

Amateur Photometry with Small Telescopes and Consumer CCD Cameras

**Presented By:
Gord Tulloch, AAVSO:TGR
RASC Winnipeg**

(Based on AAVSO presentation by Tim Crawford)

Agenda

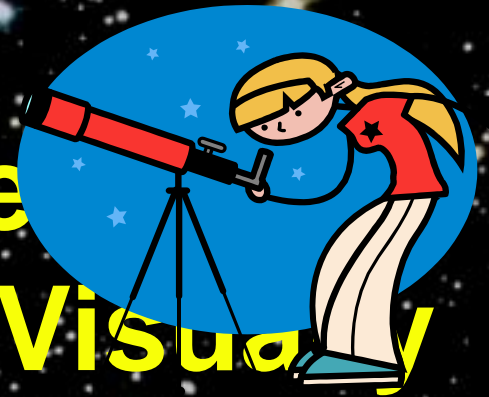
1) What Are Variable Stars

2) Why Observe Them

2) Why Amateurs Are Needed

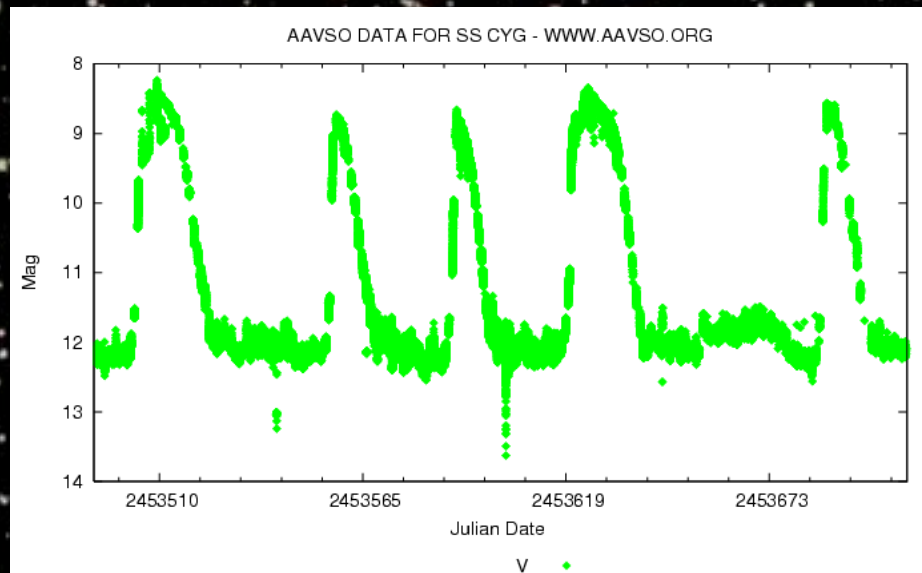
4) Observing VSO both Visually
& With a CCD

5) Envisage Demo



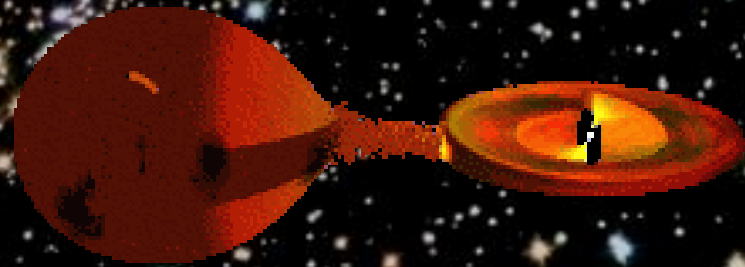
What Are Variable Stars?

Stars That Simply Vary Their Light Output Over Time



They May Be Part Of A Double Star System Or They May Be A Single Star

2 Percent Of All Stars Show A Measurable Change In Brightness



Visualization by Andy Beardmore



Hubble: Supernova 1987A

Why Observe Variable Stars?

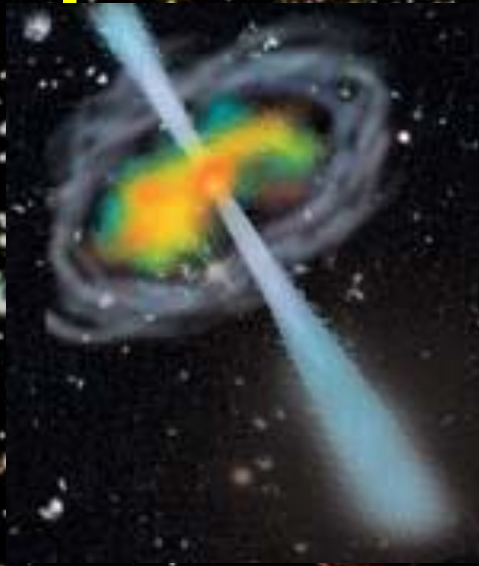
The Data Is Very Important to Astronomers & Astrophysicists

Variable Star Data,
Dependent Upon
Type, Can Be Used To Determine:
Luminosity, Temperature, Radius,
Mass Composition, Rotational
Period & Distance



There Is Also a Critical Need

**For Us To Understand & Monitor The
More Nasty High Energy Eruptive
Variables Such As GRB's (Gamma Ray
Bursts), Supernovae & BL Lac Objects
(Blazars).**

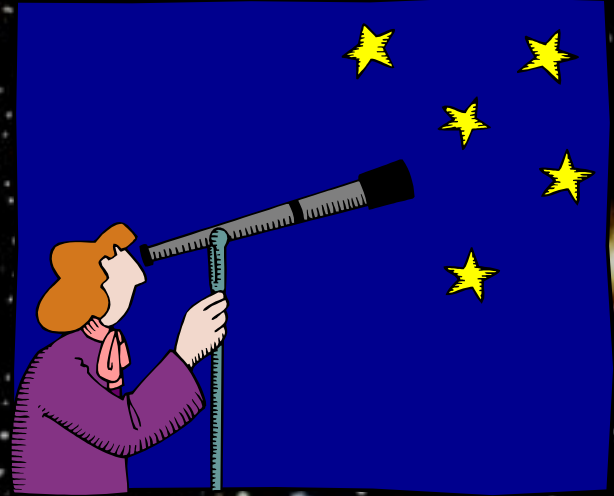


GRB Art Work, NASA

**Our Survival May Depend On These
Observations!**

Why Are Amateurs Important To The Process?

The Big Scopes Are Overwhelmed With Projects & Requests For Their Limited Observing Time. Then There Is The Humongous Size Of Our Universe With So Many Stars



The American Association Of Variable Star Observers

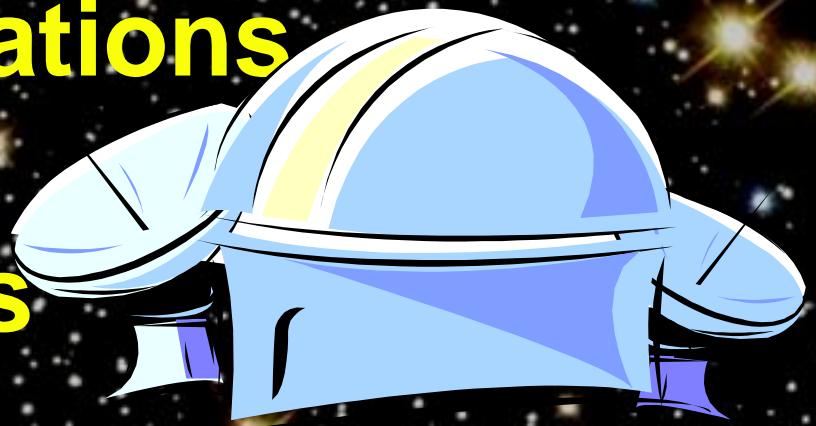
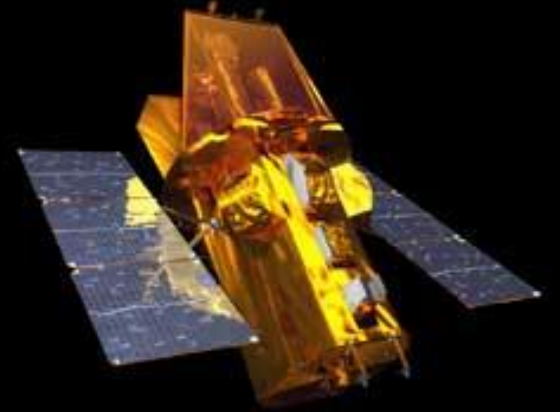
www.AAVSO.org

Has About 10,000 Stars In Their
Data Base & Approximately
4,500 Charts
Available
On Line.



AAVSO Members & Observers Are Often Asked To Support Scientific Projects

Professional Observers,
Whether Using Land or
Space Based Equipment,
Will Request Observations
Of Specific Targets
By **AAVSO** Observers

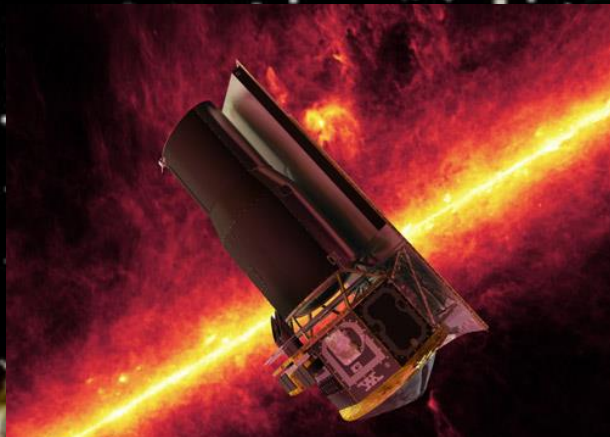


10 Requests 1/1/06-5/31/07 - 3 Examples



**Monitor CV's In Support
of the VLA & Jodrell Bank's
MERLIN For Phd @ Univ.
Of Southampton, England**

**Monitor HMXB's In Support
Of 1.85 Meter Dominion Ob.
(Victoria, BC) for Phd @ Univ.
of Saskatchewan, Canada**



**Monitor AR Uma In Support
Of Spitzer Space Telescope
For Two Phd's, One @ NOAO &
One @ Spitzer Science Center**

The AAVSO Receives Frequent Requests for Variable Star Data From It's Data Base

“Typical” 2 Month AAVSO Data Requests For Single Observer

Star	Requestor	Purpose
SS CY	Amateur Astronomer	education
W COM	Professional Astronomer	dataanalysis
MARK 421 2	Professional Astronomer	dataanalysis
MRK 501	Professional Astronomer	dataanalysis
3C 279 VIR	Professional Astronomer	dataanalysis
SS CY	Other	figure
AM HER	Professional Astronomer	correlate
AM HER	Professional Astronomer	figure
BL LAC	Educator	education
TU CAS	Educator	education
U GEM	Educator	education
U GEM	Student	dataanalysis
V838 MON	Professional Astronomer	dataanalysis
U GEM	Professional Astronomer	observingrun
U GEM	Other	basicanalysis
SS CY	Student	dataanalysis
AM HER	Professional Astronomer	correlate
AM HER	Professional Astronomer	correlate
GK PER	Professional Astronomer	observingrun
SU UMA	Student	dataanalysis
SU UMA	Student	dataanalysis
AM HER	Professional Astronomer	dataanalysis

**Variable Star Observing Is An
Adventure That Lets You Make
Valuable Scientific
Contributions**

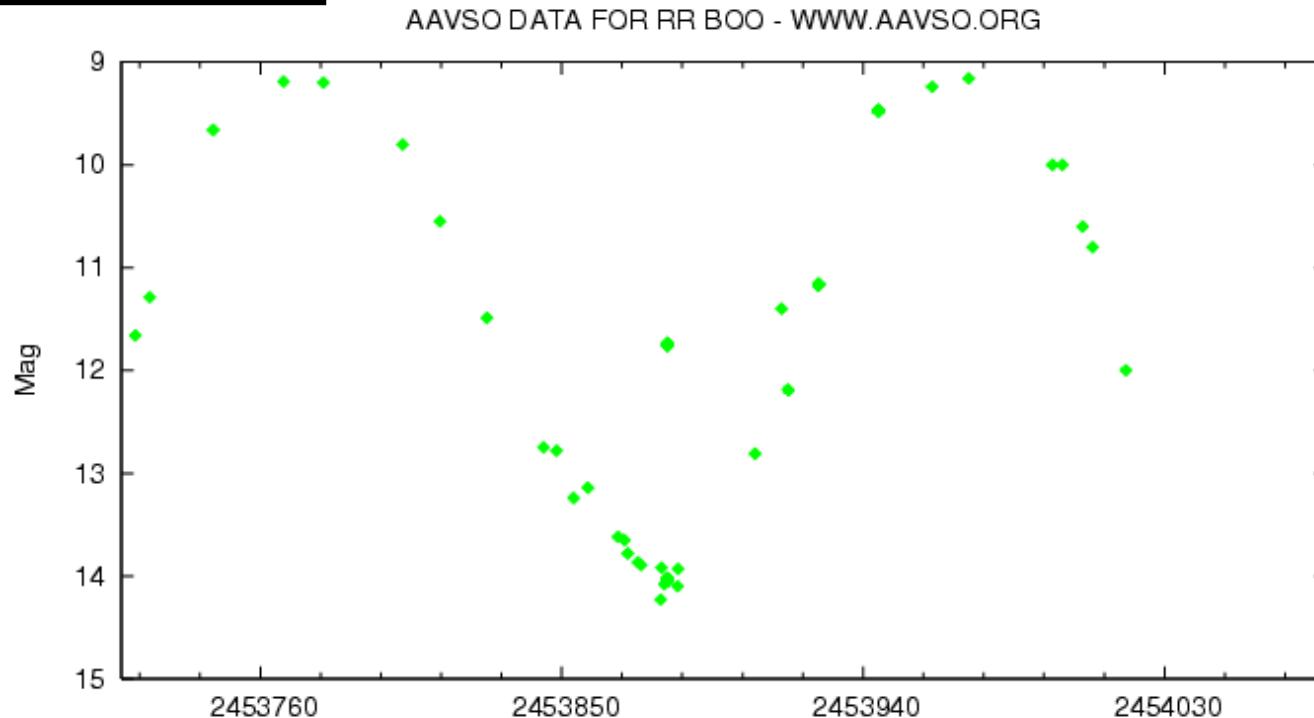


**Plus You Can Also Do Some Fun
& Really Neat Stuff With Your
Own Observations As Well As
The Observations of Others**

Light Curve: Mira Class Star

A Pulsating Variable: **RR Boo**

Light Curves Are Made From Multiple Individual Observations!

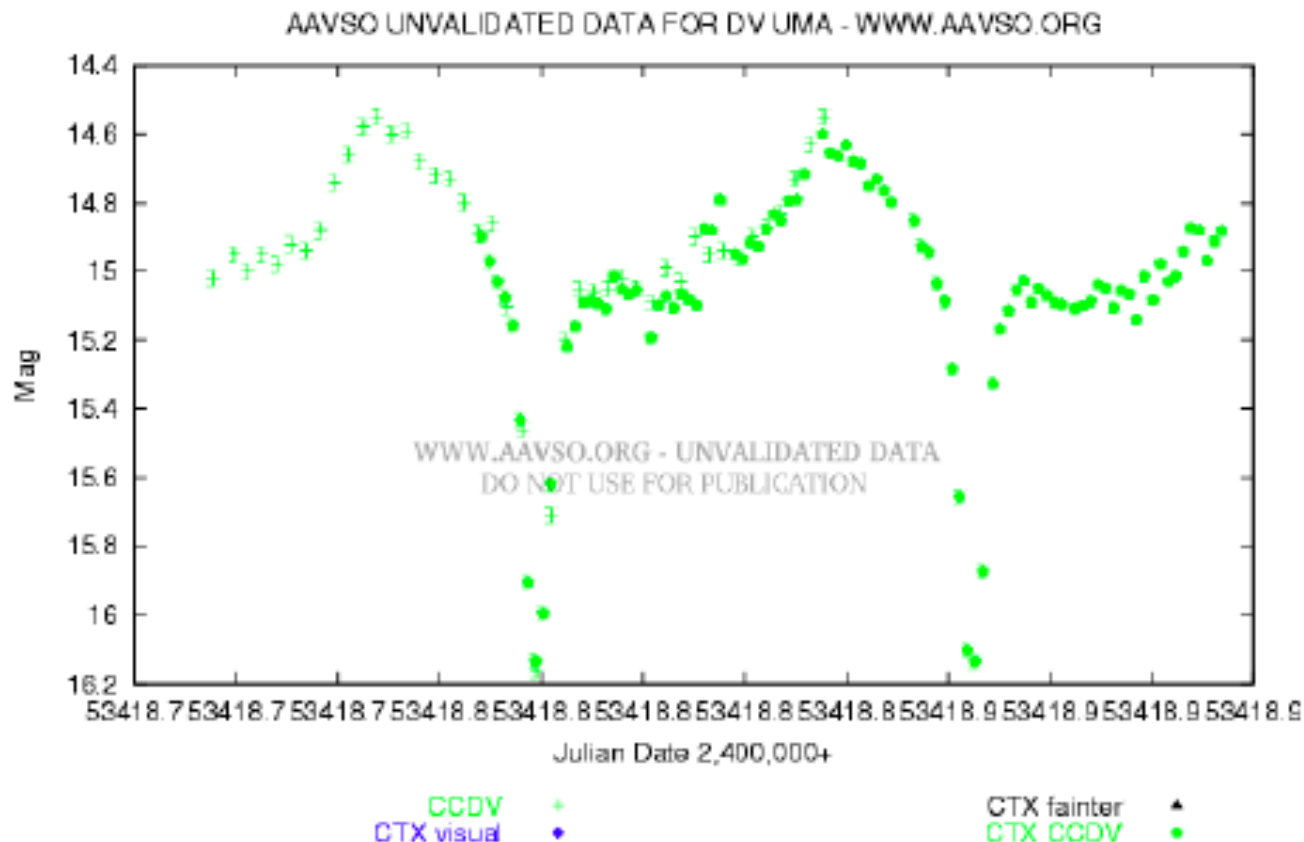


Approximately 300 Days Shown

Light Curve: Eclipsing Dwarf Nova - Single Observer

AAVSO Light Curve of DV UMA (0940+45) for 2453418.7069
through 2453419.7069

~ 4 Hours Data

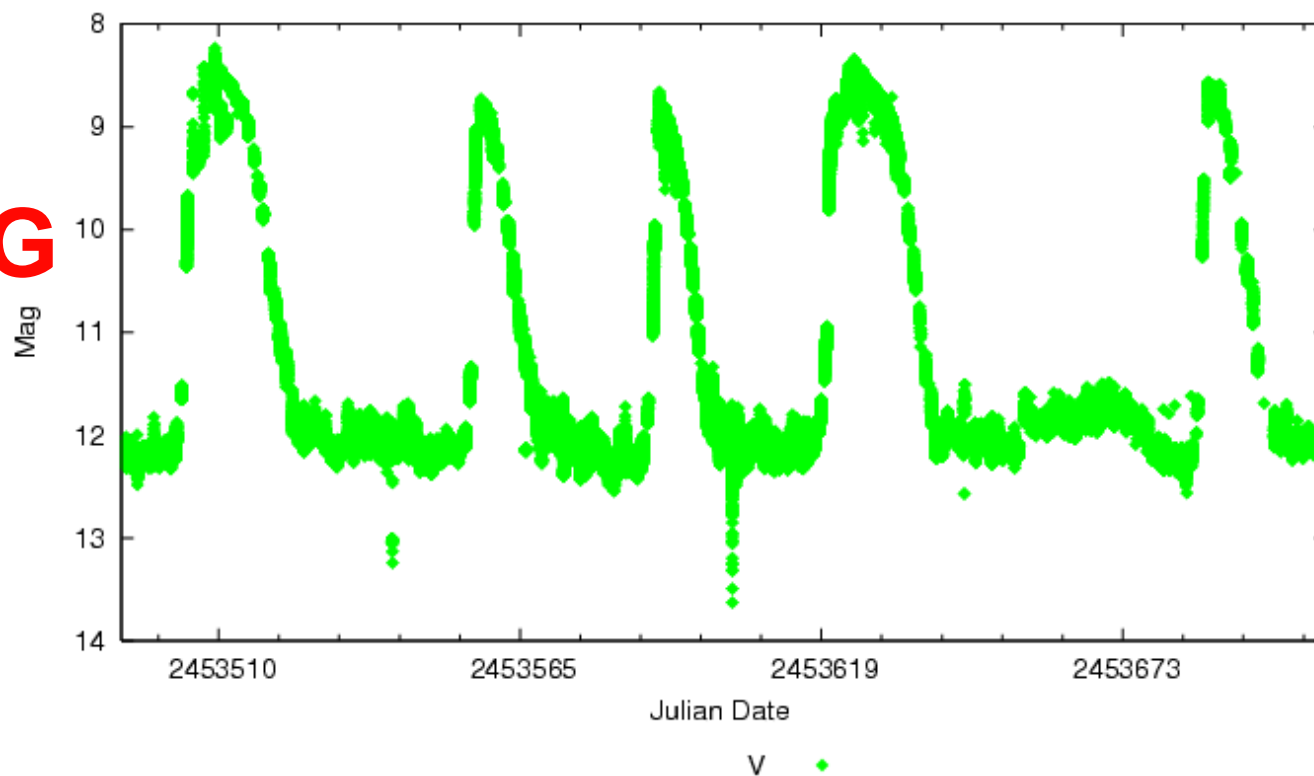


Light Curve: Dwarf Nova Outbursts - Multiple Observers

Approximately 200 Days Shown

AAVSO DATA FOR SS CYG - WWW.AAVSO.ORG

SS CYG



M51

Supernova Are A Blast

< SN 2005CS



Compute Temperature Example

Black Dots: = V Filter

Blue Dots = B Filter

Red Dots = R Filter

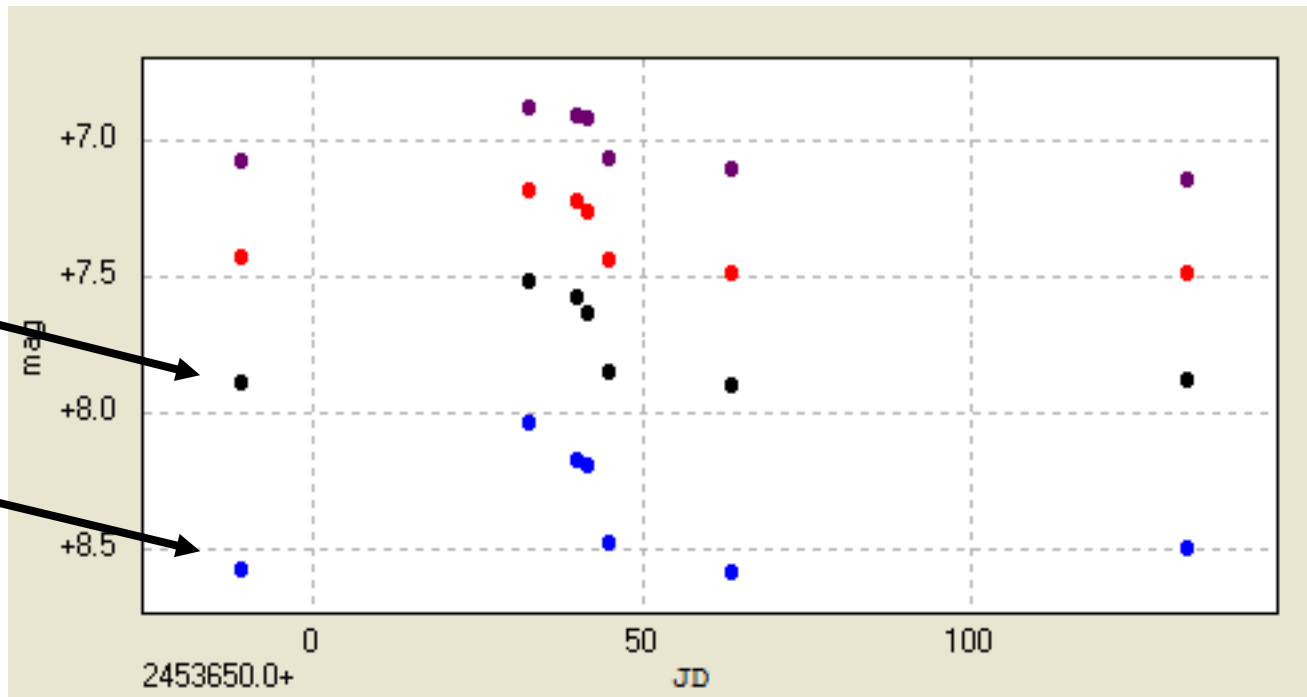
Purple Dots = I Filter

Average B-V Difference = .616

Tu Cas: Cepheid Variable (Yellow Giant Star)

V Filter

B Filter



With a “B-V” of .616

Star is Most Likely a G1 or G2 Spectral Type
& is Actually Classified As a “Yellow Giant”

Temperature Range: 5700-6000 K

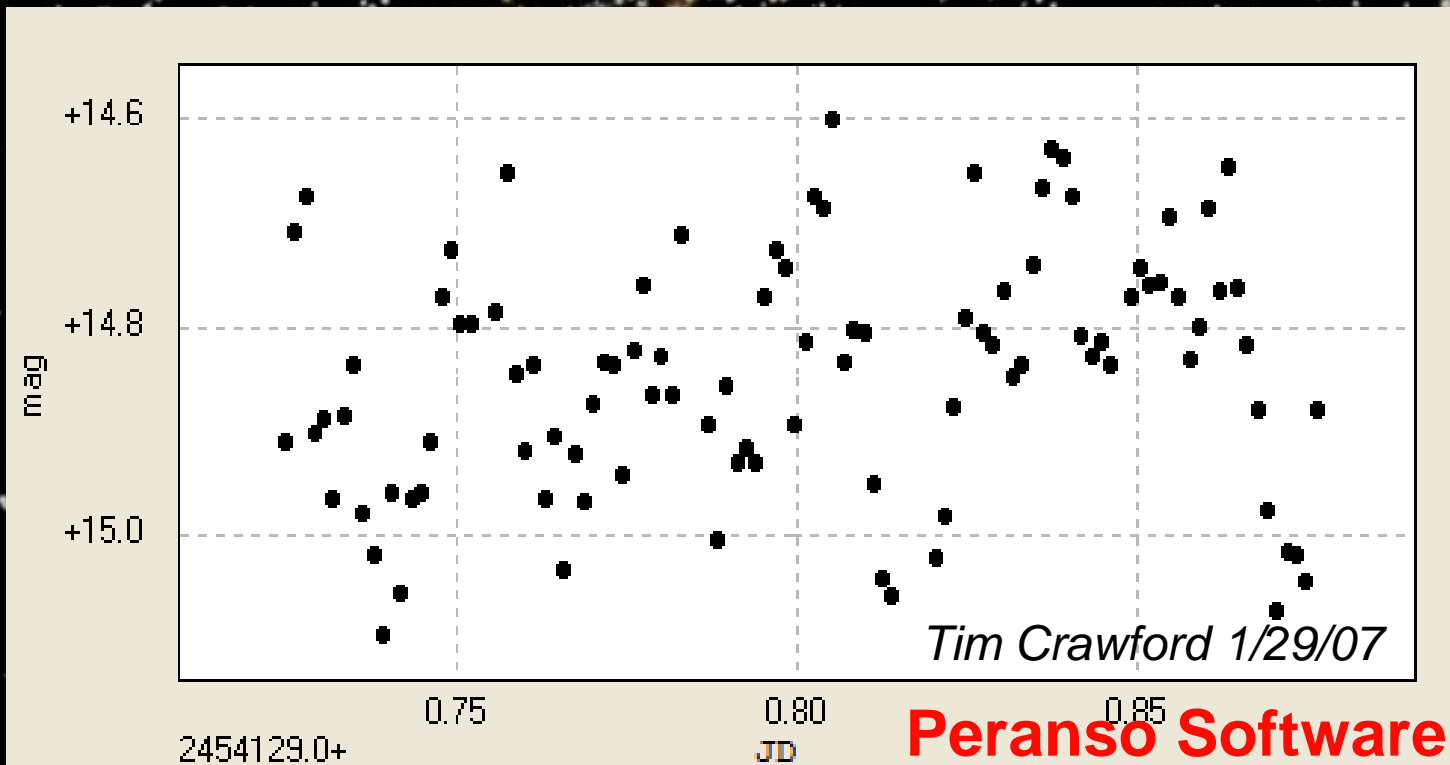
TABLE 2.1. Color Indices and Temperatures for Main Sequence Stars

Spectral Type	$(B - V)$	$(U - B)$	Effective Temperature ($^{\circ}\text{K}$)
O5	-0.32	-1.15	54,000
B0	-0.30	-1.08	29,200
B5	-0.16	-0.56	15,200
A0	0.00	0.00	9600
A5	+0.14	+0.11	8310
F0	0.31	0.06	7350
F5	0.43	0.00	6700
G0	0.59	0.11	6050
G5	0.66	0.20	5660
K0	0.82	0.47	5240
K5	1.15	1.03	4400
M0	1.41	1.26	3750
M5	1.61	1.19	3200

SOURCE: Novotny, E. 1973. *Introduction to Stellar Atmospheres and Interiors*. New York: Oxford University Press, p. 10.

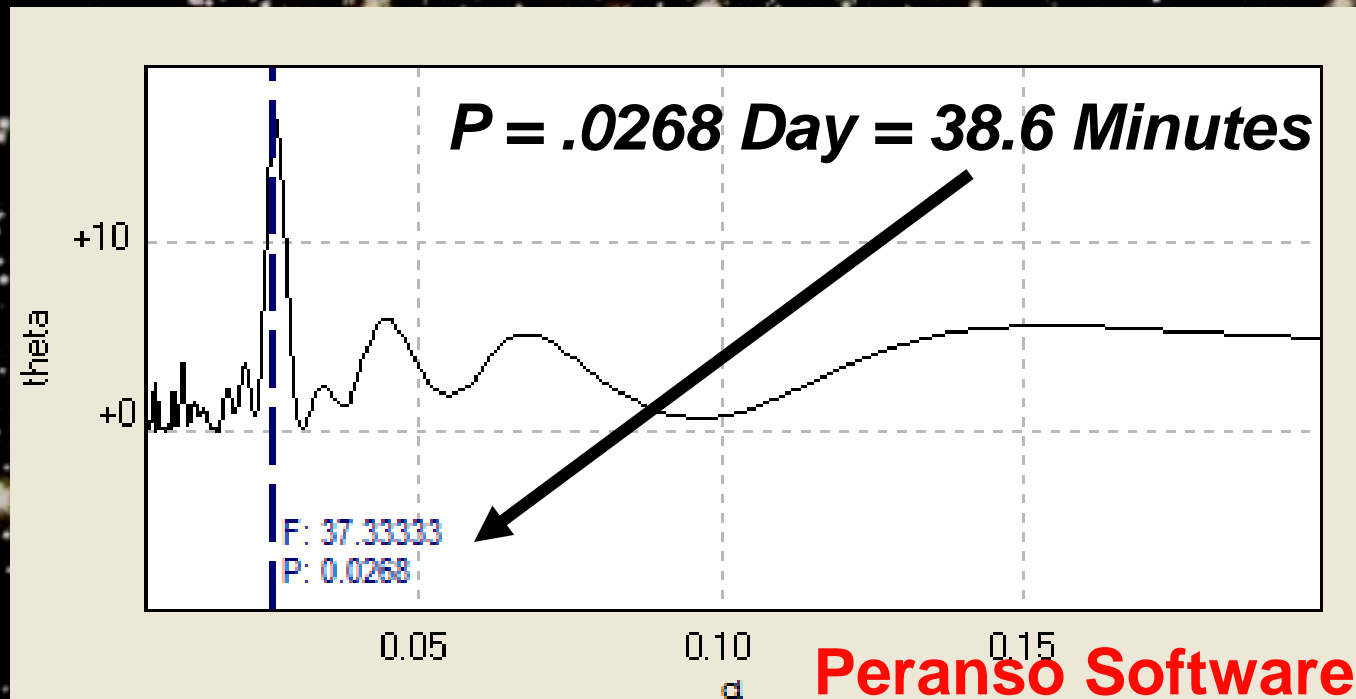
3.6 Hour Light Curve Of DW Cnc

DW Cnc Is An Intermediate Polar CV
Consisting Of A White Dwarf & A Cool
Companion & We Can Analyze The Data
Below For Additional Information



Example Of Computing The Spin Period Of The White Dwarf Portion Of The DW Cnc System

Using The Previous Slides Light Curve Data &
Software That Can Analyze That Data Using
What is Called the CLEANest Method



Minimum Tools For Making Visual Observations



**Your Eyes & an
AAVSO Chart**

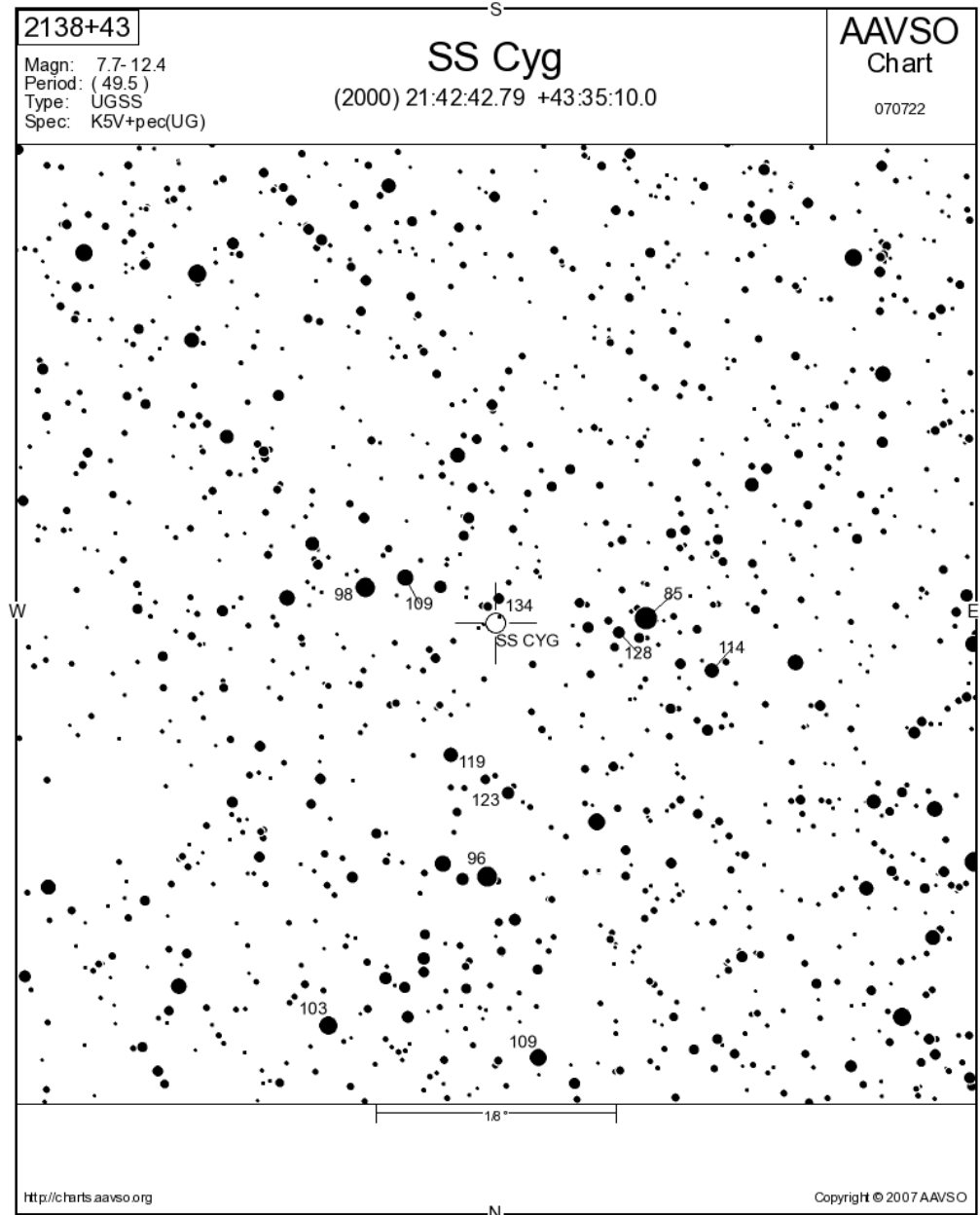
**Optically:
Binoculars & an
AAVSO Chart**



Charts

**To Make Observations
We Need Charts Which
Show Us Known
Values Of Non-
Variable Stars.**

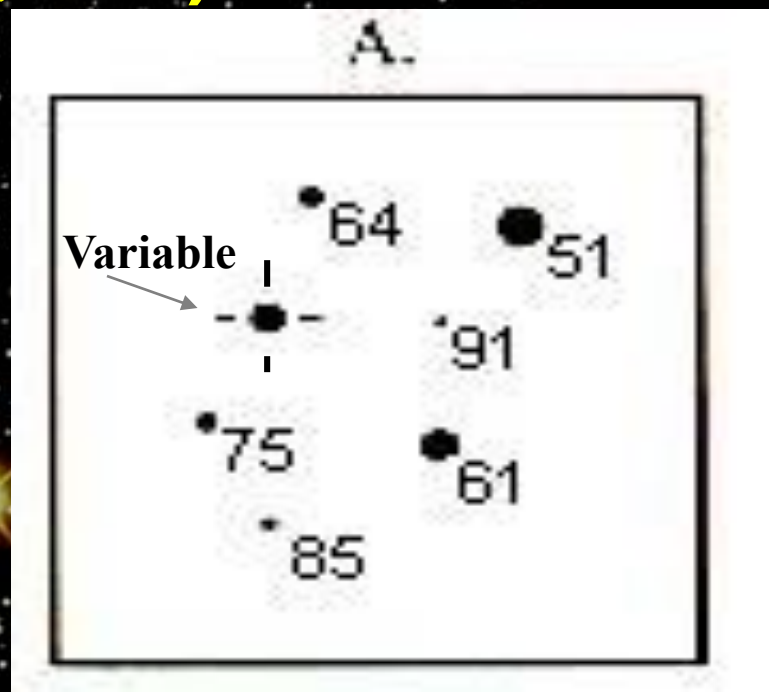
**We Call These
“Comp” Values and
Use Them To Estimate
The Value Of
The Target Variable.**



Variable & Comp Stars Chart Segment

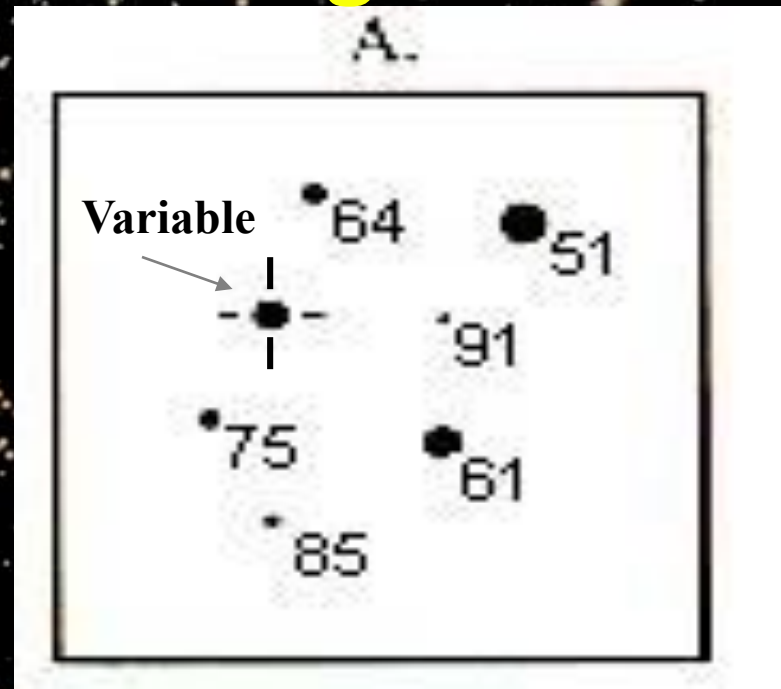
The variable is shown between the four focus lines. The magnitudes of the comparison (“comp”) stars are shown on the chart next to the stars (64,51,91, etc.).

**Note Absence
Of Period! Mags
Are Actually
6.4, 5.1 7.5, etc.**



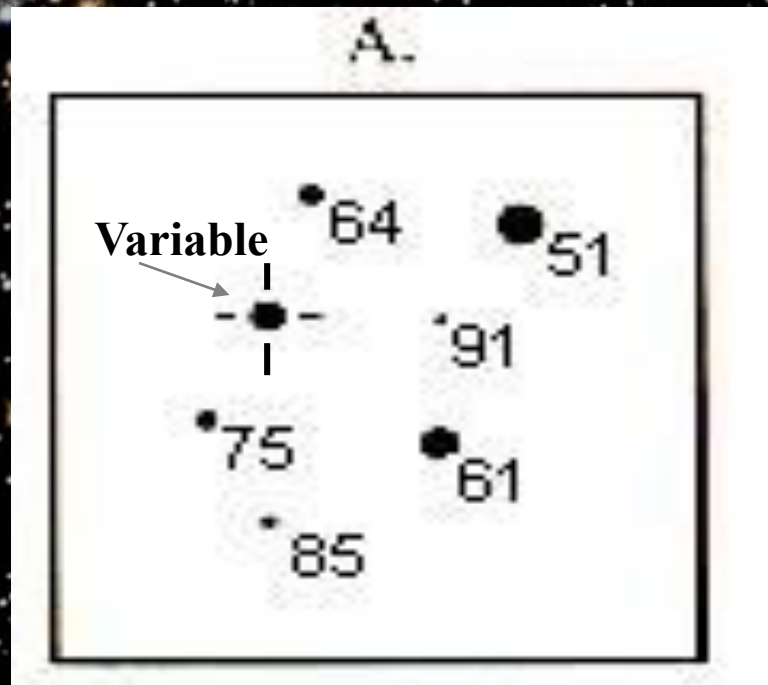
A Big Magnitude Number Is Faint, A Big Dot Is Bright!

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 For the Brighter 5.1 Star Than the 6.4 Star to Its Left.



Making Your First Estimate

Is The Variable Brighter Or Fainter Than The 5.1 Star



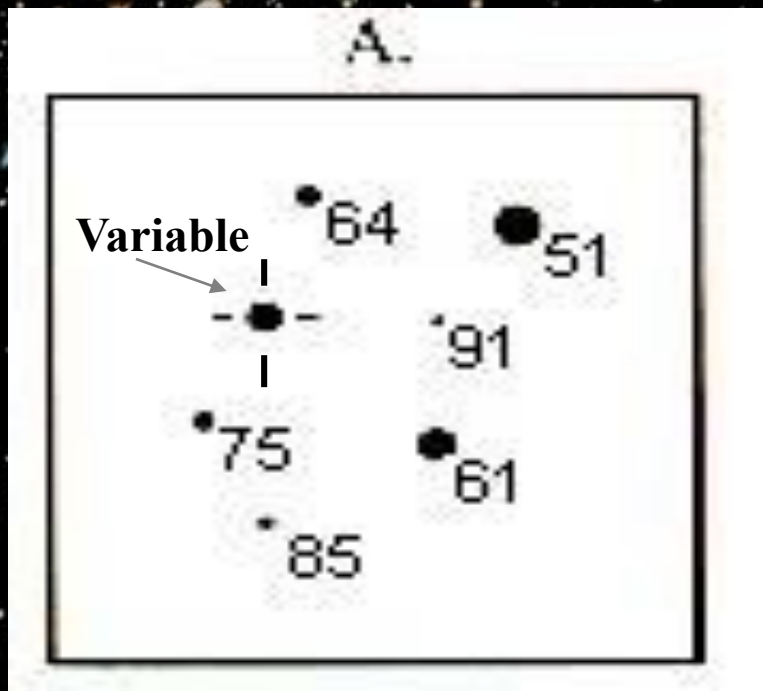
Obviously It is
Fainter

Making Your First Estimate

Is The Variable Brighter Or Fainter Than The 6.1 Star



It is Fainter

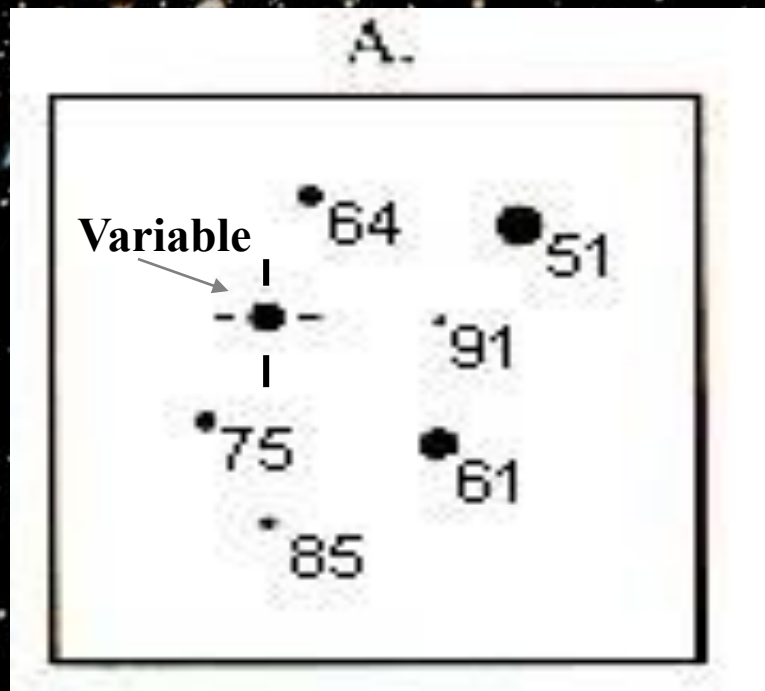


Making Your First Estimate

Is The Variable Brighter Or Fainter Than The 6.4 Star

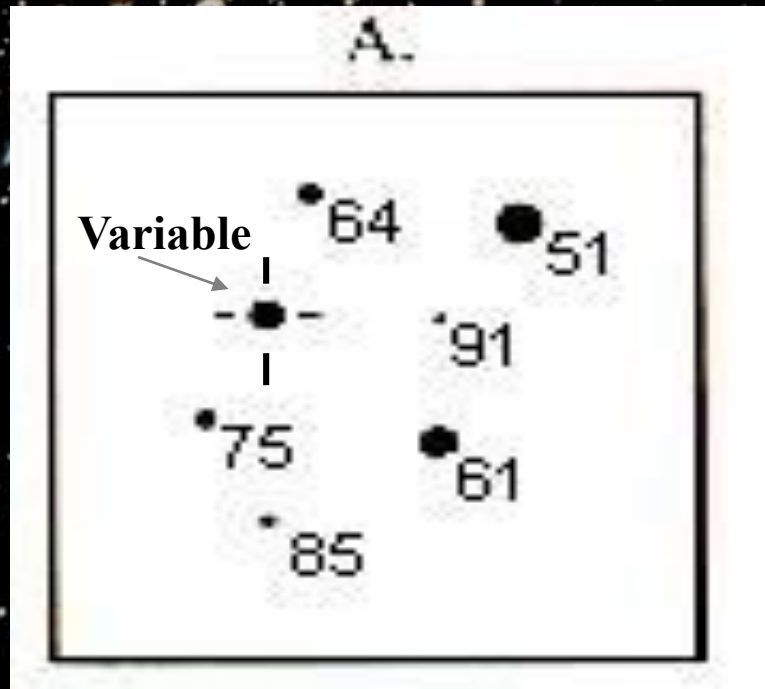


Obviously It
Is Brighter



Making Your First Estimate Now Requires Some Interpolation

Is Your Estimate Then Going to Be
6.2 or 6.3



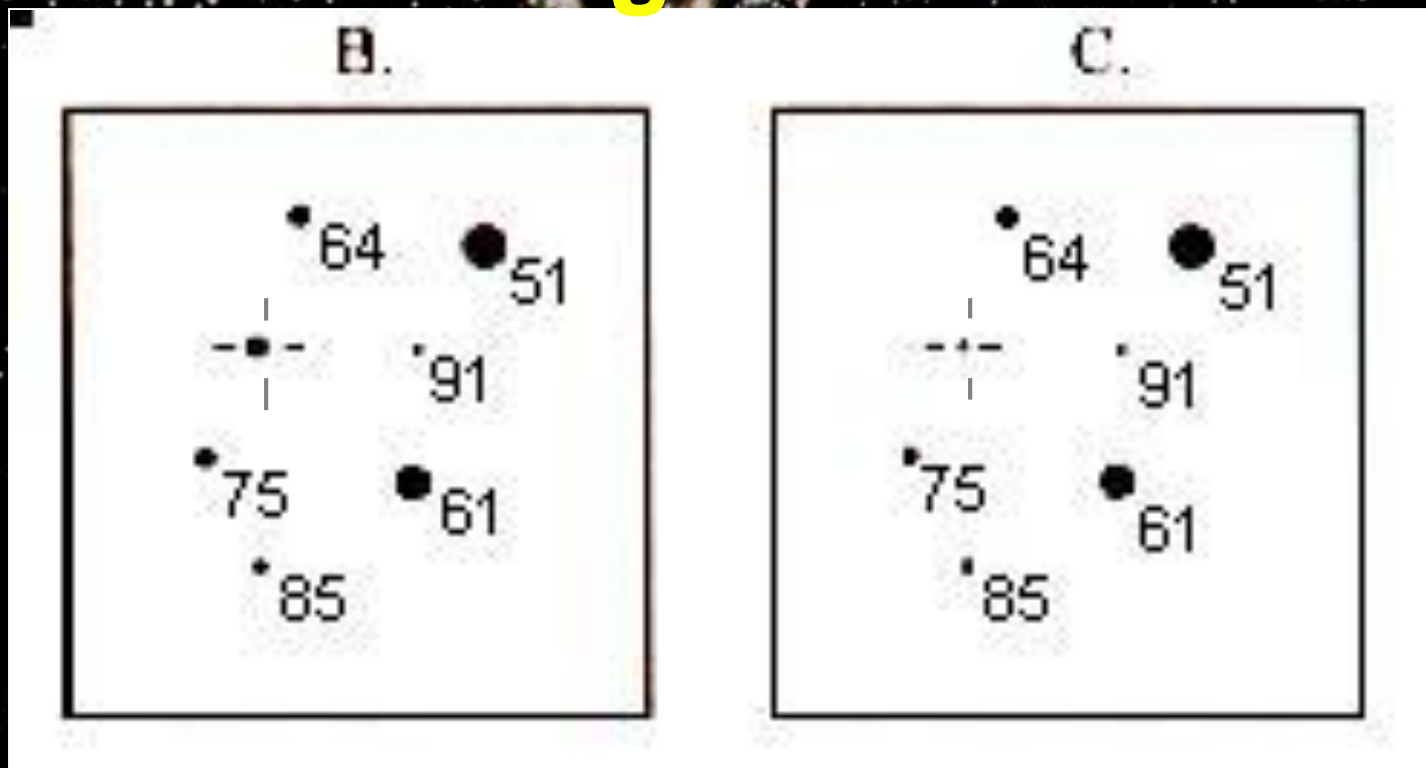
**Whatever Your Estimate
6.2 or 6.3**

**Congratulations on
Your First Variable
Star Observation!**



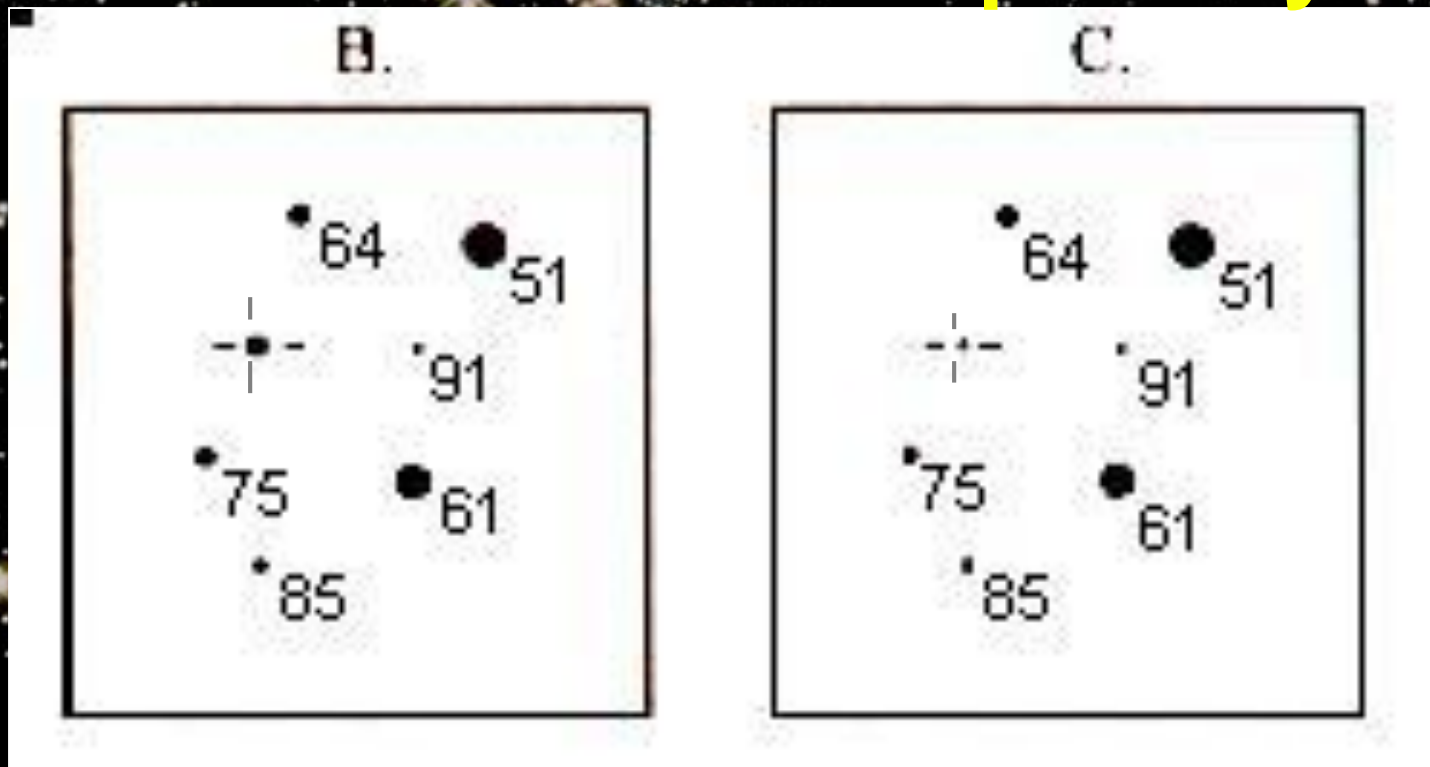
I Told You It Was Easy To Do!

This Time, Estimate the Same Variable but in Frames B and C. These Frames Could Be the Variable Star at Different Times in Its Light Curve.



Write Your Estimates Down

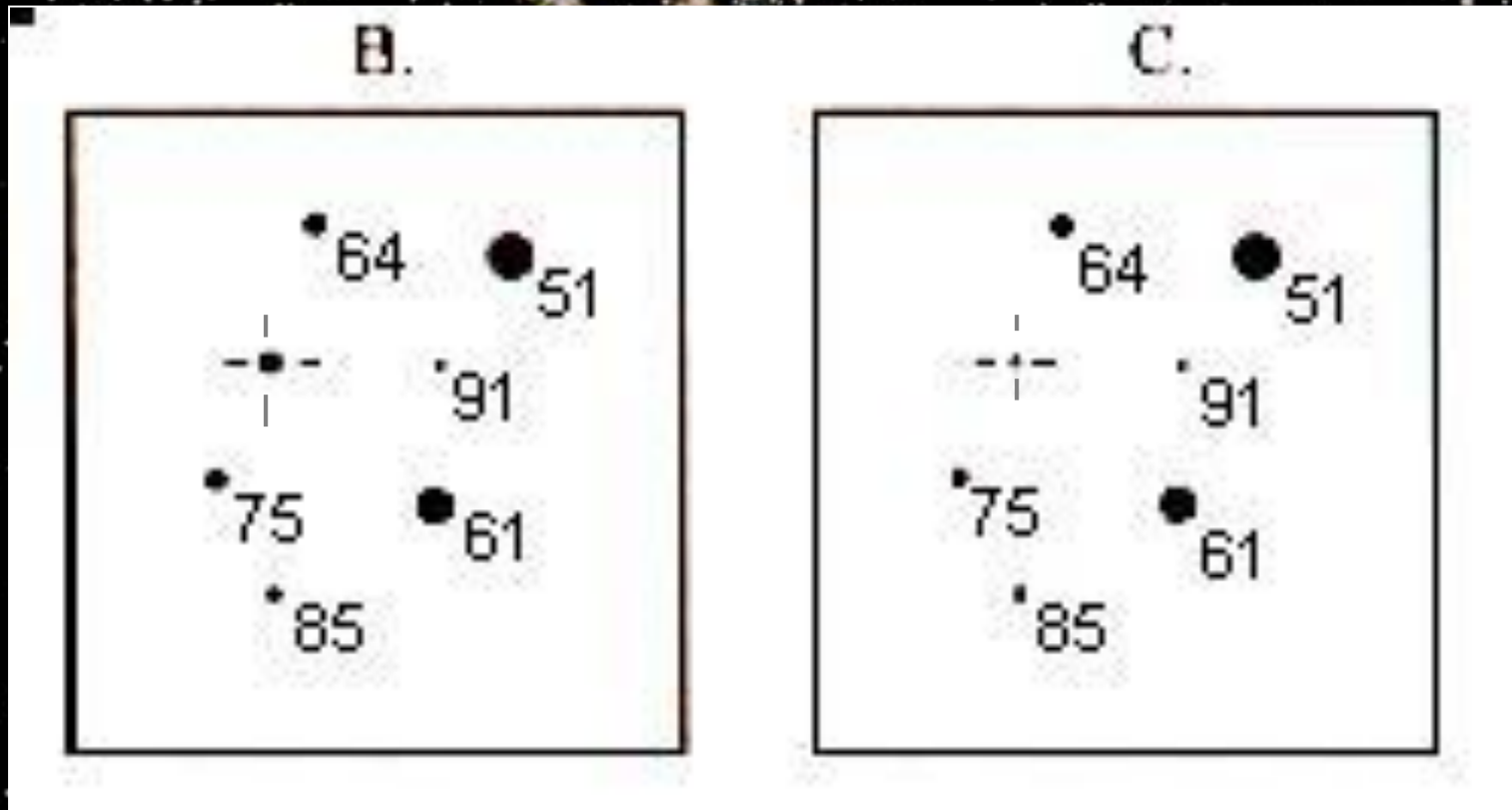
Remember To Try & Locate Two Comp Stars That The Variable Best Fits Between or The One Comp It May Match



How Did You Do?

For B Your Estimate Should Be Near 6.4

For C Your Estimate Should Be Near 9.1



All You Need To Do Now

Is to Make A Visual Estimate Of A Real Variable Star (Which You Will Do In A Moment) & You Are Ready To Down Load **AAVSO** Charts and Begin Your Own Adventure Of Making Contributions To Science As Well As Having Some Fun Along The Way



[Click here](#) for additional information.

AAVSO Variable Star Plotter

Name

Location*

RA Dec

Delimited by spaces or colons; sexagesimal or decimal degrees

Title

Title to be displayed top center of chart

Comment

Comment to be displayed beneath chart star field

Plot a chart of this scale:

Use this to quickly plot a chart with same dimensions and scale as AAVSO charts.

FOV*

Field of view size, expressed in arc minutes (0-240, 0-60 for DSS)

Resolution*

Print resolution of image, expressed in dots per inch (75-300)

Mag. Limit*

Limiting magnitude for stars (5-25; ignored if Use DSS Image checked)

CCD Box Limit

Maximum number of stars to include in photometry box (0 to disable)

North ☐ Up ☒ Down

East ☒ Right ☐ Left

Image ☐ Use DSS image

Query Digitized Sky Survey and render image on chart

Field Photometry ☐ Do not plot chart, just give me a table of photometry

* required
 Click [here](#) to clear your saved settings.

Down Loading Charts Is Easy

[AAVSO HOME](#)

Search

Site Map



American Association of Variable Stars

www.AAVSO.org

Pick a star

- ☐ Create a light curve
- ☐ Recent Observations
- ☒ Find charts
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AAVSO On the Road



The AAVSO is on the Road. We take a look at Director Henden's trip out to Big Bear for the Society for Astronomical Sciences (SAS) annual meeting. Then Kate Hutton, who is here with the travelling AAVSO display, describes her trip to the Riverside Telescope Making Conference (RTMC) Astro Expo also near Big Bear, California.
[Read article](#)...



[AAVSO Spring Meeting](#)

[click here to](#)
DONATE

News and Announcements

Special Notice #52 AM Her increasing in brightness 07/06/07

AAVSO Preprint *Analysis of AAVSO Visual Measurements of T Tauri Variables
 alaniappa 07/06/07
Variable Star Notes New charts, customized star charts for over 4,000 variable stars

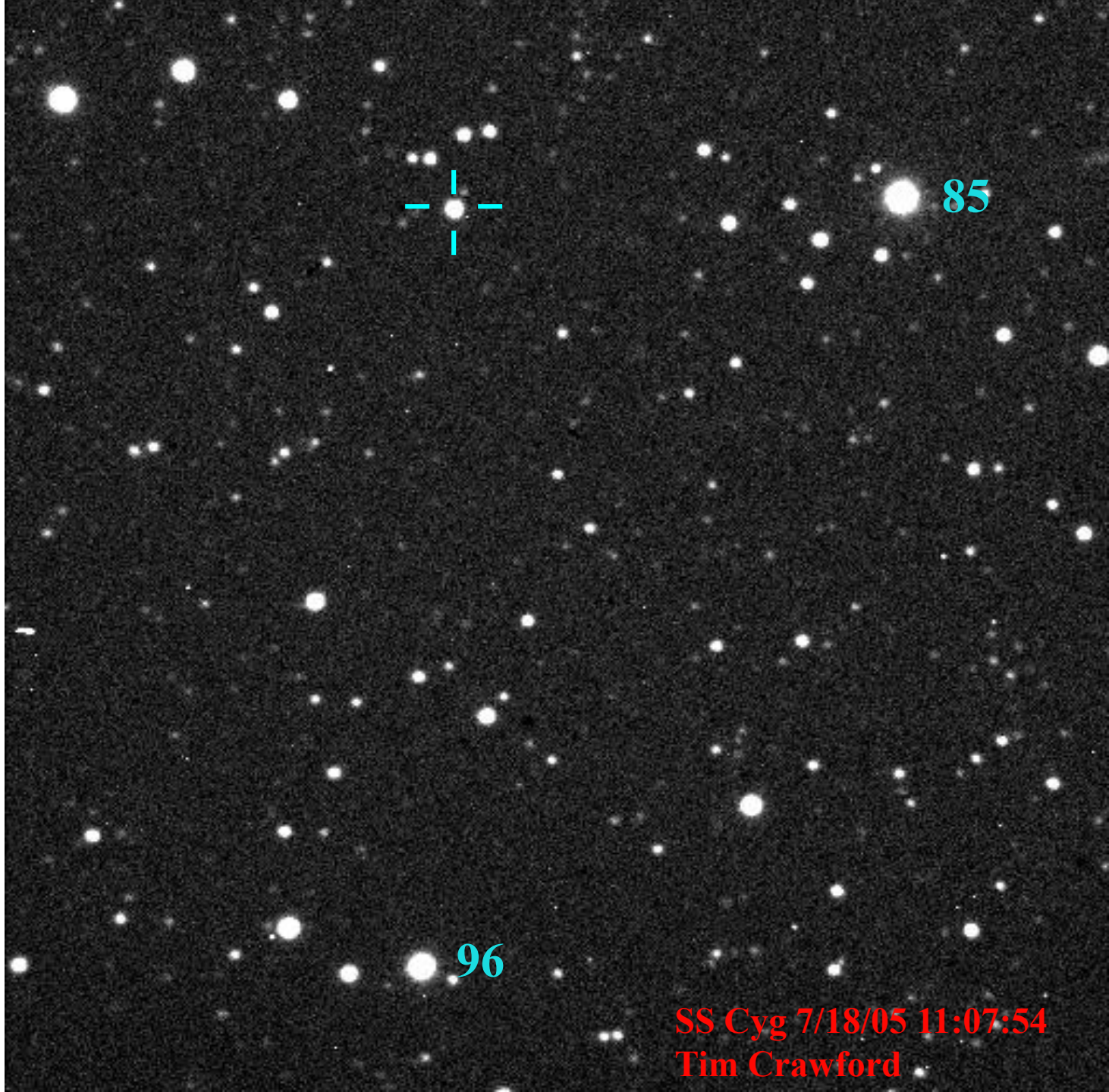
Special Notice #51 V5558 Sgr chart update 06/29/07

May Solar Bulletin Includes SID and sunspot data 06/21/07

Alert Notice 352 V390 NOR = NOVA NORMAE 2007 06/20/07

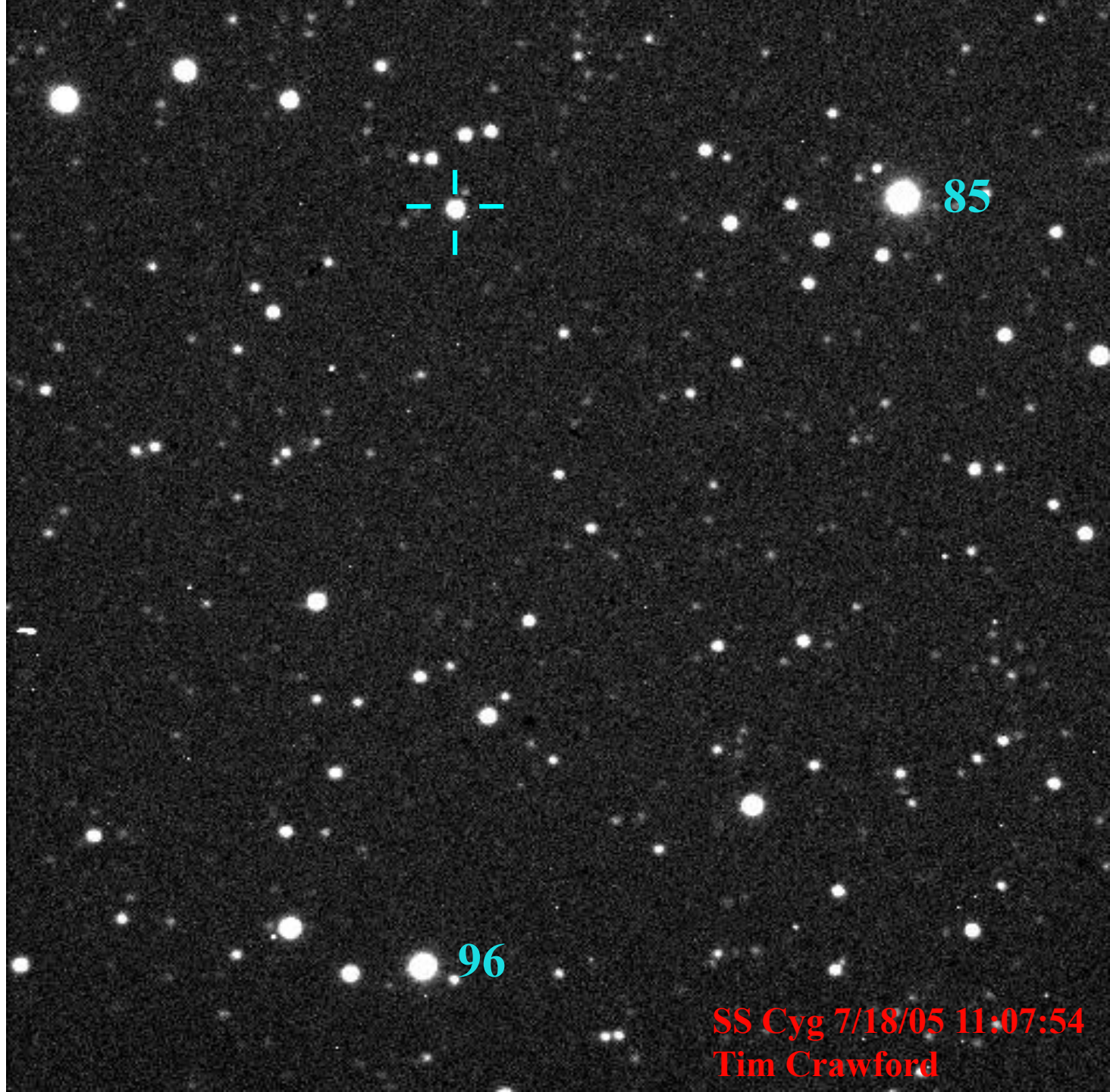
Special Notice #49 Possible Nova in Nor 06/17/07

**Now Take
The SS
Cyg
Chart
That Was
Handed
Out &
Match It
To This
FOV**



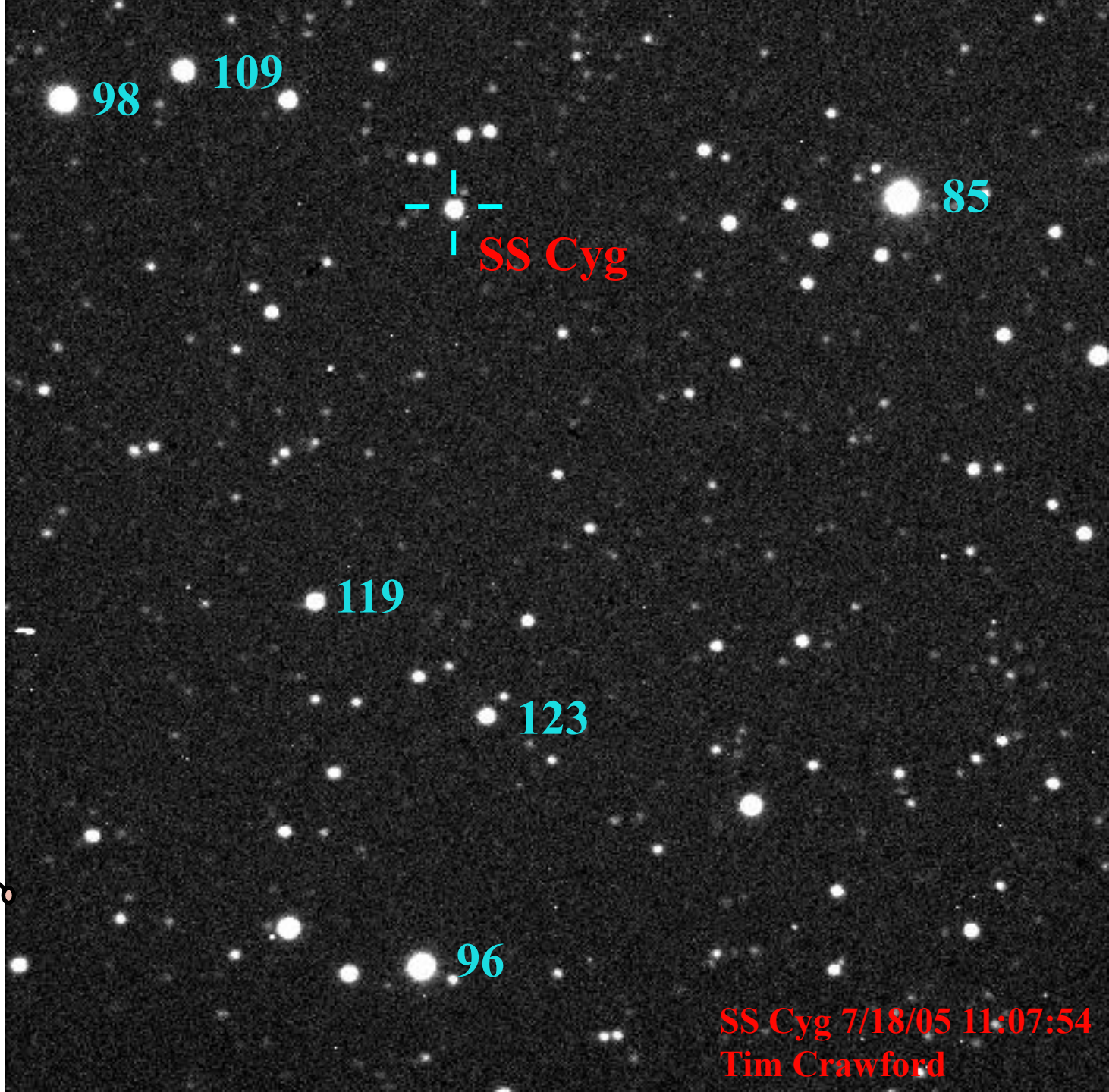
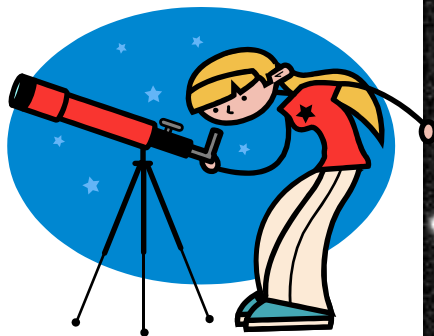
**SS Cyg 7/18/05 11:07:54
Tim Crawford**

**Now Make
Your
Visual
Estimate
Of The
Magnitude
Of
SS Cyg**



**SS Cyg 7/18/05 11:07:54
Tim Crawford**

**Your
Answer
Should Be
Real Close
To 11.9
As This Is
Actual
Value**



**SS Cyg 7/18/05 11:07:54
Tim Crawford**

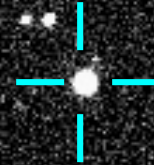
Now Wasn't That Easy!

However.... A Lot Of Times There Will Not Be A Comp Star With The Same Magnitude As The Variable Star. When This Happens You Just Have To Interpolate Your Estimate As Best As You Can.



**Make An
Estimate
Of SS
Cyg At A
Different
Time**

**Locate
The
Closest
Two
Comps**

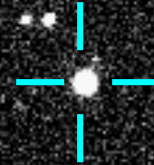


**SS Cyg 7/8/06 09:41:44
Tim Crawford**

**You
Should
Have
Picked
The 98 &
109
Comps
As Being
Closest**

**What Is
Your
Estimate?**

98 109



**SS Cyg 7/8/06 09:41:44
Tim Crawford**

**While
The
Actual
Answer Is
10.5
Anything
Between
10.4 &
10.6
Would Be
OK**

98 109

SS Cyg

**To My Eyes The Variable
Star Looks About 1/2 Way
Between The 9.8 and the 10.9
Comps**

SS Cyg 7/8/06 09:41:44
Tim Crawford

Down Load A Free Observing Manual: www.AAVSO.org

Pick a star

- ☐ Create a light curve
- ☒ Recent Observations
- ☐ Find charts
- ☐ VSX ☒ GO

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Especially for ...

[New Observers](#)

AAVSO Manual for Visual Observing of Variable Stars



Visual Vs CCD Observing

Visual

- ❖ Quicker Observations
- ❖ Easier To Learn
- ❖ Lower Equipment Costs

CCD

- ❖ Can Target Fainter Stars
- ❖ Can Do Time Series
- ❖ Can Use Filters For Color/Temp Information

CCD Observing Requires A CCD Camera - Preferably One Designed For Photometry & A Telescope



ST-402ME

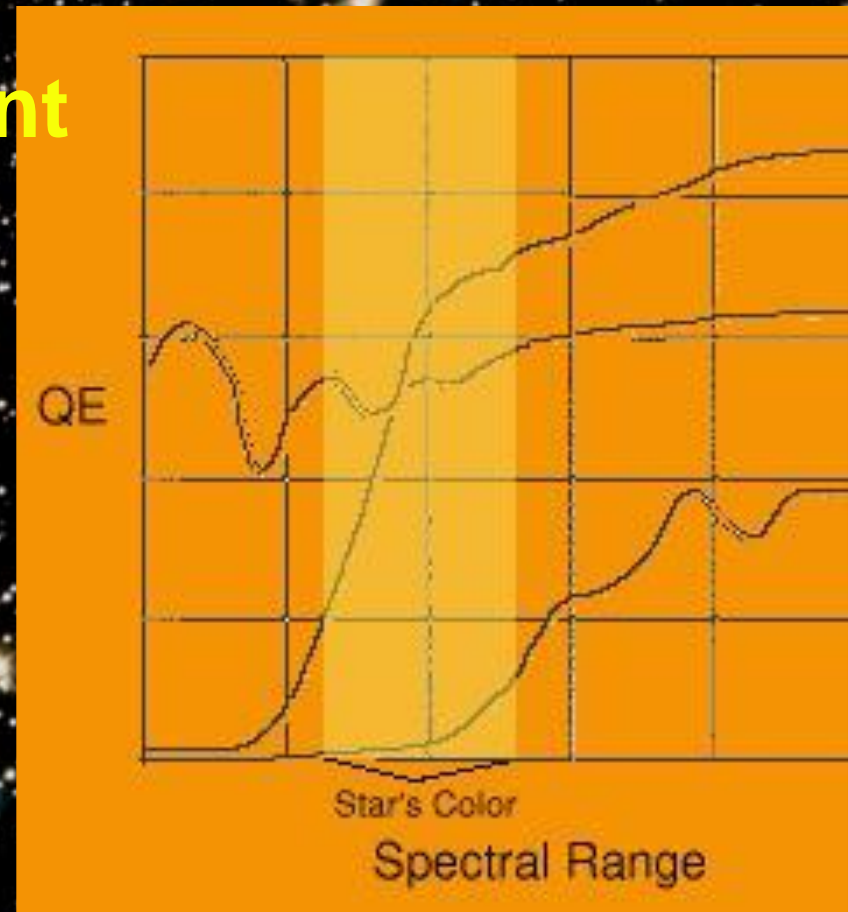


ST-7/8/9/10XME

Different Models of CCD Chips Have Different Spectral Responses

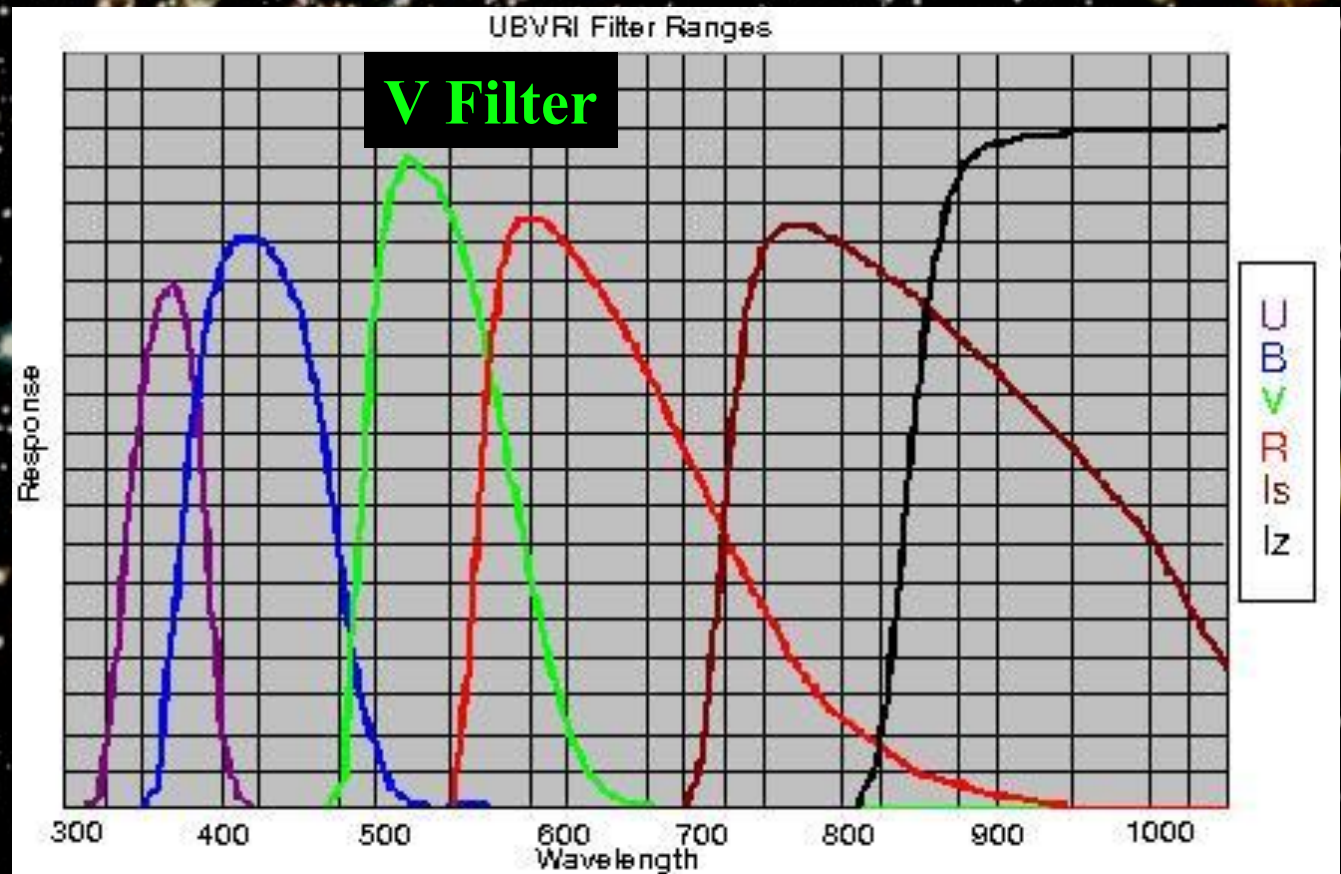
Each of the three popular chips shown has a different Spectral response in the region of a Star's Light.

If unfiltered observations were made with each then the reported magnitudes would be wildly different



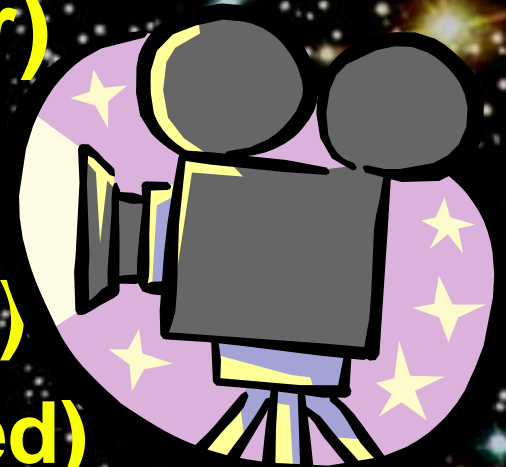
One of the Strengths of CCD's Is That When We Use the "Right" Filter We Can Equalize the Passbands of the Various Types of CCD's. **Observe With V Filter!**

The
Johnson-
Cousins
Filter
Standard
System



Integration Software Is Required For Imaging (CCD Control) - A Few Options

- Meade Envisage (Autostar)
- CCDOPS (SBIG)
- CCDSOFT (Software Bisque)
- MAXIM DL (Diffraction Limited)



Lastly You Need Software For The Differential Photometric Analysis Of Your Images - Some Options

- **Autostar IP**
- **AIP4WIN**
- **CCDSOFT**
- **IRAF (free on web)**
- **MaximDL**
- **Mira**
- **MPO Canopus**
- **jlimage**

Observing

Observing Programs

Visual

CCD

Exoplanet Transit Search

High Energy Network

Photoelectric (PEP)

Infrared Photometry

Supernova Search

Nova Search

Eclipsing Binary

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CCD Observing Manual

This manual is a basic introduction and guide to using CCDs to make variable star estimates. The target audience is beginner to intermediate level CCD observers, although advanced CCD users who have not done any photometry will also find this helpful.

This document is a work in progress and *always under revision*. Please don't mirror it offline and check back often for changes and additions.

Here is a [PDF format version of the manual](#). If you need the pdf viewer, [you may download it for free from the adobe website](#).

Please send any feedback or suggestions to aavso@aavso.org

- [What's New](#)

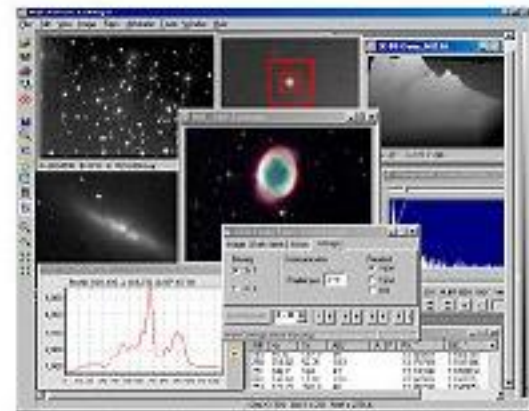
1.0 Introduction

- 1.1. [Target Audience](#)
- 1.2. [CCD vs. Visual Observing](#)
- 1.3. [Are You Ready? \(Prerequisites\)](#)
- 1.4. [Expectations](#)
- 1.5. [Why CCDs?](#)

2.0 Equipment

- 2.1. [Telescope](#)
- 2.2. [CCD camera](#)
- 2.3. [Filters](#)
- 2.4. [Computers & Software](#)

3.0 CCD Camera Skills



Minimal CCD Setup

- 4"-8" w/ decent tracking mount
- Cheap \$125 camera (mono)
- \$60 V filter
- Free software

Gord's Hardware

- C8S On ASGT mount
- Orion Accufocus / Shoestring FCUSB
- Meade DSI Pro (stock)
- V filter in ATIK filter wheel w/Meade f3.3 FR
- 80mm Refractor / DSI-C / Shoestring GPUSB ST4
- P4 2.8 ghz PC w/ 1 gb Ram in hotbox
- Roll-off roof shed

Gord's Software

- Astroplanner /
Cartes du Ciel /
Maxpoint
- Meade Autostar
Envision (imaging)
- Meade Autostar
Image Processing
(diff. photometry)
- VNC remote
desktop