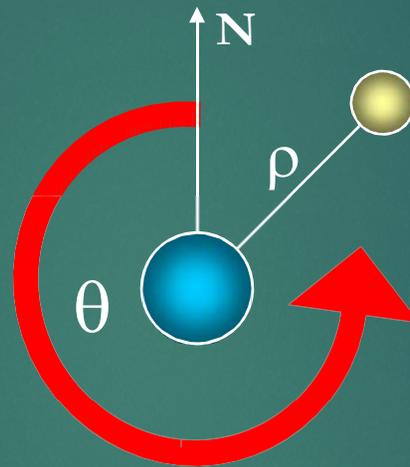


Double Vision



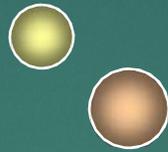
An Introduction to Double Star Observations

David Lee

What are Double Stars?

- A binary star system is bound by gravitational force
- Star systems can involve more than a pair and are called multiple star systems
- Visual: true binary system
- Optical: apparently binary but not related

Double Star Types



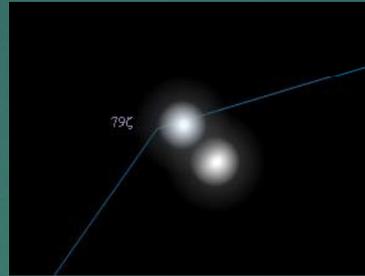
- Spectroscopic: visible only through spectral analysis
- Eclipsing binary: line of sight orbits result in mutual eclipse
- Astrometric: only one star is visible, presence inferred by “wobble”

Presentation Scope



- For the purposes of this presentation definitions and observing methods will be discussed for simple binary systems
- Observing eclipsing binaries will be a future topic

Some History of Double Star Observing



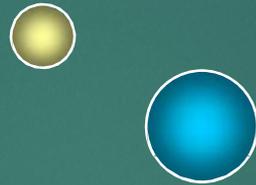
From the Sky 6 (Mizar)

- Castelli and Galileo studied the first double star known as Mizar in 1617
- The first catalog of double stars (80) was compiled by Mayer in 1778
- Herschel followed with a catalog of 269 pairs in 1782 and a catalog of 700 pairs in 1785
- The definitive source today the Washington Double Star Catalog contained over 118,000 pairs as of August 1 2012

Shifting Interest

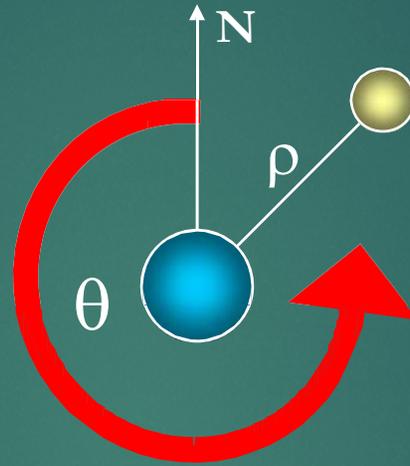
- Starting in the late 19th century the observation of double stars was of prime interest for both amateurs and professionals
- Studying the orbits of binary star systems enabled the calculation of star mass and gave insight to stellar formation
- This required the collection of data over long periods of time
- In the later part of the 20th century the astronomical community shifted interest towards clusters and galaxies spurred by photographic and electronic measurement leaving double star observation with diminishing support
- Amateurs have an opportunity to help in maintaining the legacy of double star information

Why are they of interest to amateur astronomers?



- Provides an estimate of seeing conditions
- Demonstrates colour differences of stars
- Improves observing skills
- Relatively unaffected by light pollution
- Participate in the measurement of neglected doubles

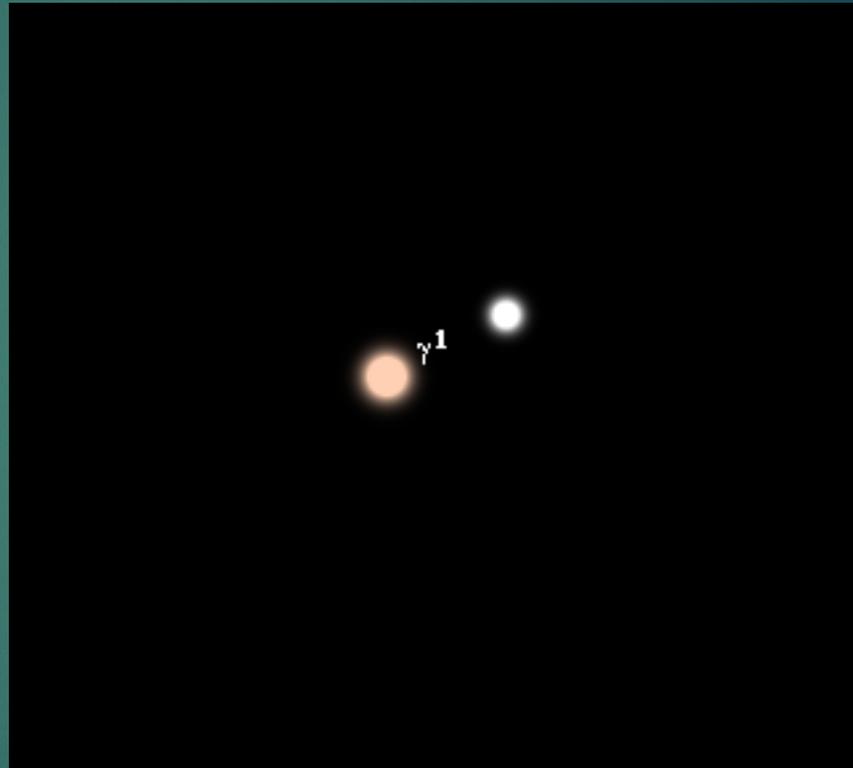
Attributes of Double Stars



- Magnitude differences – may be large or small
- Colour differences – Hagen Color Index (HCI)
- Separation – ρ (rho) measured in arc-seconds
- Position angle – θ (theta) measured in degrees counter clockwise from North

Some Classic Examples

- Alcor and Mizar
- Alberio
- Epsilon Lyrae
- Almaak
- Polaris



From SkyTools2 (Almaak)

Equipment for Observing

- Telescopes: aperture and Dawes limit, resolving ability increases with aperture ... with exceptions
- Eyepieces: focal length, tight doubles require magnification to resolve
- Reticle eyepiece: aids in measuring separation and position angle
- Lists: organized by constellation, separation
- Star charts: aid in locating doubles
- Software: build custom observing programs



Aperture and Resolving Power

Dawes Limit

$$R = 11.6 / D$$

Where R is the resolving power of the instrument in arc-seconds
D is the diameter of the optics in centimetres

A 101mm refractor would be able to resolve $R = 11.6 / 10.1 = 1.15$ arc-seconds

An 8 inch SCT would be able to resolve $R = 11.6 / 20.3 = 0.57$ arc-seconds

Other Optical Considerations

- Aperture is important but sometimes less is more, especially in cases of poor seeing
- Larger instruments often need greater cool down time for optimal clarity due to tube currents
- Contrast is important in discerning doubles of with great differences in magnitude which is related to optical design

Eyepiece Selection

- A range of eyepieces is desirable for double star observation
- Wider fields are used initially to find the object with increasing magnifications used to split the double distinctly
- Eyepieces of simpler design are typically better contrast wise but suffer from smaller fields of view eg. Orthoscopics
- Good Plossl designs are usually recommended
- For tight doubles image amplification may be required in the form of a Barlow lens or Televue Powermate

Specialty Eyepieces

- Though not necessary specialty eyepieces can add to the experience of observing doubles by allowing us to measure attributes such as separation and position angle
- Multi-reticle eyepieces have laser-etched reticles and can be used to measure both
- Simple reticle eyepieces with some modification can be used to make similar observations

Modified Reticle Eyepiece



<http://www.skyandtelescope.com/observing/objects/doublestars/3304341.html>

Robert Tanguay in a Sky and Telescope article showed how he modified a simple reticle eyepiece for measuring the position angle of double stars

Observing Methods

- Planning your observations
- Splitting the double
- Evaluating colour (HCI)
- Describing magnitude differences (Mag)
- Calibration of a reticle eyepiece
- Measuring separation (Sep)
- Orientation of field of view (FoV)
- Measuring position angle (Pa)
- Recording your results

Planning your observations

- Double star lists can help in selecting and planning your observations
- Choose easy targets at first and work towards more challenging ones
- Keep in mind the limitations of equipment and seeing conditions
- Star charts and planetarium software can help in building finder charts for your targets

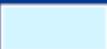
Splitting the Double

- Acquire the double using a wide field eyepiece
- Use progressively higher magnifications and observe the earliest point at which the double is just perceived
- When the double is about to split it will take on a “football” shape while other stars in the field remain pinpoint
- Note the minimal magnification to split distinctly

Describing Magnitudes

- Magnitudes of stars can be estimated by using the known magnitude of reference stars in the same field of view and comparing visually
- Sometimes it is sufficient to describe the differences or similarity in magnitude of the two stars
- More precise descriptions require CCD photometric measurements

Evaluating Colour

-3	Pure Blue	
-2	Pale Blue (Bluish)	
-1	Blue / White	
0	Pure White	
1	Yellowish/white	
2	Pale Yellow (Yellowish)	
3	Pure Yellow	
4	Orange /Yellow	
5	Yellow / Orange	
6	Pure Orange	
7	Reddish / Orange	
8	Orangey / Red	
9	Red / Orange	
10	Pure Red	

Hagen Color Index

- Colours are exaggerated in the chart
- There's a limitation to perceiving colour under low illumination
- Colour perception is very individual
- Defocusing the stars can make colour easier to perceive

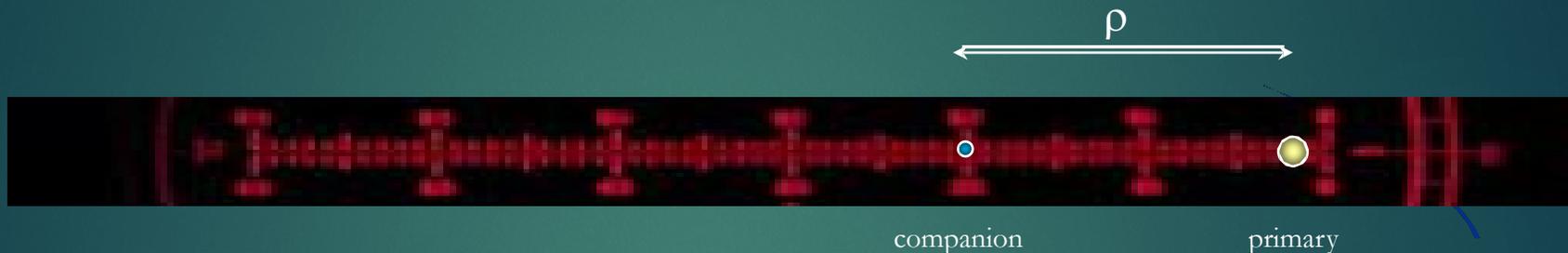
Adapted from Southern Astronomical Delights © [Andrew James](#) (2005)

Calibration of a Reticle Eyepiece



A reticle eyepiece's linear scale can be calibrated by timing the drift of a star. Each division in the scale can then be related to a number of arc-seconds which can be used to measure the separation between the primary and companion star.

Measuring Separation



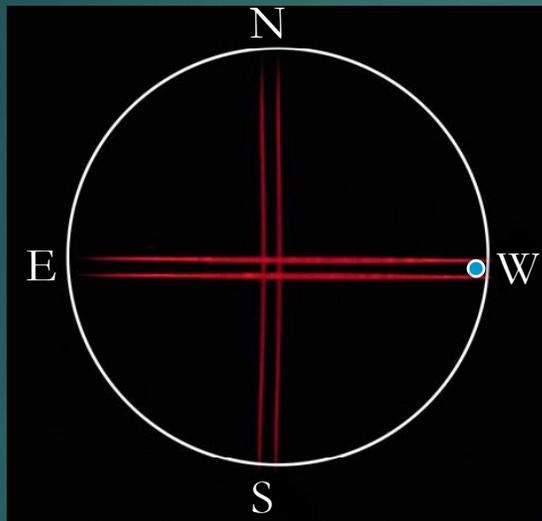
- The brightest star is called the primary and the corresponding star the companion
- The separation ρ can be calculated by multiplying the number of divisions by the number of arc seconds per division determined during calibration

Orientation of FoV

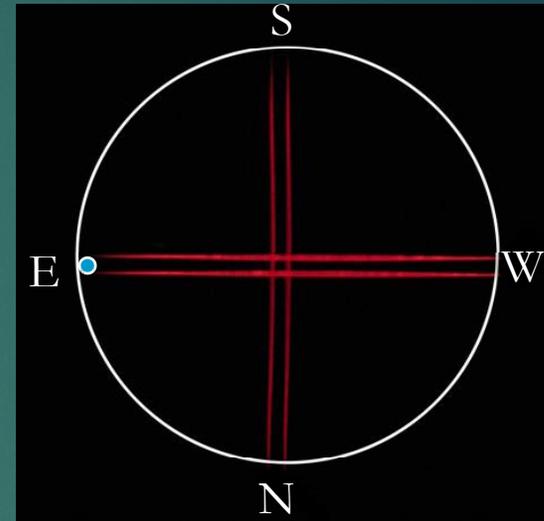
- Measuring position angle requires knowledge of the orientation of the eyepiece field of view
- This can be determined using the following facts
- Objects drift out of the West side of the eyepiece; East is 90° clockwise from North in a mirror image, odd no. of mirrored surfaces; East is 90° counterclockwise from North for an even no. of mirrored surfaces
- This can be done by observing the motion of stars against the linear scale eg. rotate eyepiece until the path coincides with the scale

Orientation of FoV

Northern Hemisphere Views



Telescope with a star diagonal.



Newtonian view or refractor
without diagonal

Observing star drift you can determine the West orientation as stars drift out the West side of the view. Rotate the eyepiece so stars drift along the East-West lines of the reticle. You can determine North-South using the guide above.

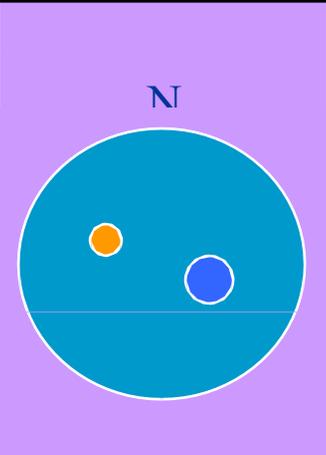
Measuring Position Angle



Each division of the protractor view is 10 degrees. The position angle is measured counter clockwise from a line drawn from the primary star in the North direction to a line drawn from the primary to its companion star. In this example $P_a = 310$ degrees

Recording Observations

Date	Time	Object		
Instrument	Seeing Conditions	Colours	Magnification	
Description				

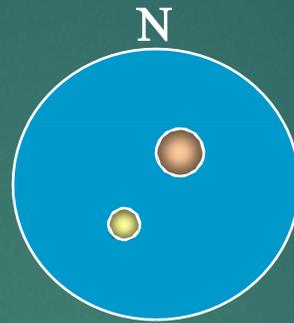


The diagram shows a circular field of view on a purple background. At the top of the circle is a white 'N' indicating North. Inside the circle, there are two stars: a larger orange star on the left and a smaller blue star on the right. A horizontal white line bisects the circle.

Based on Double Star Club Observation Log Sheet

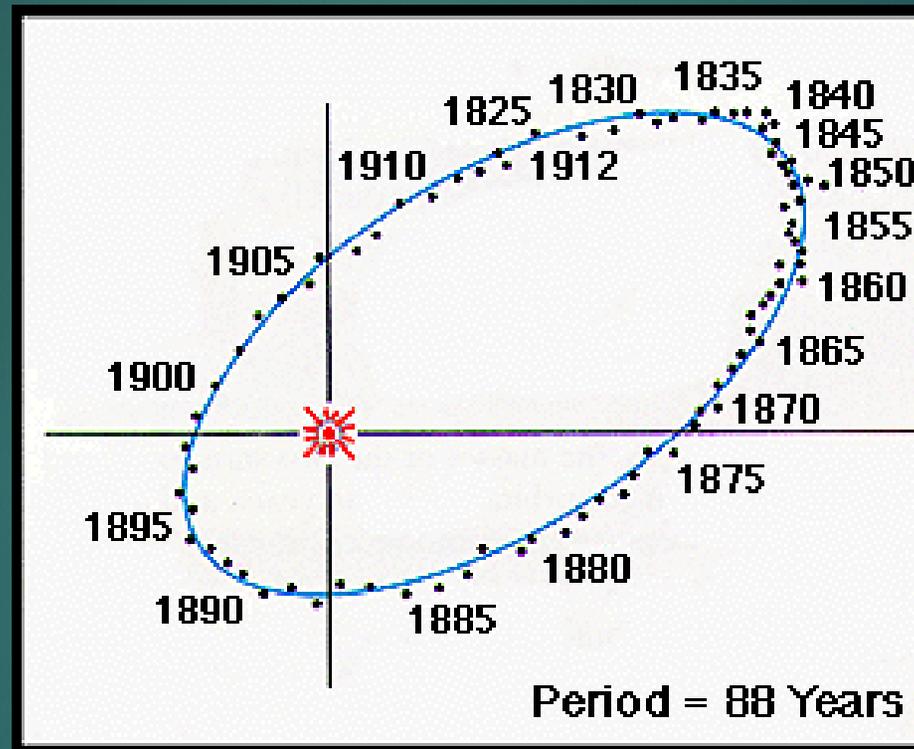
- Date, time, separation, magnitudes, colours, position angle
- Weather, observing conditions, optics, magnification required to split double star

The Sketch or Image



- Along with the textual data you will want to add a visual record of your observation
- This can be as simple as a sketch or a photographic image of the double
- Many observers have created hybrid records by sketching in the field and creating illustrations later with software such as Photoshop

Extended Projects – Orbital Plots



From NASA's Imagine the Universe Website

Resources

Websites

- The Astronomical League Double Star Club
<http://www.astroleague.org/al/obsclubs/dblstar/dblstar2.html>
- Sky and Telescope Article on Double Star Observing
<http://www.skyandtelescope.com/observing/objects/doublestars/3304341.html>
- Journal of Double Star Observations <http://www.jdso.org/>
- Binary Star (wiki) http://en.wikipedia.org/wiki/Binary_star
- The Washington Double Star Catalog
<http://ad.usno.navy.mil/wds/>
- The Spirit of 33 - <http://www.carbonar.es/s33/33.html>
- The Webb Deep Sky
<http://www.webbdeepsky.com/notes/doublest01.html>

Resources

Books

- Double and Multiple Stars and How to Observe Them – James Mullaney (2005)
- StarList 2000: A Quick Reference Star Catalog for Astronomers – Richard Dibon-Smith (1992)
- The Cambridge Encyclopedia of Stars – James Kaler (2006)
- Sky and Telescope's Pocket Sky Atlas – Roger W. Sinnott (2006)
- Burnham's Celestial Handbook Volumes I-III– Robert Burnham Jr. (1978)
- Finder Charts of Select Double Stars – Brent Watson (2002)
- Binary and Multiple Systems of Stars – Alan Batten (1973)
- The Binary Stars - Robert G. Aitkens (1964)
- Observing Visual Double Stars – Paul Couteau ; translation by Alan Batten (1978)

Resources



Software

- The Sky – Software Bisque
- SkyTools 2 – Skyhound
- Starry Night – Imaginova
- AstroPlanner – Ilanga
- Washington Double Star Catalogue – U.S. Naval Observatory