the full formula again
- alpha=Arcos(Cos(Azimuth-theta)Cos(altitude))
- Beta=Arcos(d/sqrt(h^2+d^2)

- So Delta= D cos(alpha+ Beta)
- And Delta t is Delta/c and c is speed of light.
- I will be using this formula in my code.

$$\Delta = D \cos(\alpha + \beta)$$

$$D = \sqrt{d^2 + h^2} \qquad d = \sqrt{x^2 + y^2}$$

$$\Delta = \sqrt{x^2 + y^2 + h^2} \cos(\alpha + \beta)$$