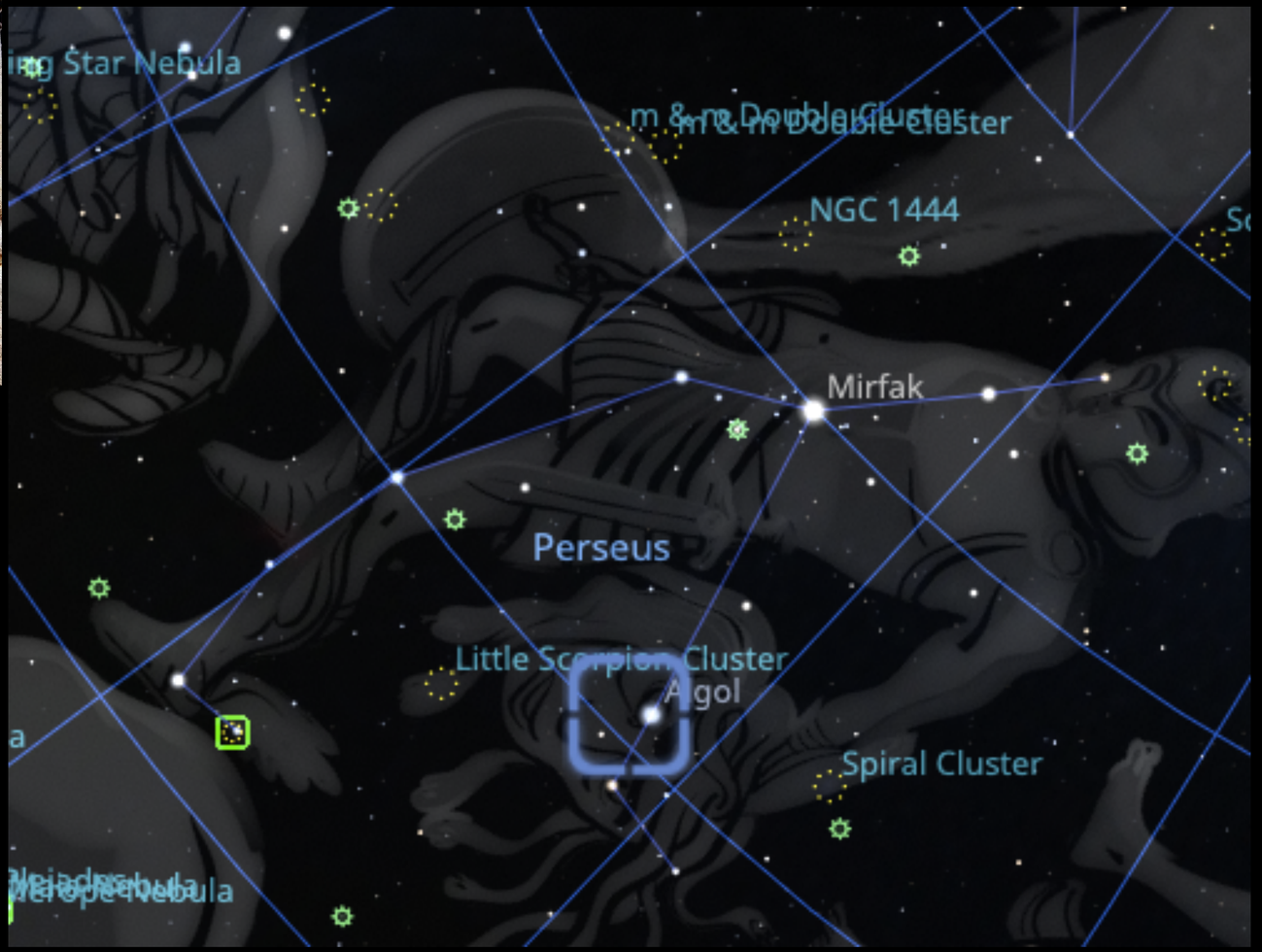
OBSERVING VARIABLE STARS

Arnav Ranjekar 21/10/2023


Star Nebula
m & m Double Cluster
NGC 1444
Mirfak
Perseus
Little Scorpion Cluster
Algol
Spiral Cluster

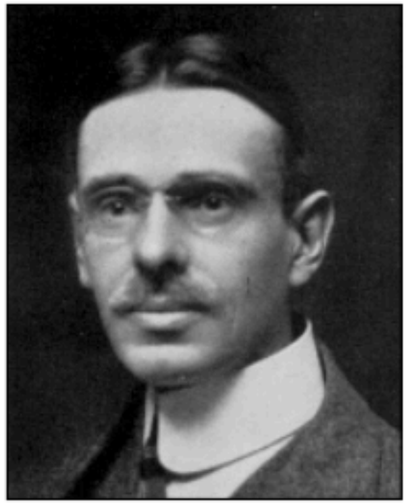
The first variable star charts...

By the mid-1890s, Harvard College Observatory Director, Edward C. Pickering saw that the key to involving many more amateurs in variable star observing—while ensuring the quality and consistency of measurements—would be to provide standard sequences of comparison stars that have assigned magnitudes. For the novice observer, this would make variable star measurement a much simpler activity than having to follow the cumbersome step method (invented by William Herschel and promoted and refined by Argelander), and it would do away with the laborious reductions needed to derive a light curve.

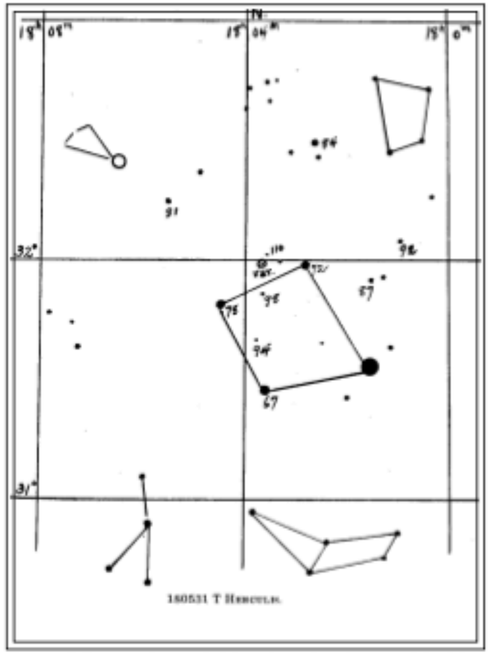
Edward C. Pickering

Pickering (and later AAVSO Co-founder William Tyler Olcott) began providing variable star observers with sets of charts which had the variable star and its comparison stars marked directly on them. The charts were traced from the German star atlas, the *Bonner Durchmusterung*, and the comparison stars were marked with letter-names (a, b, etc.).

In 1906, Pickering made an important change to his chart format, which went hand-in-hand with the way that variable star estimates were to be made. He now entered the photovisual magnitudes of a sequence of comparison stars directly onto photographically reproduced charts. The observation is made by comparing the variable directly with a brighter and a fainter comparison star, and matching or interpolating the variable's magnitude from the given comparison star values. It is a method commonly in use today.



William Tyler Olcott



One of the early variable star charts provided by E. C. Pickering, which W.T. Olcott used in his 1911 Popular Astronomy article, "Variable Star Work for the Amateur with Small Telescopes".

> Courage! Each step forward brings us nearer the goal, and if we can not reach it, we can at least work so that posterity shall not reproach us for being idle or say that we have not at least made an effort to smooth the way for them.
>
> – Friedrich Argelander (1844)
> the "father of variable star astronomy"

Viewing

- Eye-Releif: This refers to the distance that necessarily exists between the eye and the eyepiece at the point where the whole field is visible and in focus. In general, the higher the magnification of the eyepiece, the smaller the exit “hole” through which you look will need to be, and the closer you will have to place your eye to the lens.

- Field of view(FOV) : $FOV = drifttime * cos\delta * 360 \div 86164$

A. Apparent field - AF refers to the subtended angle of the eyepiece alone, and it is dependent upon the diameter of the eyepiece lenses.

B. True field -TF refers to the area of the sky that you can see through your instrument, and it depends upon the amount of magnification provided by the eyepiece. $TF = AF \div M$

- Exit Pupil: That’s the name given to the hole of the eyepiece through which we see. If it is greater than about 7mm in diameter, some of the transmitted light is “wasted” because that value is approximately the maximum diameter of the diaphragm of the fully dark-adapted eye of a young, healthy person; if it is less than about 2mm, so little light enters the eye that a star of low magnitude may not be seen at all. $EP = f \div FR$

Instruments to be used

- Big Dobsonian - 8” reflector
- Barlow lenses (for magnification if needed)
- New skywatcher mount(Later)

Types of Variables

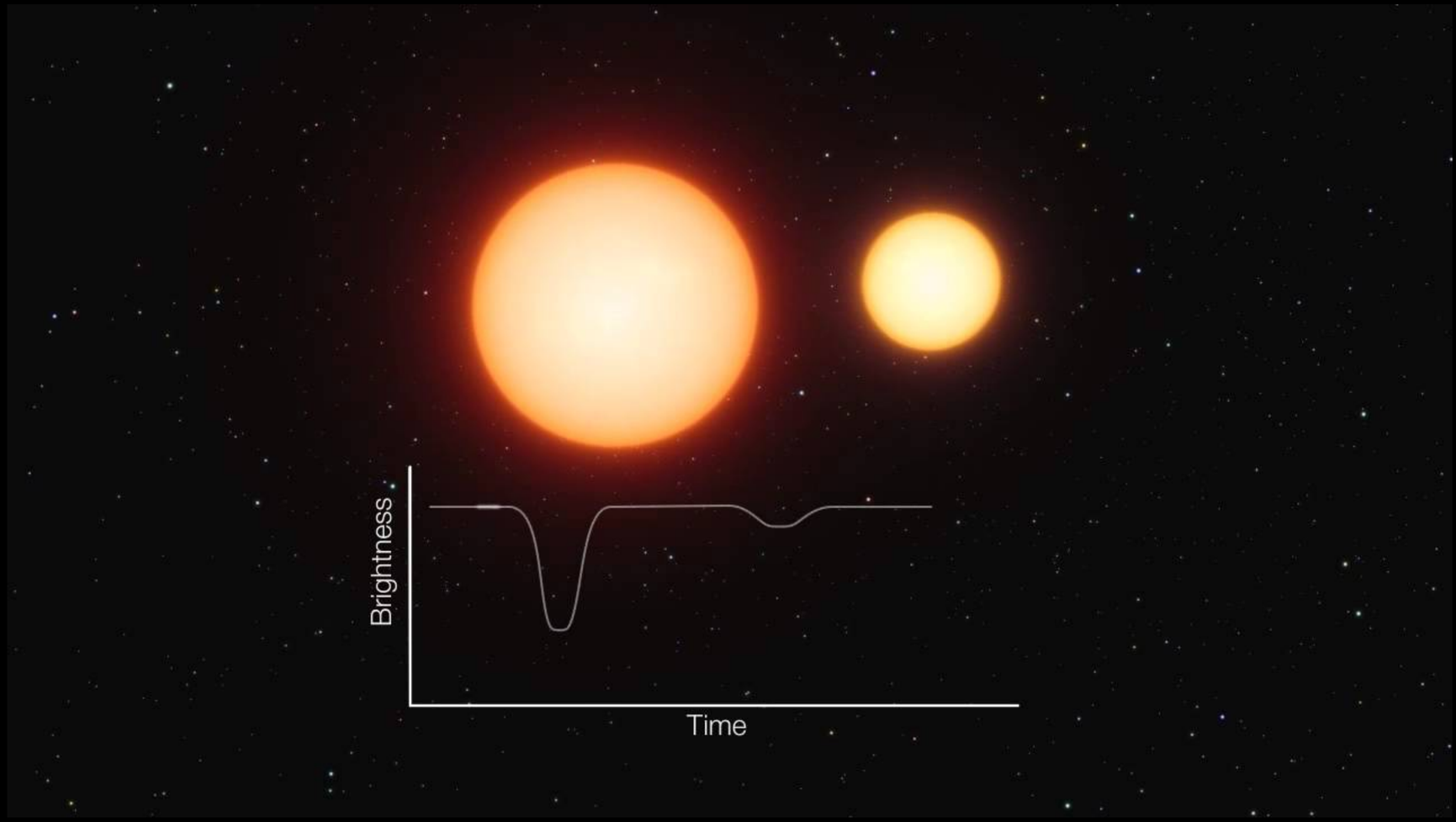
- Variables are usually classified into intrinsic, pulsating, cataclysmic, erupting variable stars and extrinsic eclipsing binary and rotating stars.

- Pulsating variables: Show periodic expansion/contraction on their surfaces. Types of pulsating variables may be distinguished by the pulsation period, the mass and evolutionary status of the star, and the characteristics of their pulsations. Classified into cepheids, RR Lyrae, RR Tauri, Long period variables & irregular.

- Cataclysmic: Occasional violent outbursts caused due to thermonuclear processes on the surface or interior. Usually, they occur in binary systems. Supernovae, Novae, recurrent novae, dwarf novae and symbiotic stars.

- Erupting variables: Variations due to flares/ violent processes occurring in the chromosphere or corona.

- Eclipsing binaries: As the name suggests, variation in the brightness of stars is due to eclipse with its binary.
- Rotating variables show brightness due to patches of bright/dark spots induced by their binary component.



Observing

Magnitudes

- Apparent magnitude: This is the star's relative brightness as perceived by us. Hipparchus was the first to classify stars into 6 magnitudes. N.R. Pogson observed that we receive 100 times more light from a mag 1 star than from a mag 6 star.

- $m2 - m1 = 2.5 \log(F1/F2) = 5 \log(d2/d1)$

- Absolute magnitude: This is the magnitude of a star as seen at a distance of 10 parsecs. 1pc = 3.26 ly

- Limiting magnitude: The magnitude of the faintest celestial object visible through the instrument. $4.5 + 5 \log(D)$

Observing

Steps to correct visual observations

- We shall start with visual observations of variable stars. To start with we shall observe these easily found stars shown in the 10-star tutorial.

	Star Name	Season	Notes
1	alpha Orionis	Fall, Winter	a.k.a. Betelgeuse, a red star in the “armpit” of Orion
2	eta Geminorum	Fall, Winter	
3	gamma Cassiopeia	All Year	Cassiopeia is an easy constellation to find - it looks like a giant “W” written on the sky.
4	beta Persei	Winter	This star has an entire eclipse in one night! See chart for more info.
5	beta Lyrae	Summer	Very easy to find in the summer – it’s next to the bright star straight overhead!
6	R Lyrae	Summer	
7	miu Cephei	All Year	Note the spelling of “miu”. This is intentional- to replace the greek character “mu”.
8	delta Cephei	All Year	
9	eta Aquilae	Summer	
10	epsilon Aurigae	Winter, Spring	Our VIP star!

- We shall record observations by the method of interpolation. For this, we use one or two comparison stars near the variable to record its brightness. Over the years, astronomers perfected this technique to generate vast catalogues which are reasonably accurate.

- The AAVSO provides comparison charts with the magnitudes listed, as shown further. These stars can be obtained through the Variable Star Plotter(VSP) on the website. https://app.aavso.org/vsp/

- You can find past data at the ‘AAVSO International Database’. https://www.aavso.org/aavso-international-database-aid

- Step 1: Find the field

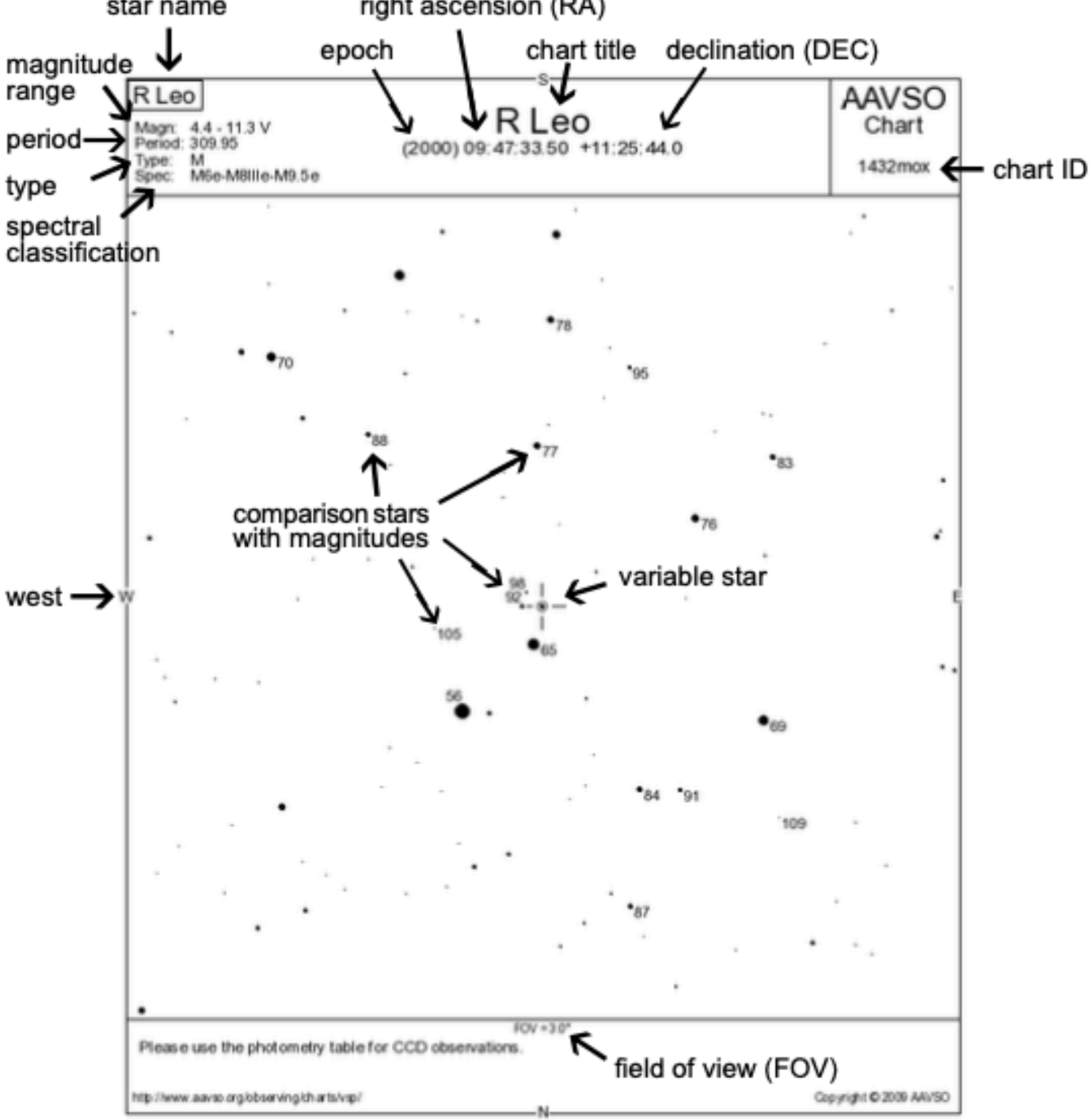
- Step 2: Find the variable star

- Step 3: Find the comparison stars & and begin

- We are to record the date and time of our observation and the magnitude of the variable star. The seeing conditions at that time are also to be noted.

- The charts contains magnitudes of stars multiplied 10 times.

- The comparison stars should be within 0.5-0.6 magnitudes of the target star. When observing redder variable stars, it is recommended to take a quick glance. Red light excites the retina more than blue; as a result they appear brighter than they should leading to errors in observations. ‘Purkinje effect’


star name
right ascension (RA)
magnitude range
epoch
chart title
declination (DEC)
R Leo
Magn: 4.4 - 11.3 V
Period: 309.95
Type: M
Spec: M6e-M8IIIe-M9.5e
R Leo
(2000) 09:47:33.50 +11:25:44.0
AAVSO
Chart
1432mox
chart ID
period
type
spectral classification
comparison stars with magnitudes
variable star
west
field of view (FOV)
Please use the photometry table for CCD observations.
http://www.aavso.org/observing/charts/vsp/
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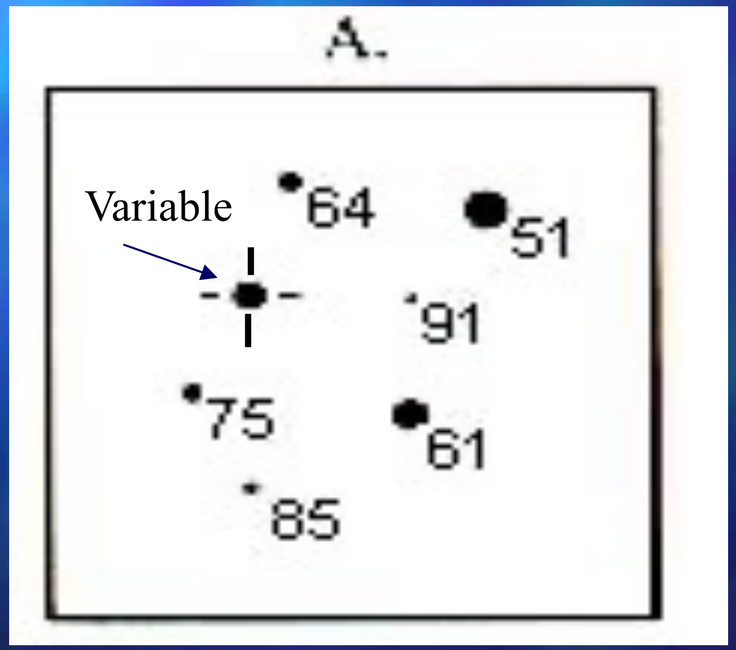
Variable and comparison stars

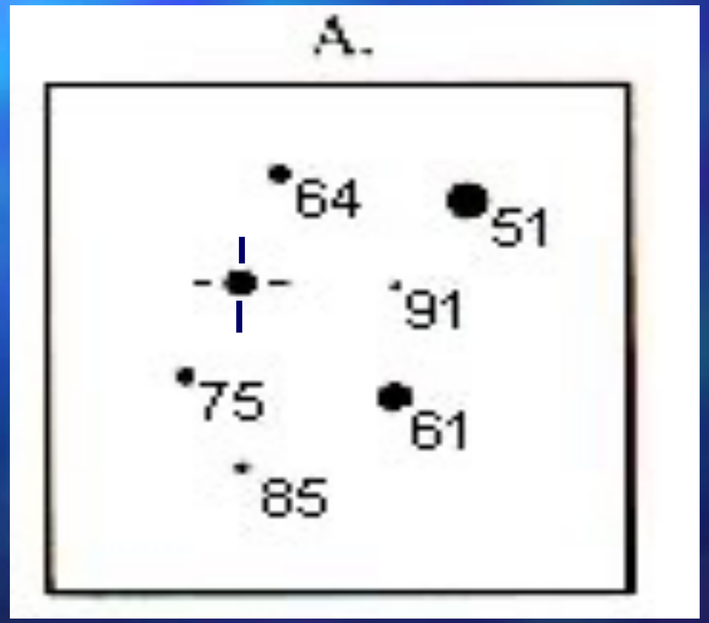
Look at the example below. The variable is shown between the four focus lines. The magnitudes of the comparison (“comp”) stars are shown on the chart next to the stars (64,51,91, etc.).



Credits - aavso.org

A big magnitude number is faint, a big dot is bright!

The brighter the star is, the smaller its magnitude number.
5.1 is brighter than 6.4.
On the chart, notice that the dot is bigger (brighter) for the 5.1 star than the 6.4 star to its left.



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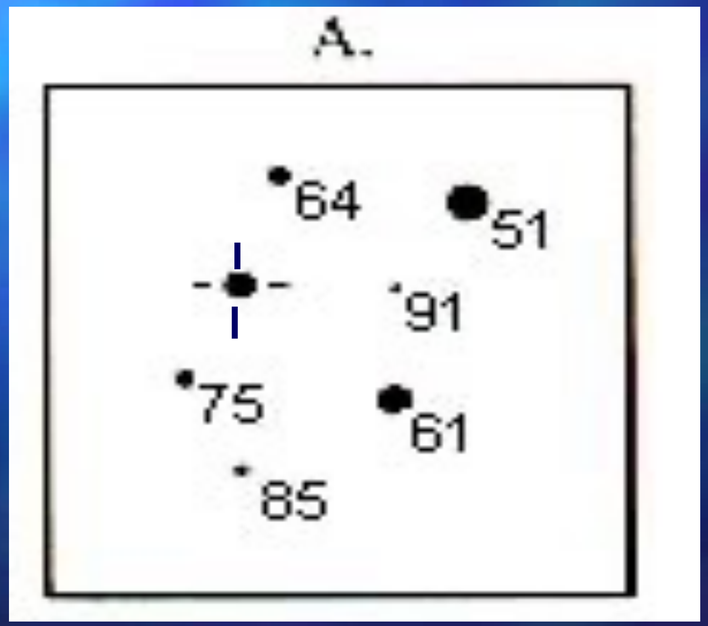
Making your first estimate

Is the variable brighter or fainter than the brightest (5.1) star?



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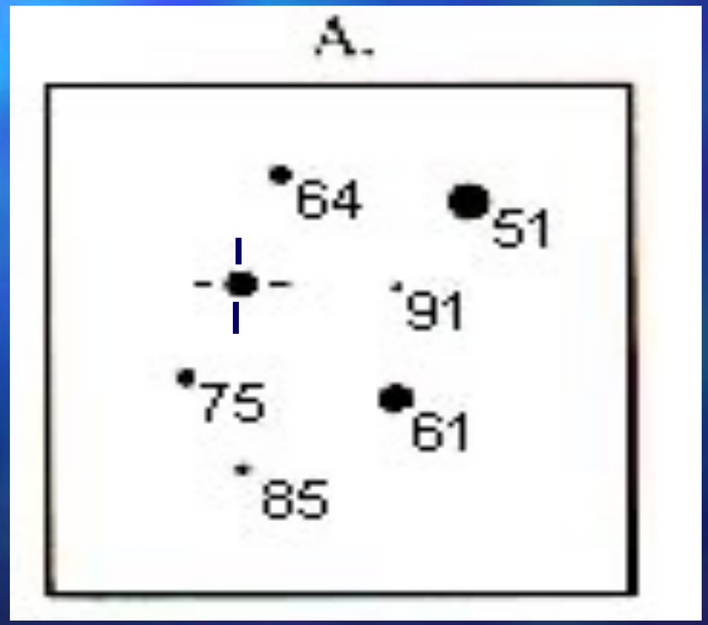
Making your first estimate

Is the variable brighter or fainter than the brightest (5.1) star?

Fainter!



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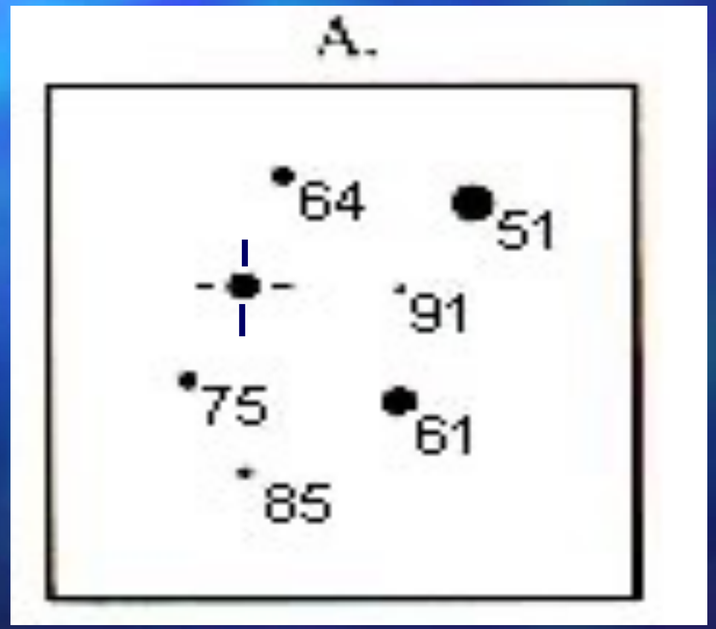
Making your first estimate

Is the variable brighter or fainter than the next brightest star (6.1)?



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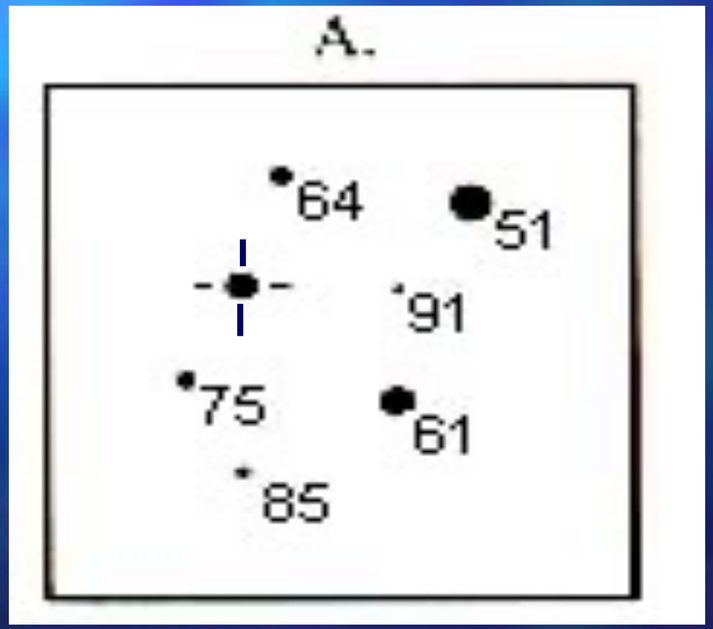
Making your first estimate

Is the variable brighter or fainter than the next brightest star (6.1)? **Fainter!**



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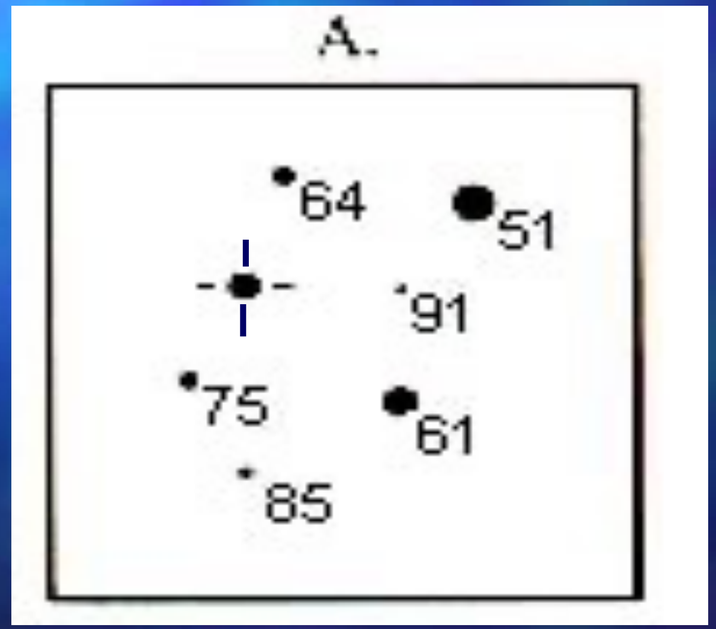
Making your first estimate

Is the variable brighter or fainter than the next brightest star (6.4)?



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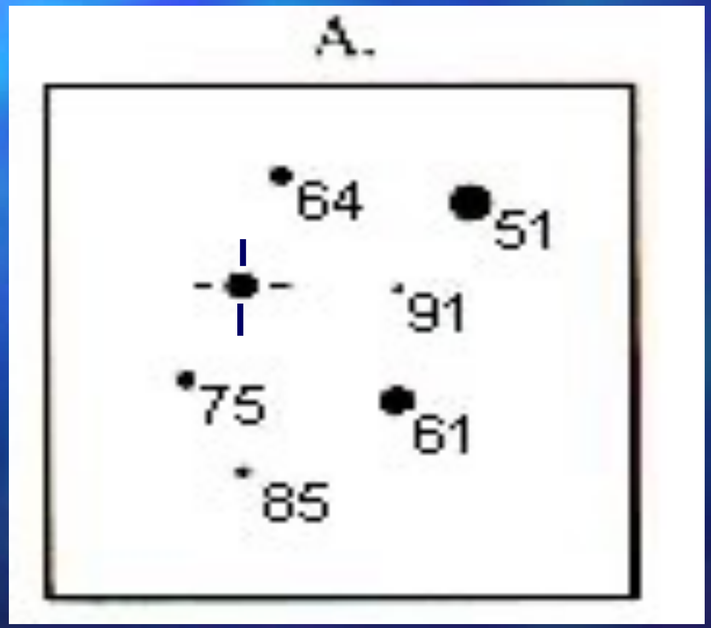
Making your first estimate

Is the variable brighter or fainter than the next brightest star (6.4)? **Brighter!**



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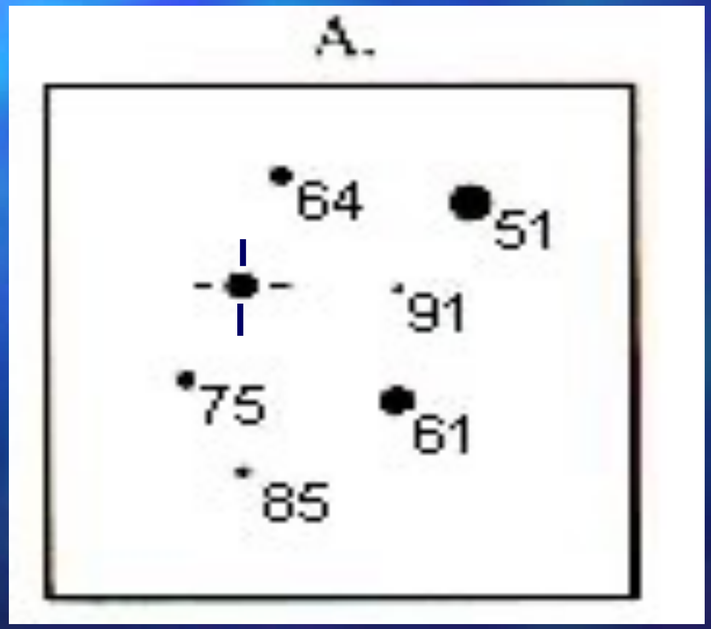
Here comes the gas gauge!

So, the variable is brighter than 6.4 but not as bright as 6.1. What are you going to do with those numbers?

Interpolate!



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Submitting the observations

Nomenclature of variables

- Variable stars are generally named with 1/2 Roman/Greek letters followed by a number and the constellation name. Eg. V746 Oph, V2134 Sgr.

- Names as published in GCVS(General Catalogue of Variable Stars) are decided by the Sternberg Astronomical Institute in Moscow. Starts from R goes upto Z; then RR, RS and so on. This was chosen by Friedrich Argelander.

- AUID: To be submitted. More information about the variable & its AUID is given in the ‘Variable Star Index’(VSX). https://www.aavso.org/vsx/

- The observations are to be submitted in a specific format to AAVSO, as given in the next slide.

Enter Observations Individually

What type of observation are you submitting? *

Visual

Observer Code RARD

Star Identifier *

The name, desig, or AUID of the star you observed. More help...

Date/Time of Observation *

Exact (UT) time of observation in JD or yyyy/mm/dd/hh/mm/ss format. More help...

Magnitude *

Estimated magnitude of the variable star. A decimal point is required. More help...

Check this box if your magnitude is a *fainter-than*.

First comp star *

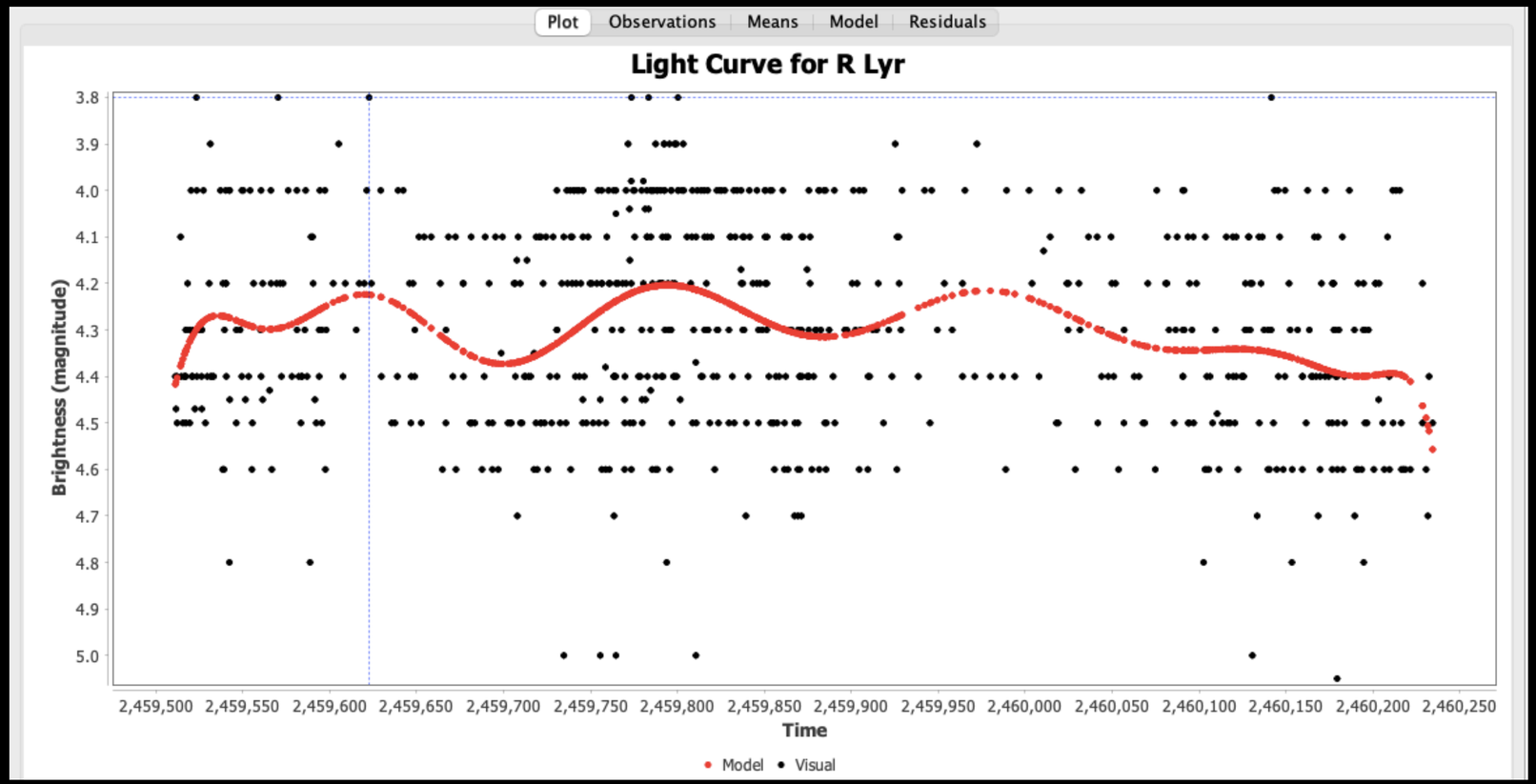
The 1st comparison star used to make the estimate. Enter the label as it is shown on the chart. More help...

Second comp star

The label of the 2nd comparison star you used to make the estimate. More help...

Chart ID

Results

- Once submitted we can view our data in applications given by AAVSO namely Zapper & VStar.
- Photometric results for the observations are also available on software provided by the AAVSO.
- 

Looking forward

- Once we get good at observing the 10 easy stars, we shall move on to more stars.
- This can be achieved by starting observations with our binoculars and being a part of the AAVSO's binocular program.
- Observing with DSLR.
- This will expand our program to various types of variable stars and help improve our own understanding.

- **TCrB: A recurring nova in corona borealis expected to erupt between March & June next year!!**