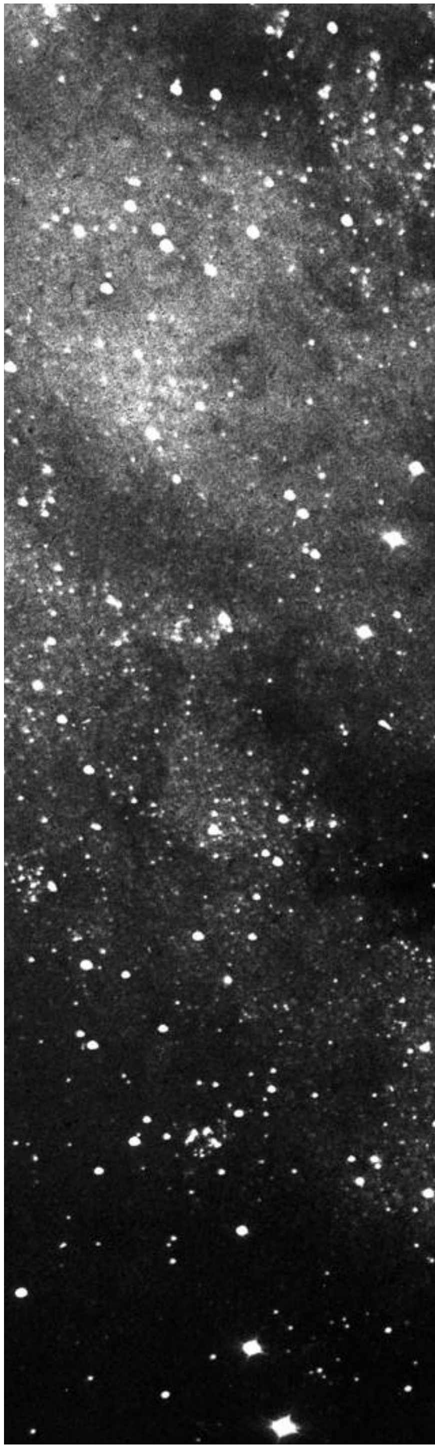
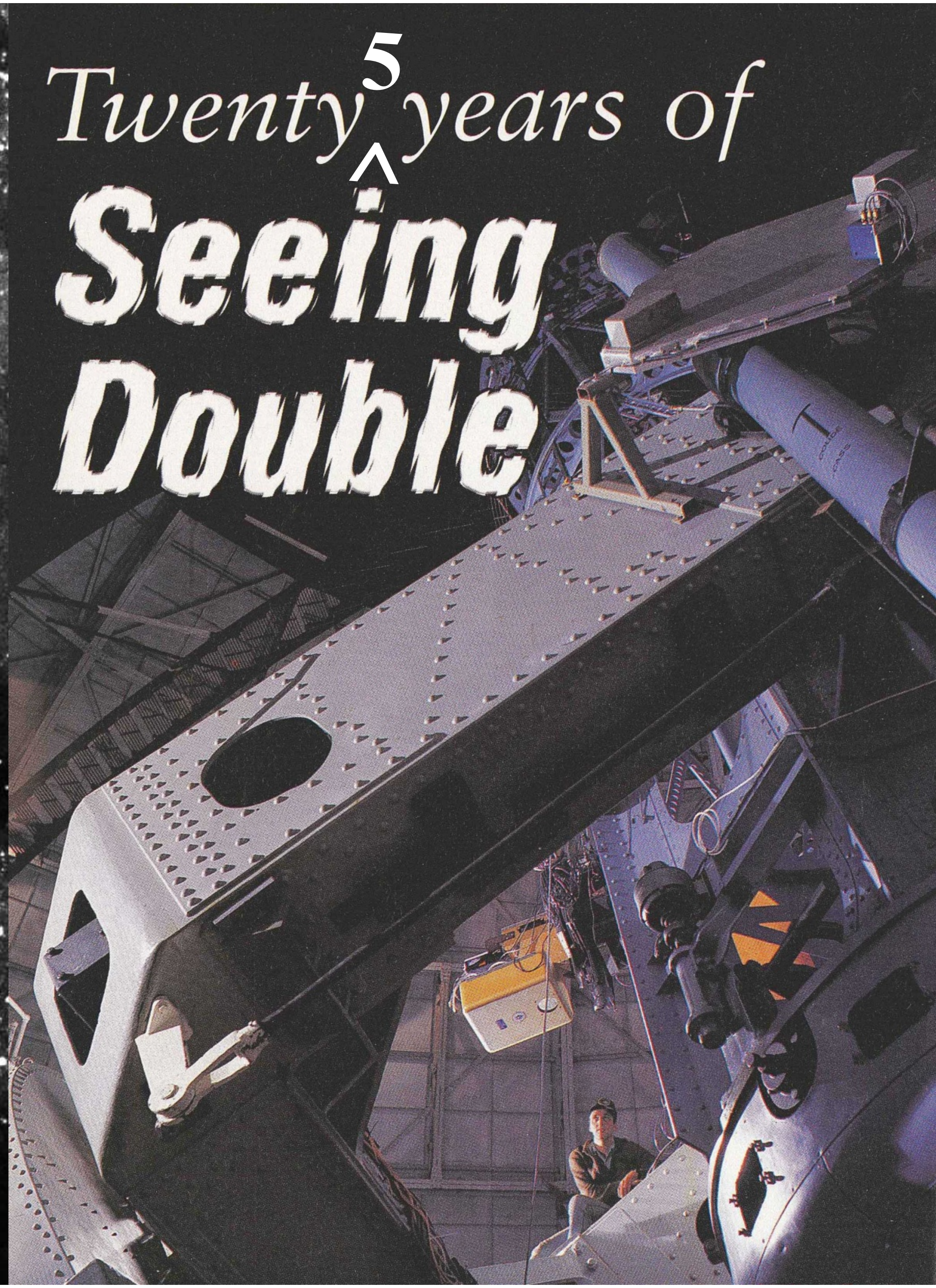




Twenty 5 years of
Seeing
Double

Why Study Binary Stars?

- **Stellar Mass Determination:**
  - **Binary star orbits provided the only means for direct, fundamental determination of stellar mass.**
  - **"Vogt' s Law" – *The entire course of evolution of a star is determined by its initial mass and chemical composition.***
  - **Current challenge is to determine masses of high accuracy (better than 1%) and for stars of all masses & evolutionary states.**

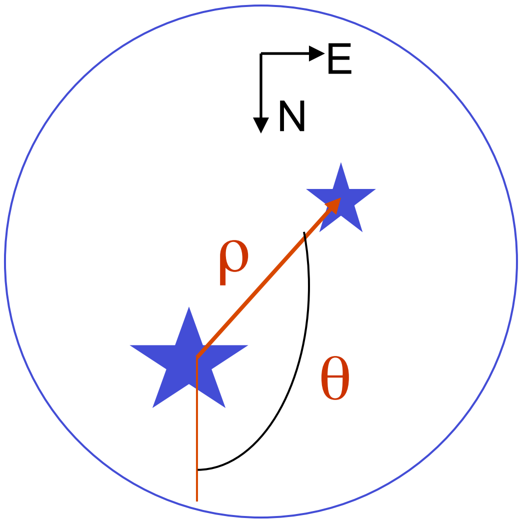
- **Duplicity/Multiplicity Determinations:**
  - **What fraction of stars are non-single?**
  - **How does this relate to planets (and even life in the Universe!)**

- **Star Formation Processes:**
  - **What is different, if anything, in the formation of single rather than binary stars?**

- **It is also challenging and fun!**

Double Star Astronomy has a Venerable History

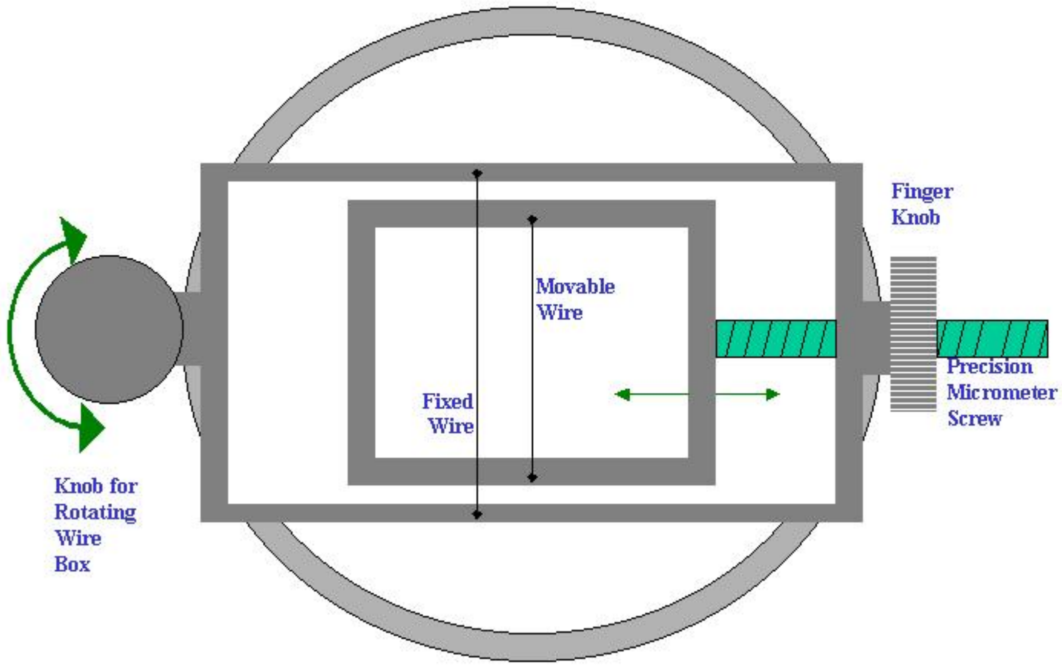
Friedrich Georg Wilhelm Struve (1793-1864) published *Mensurae Micrometicae* in 1837 as the first systematic program of discovery and synoptic observation to deduce orbital motion. He introduced the use of (θ,ρ) as standard measured quantities for binary stars.



Used the 9-inch Fraunhofer refractor at the Dorpat Observatory in Russia (Estonia) to discover 3134 pairs.

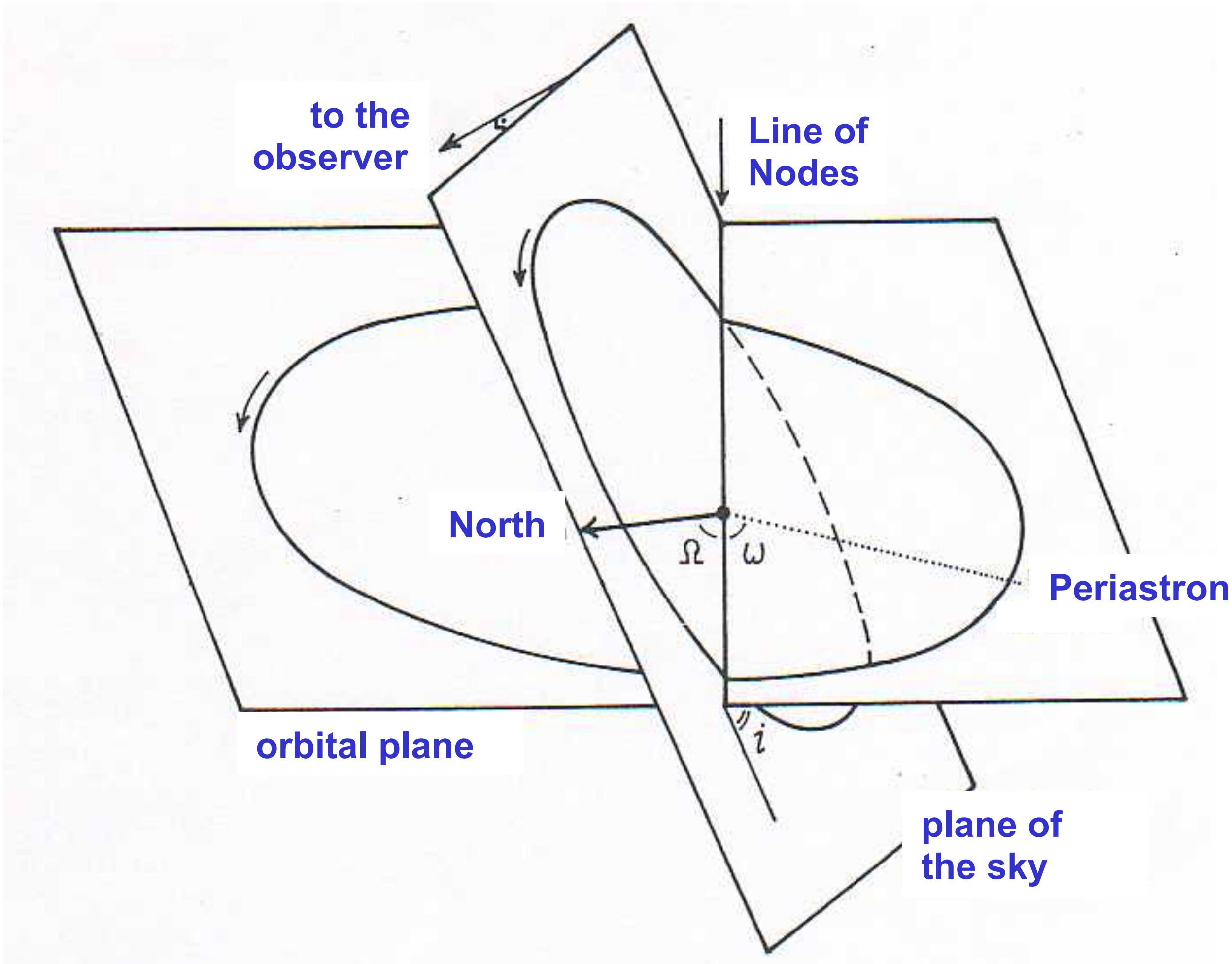
Nine-inch refractor by Fraunhofer on display at the Deutsches Museum in Bonn (identitical to that used by Struve)

The Filar Micrometer for Visual Measurement



- Micrometer screw provides angular separation measure while rotation know provides position angle measure. Micrometer threads often employed spider webs.
- Traditionally both motions measured against ruled scale, but encoders are better. (Worley was the first to take that approach.)

Orbit Geometry



From Heintz' Double Stars

"Modern" Era I.

Sherburne Wesley Burnham (1838-1921) was a court reporter who possessed a keen interest in double stars and observed at Dearborn, Washburn, Lick and Yerkes Observatories. Starting in 1870, he eventually discovered 1,336 doubles. He specialized in discovering "close" pairs (ρ as small as 0.2 arcsec) and large Δm pairs. In 1906, he published *A General Catalogue of Double Stars Within 120° of the North Pole,* containing measures and notes for 13, 665 star. (Typically referred to as the "BDS" catalog.)

"Modern" Era II.

Robert Grant Aitken (1864-1951) joined Lick Observatory in 1895 and served as Director during 1930-35. Aitken initiated a survey for duplicity of all stars north of $\delta = -22^{o}$ that resulted in 4,400 new pairs, 3,100 of which he discovered. In 1932, he published *A New General Catalogue of Double Stars Within 120° of the North Pole* with 17,180 entries (*The ADS Catalog*). His book *The Binary Stars* (1935 with several Dover reprints) is a classic of the field.

"Modern" Era III.

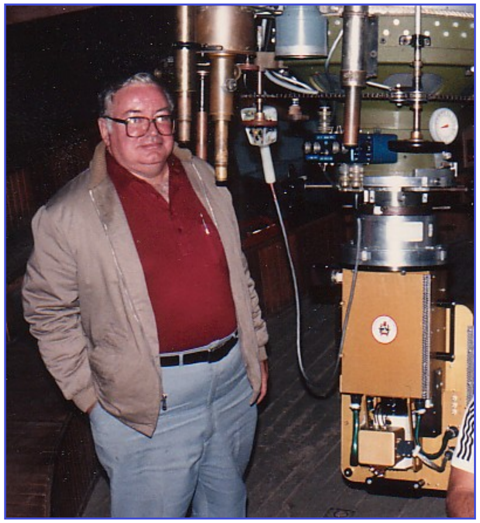
Gerard Kuiper – Discovered 117 very close pairs at Lick (1934)

Robert Jonckheere (1888-1974) – Discovered 2,000 faint, distant binaries from Marseille in 1941-45.

George Van Biesbroeck (1880-1974) – Belgian-American who, mostly at Yerkes Observatory, discovered comets, asteroids and double stars.

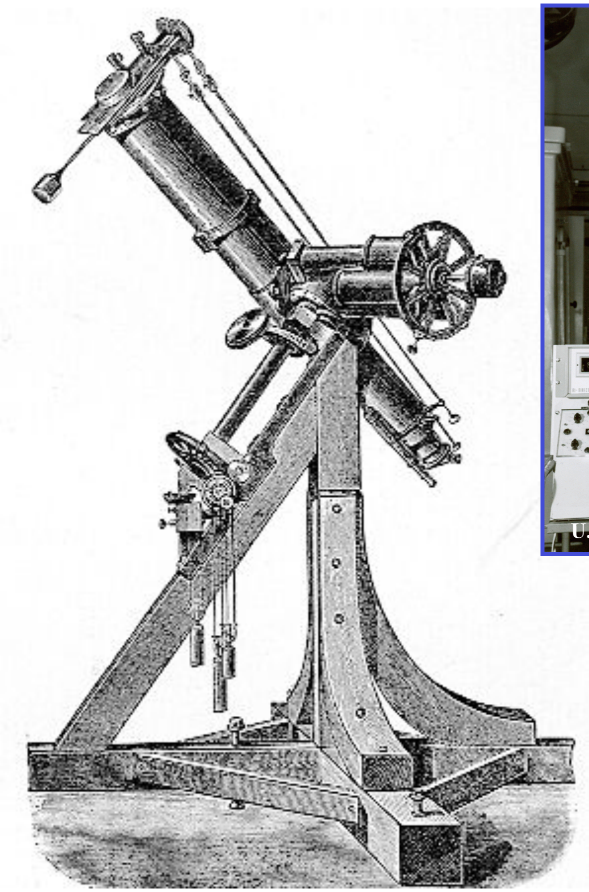
Paul Muller (1910-2000) and Paul Couteau – Initiated a long-term program at Nice discovering fainter binaries (>2,000 new pairs)

Charles Worley (1935-1997) – Surveyed nearby faint dwarfs for companions in 1960 at Lick and went on to observe close pairs at the 26-inch USNO refractor until his death. He converted from visual to speckle techniques recognizing the improved accuracy and resolution of the latter. He transferred the Lick "Index Catalogue" to the USNO and initiated the "Washington Double Star Catalogue" (WDS) which continues today under the direction of Brian Mason (GSU PhD '94)

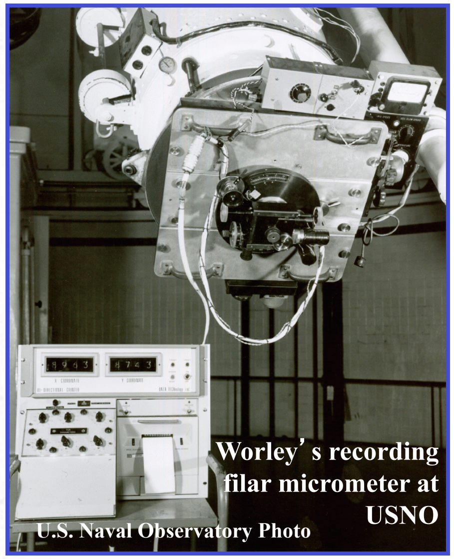


Worley with GSU speckle camera at Lowell 26-inch refractor

Some 19th & 20th C. Double Stars Instruments

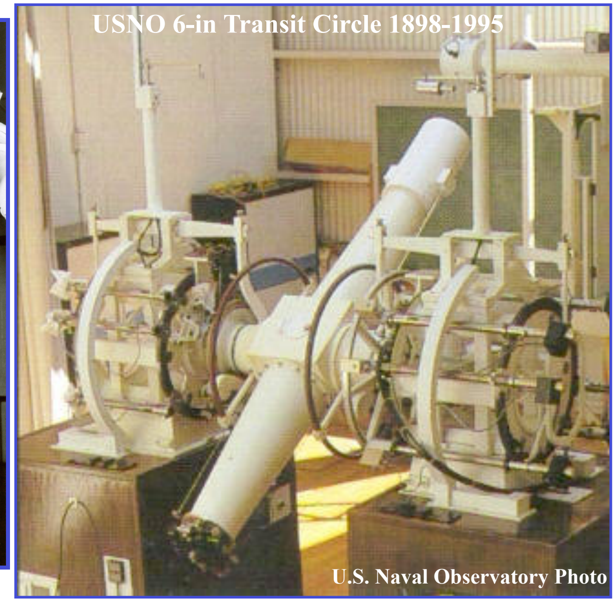


Bessel used the 6-in Koenigsburg heliometer (built by Fraunhofer) to visually measure the offset of 61 Cyg and a reference star.



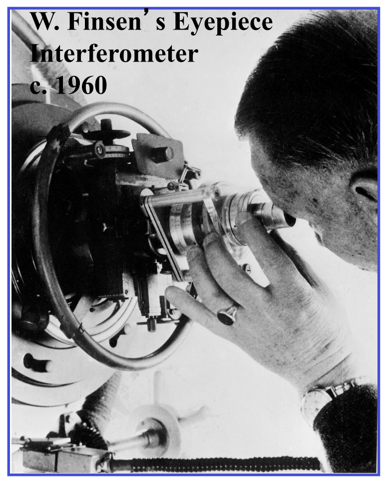
Worley's recording filar micrometer at USNO

U.S. Naval Observatory Photo

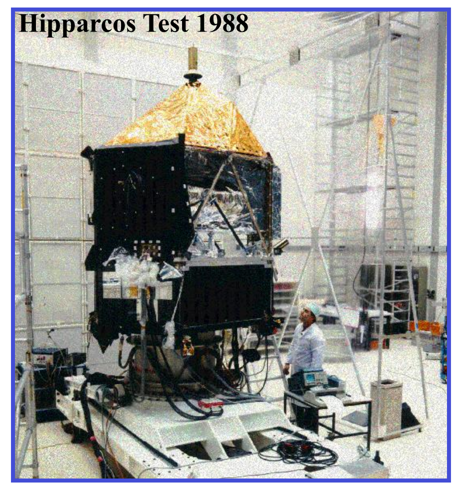


USNO 6-in Transit Circle 1898-1995

U.S. Naval Observatory Photo



W. Finsen's Eyepiece Interferometer c. 1960



Hipparcos Test 1988

ESA Photo

“Modern” Era IV.
Speckle Interferometry Arrives on the Scene

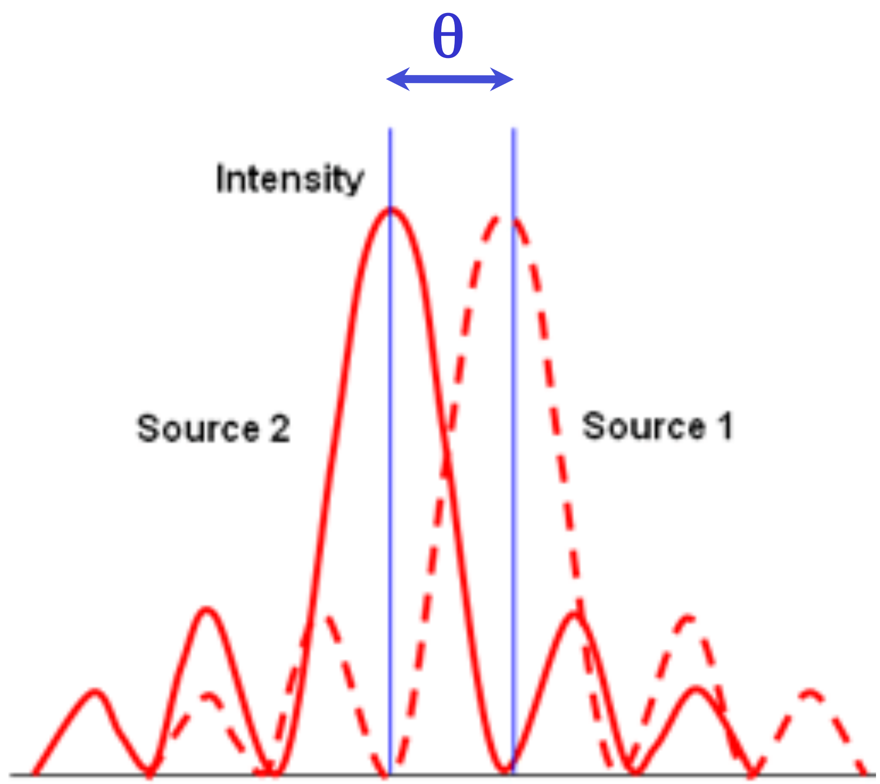
Antoine Labeyrie (1943-present) **introduced the new technique of speckle interferometry in a landmark paper (A&A, 6, 85, 1970) in which he showed how one could achieve diffraction-limited resolution at large telescope through Fourier analysis of short-exposure images. Labeyrie was a graduate student when he “invented” speckle interferometry.**

On the occasion of Labeyrie receiving the Franklin Medal in Philadelphia (April 2002). Deane Peterson (SUNY Stonybrook) and Hal McAlister (GSU) lectured at a special symposium in Labeyrie’s honor.

The Resolution Limit of a Telescope

The Rayleigh Criterion

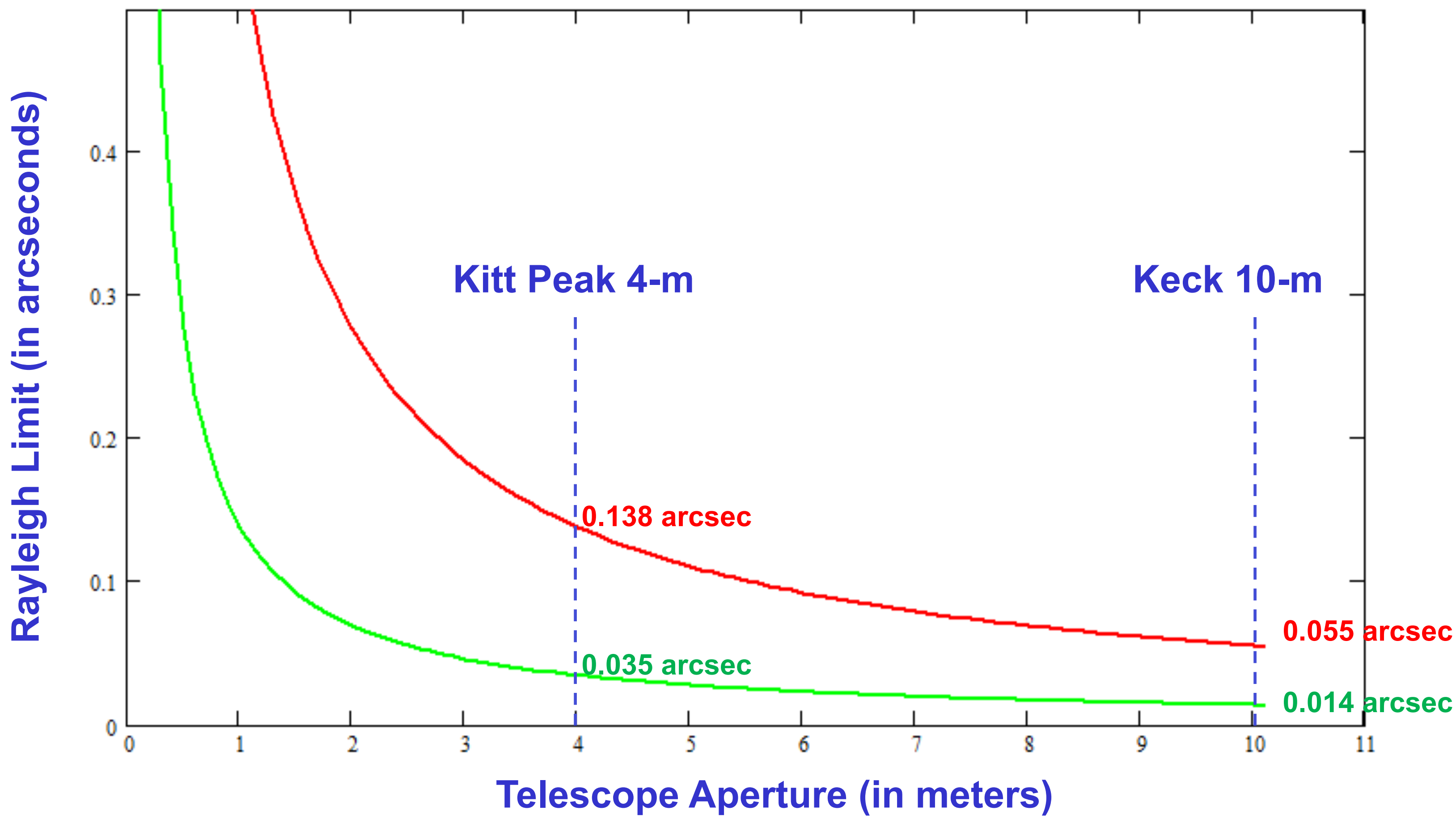
The Airy disk of a perfect telescope



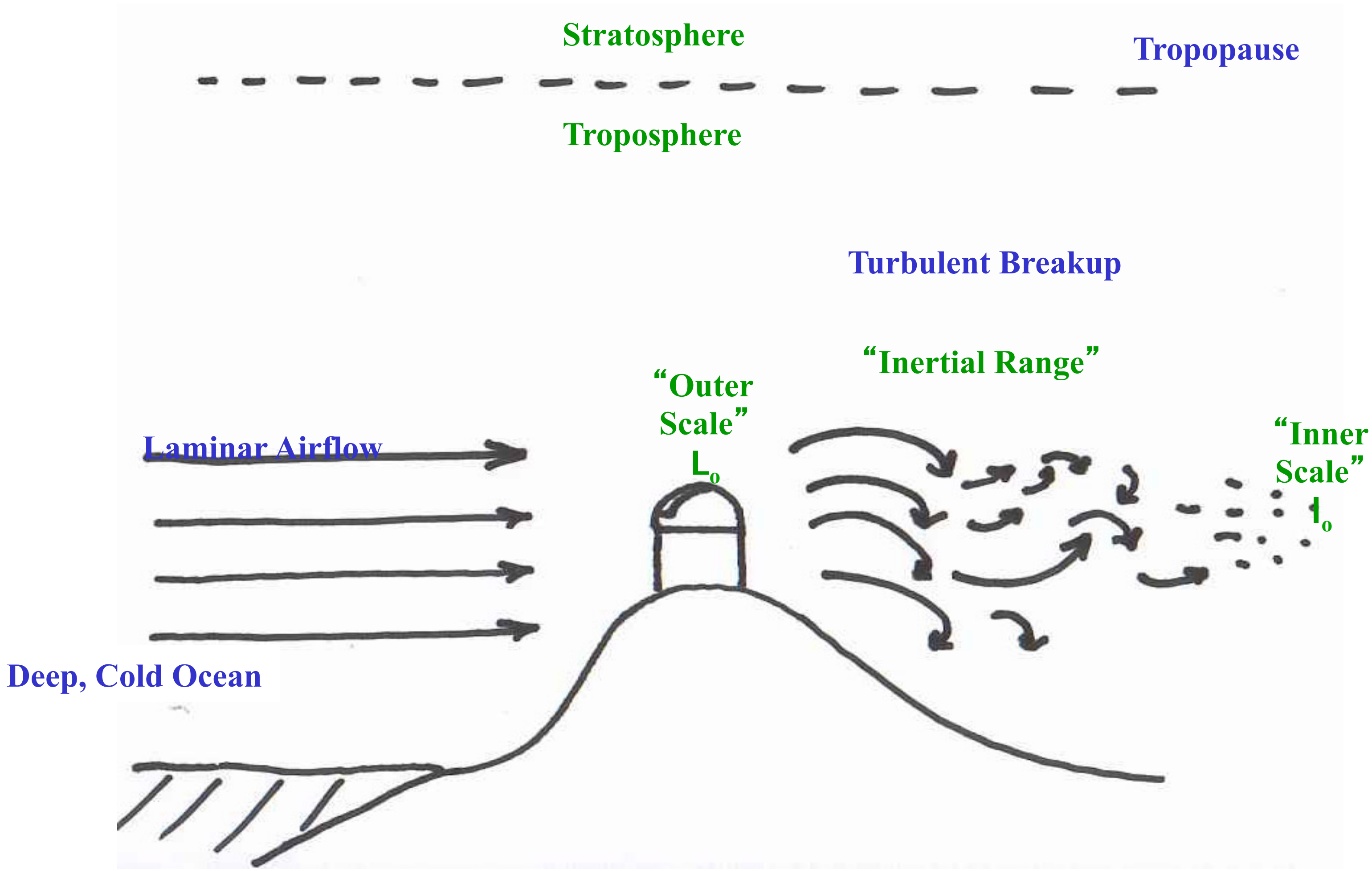
$$\theta = 1.22 \times \frac{\text{wavelength}}{\text{aperture}}$$

The Resolution Limit of a Telescope

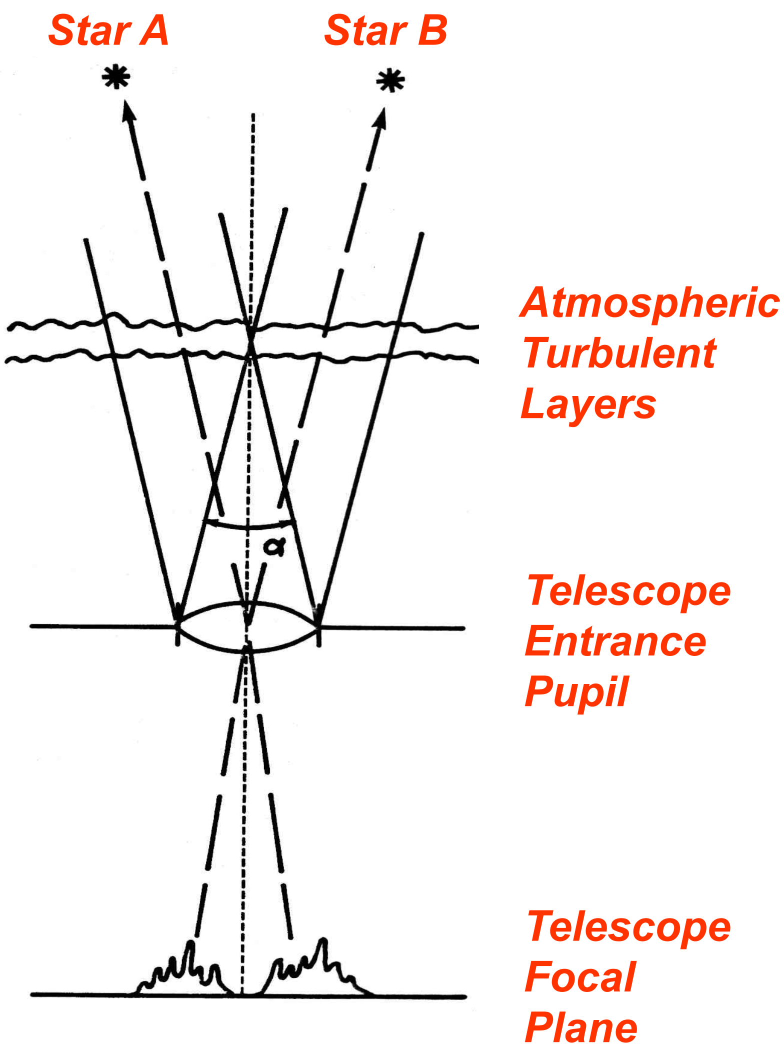
The Rayleigh Criterion

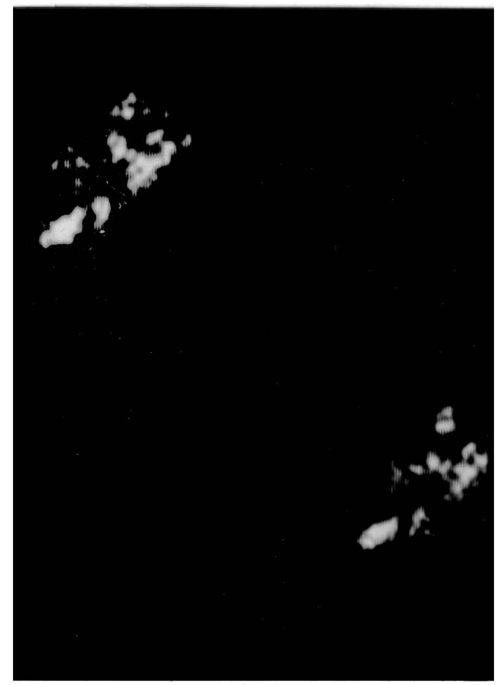


But Atmospheric "Seeing" Thwarts Reaching the Rayleigh Limit



Atmospheric Isoplanatism





ADS 11483
G2V+G2V, 1985.51, Sep = 1.74 arcsec
GSU Speckle Camera @ CFH Telescope

Real-Time Speckle Imagery

http://ad.usno.navy.mil/wds/ds_history.html

Demonstration of Isoplanicity

Speckle Interferometry Observation of

ADS 8708 (sep. — 1.008 arcsec)

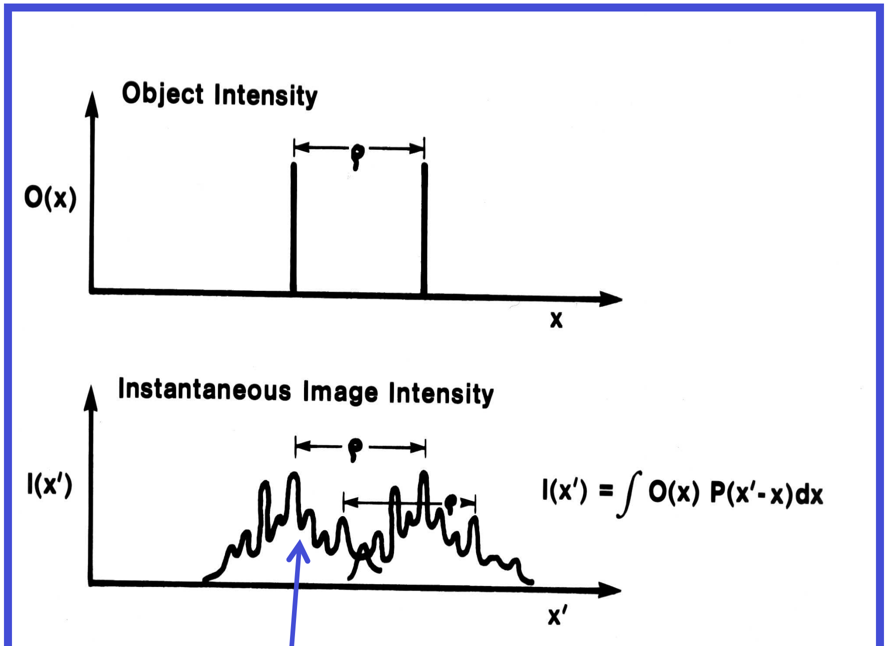
24 February 1995

Hooker Telescope, Mt. Wilson

Speckle Interferometry Basics

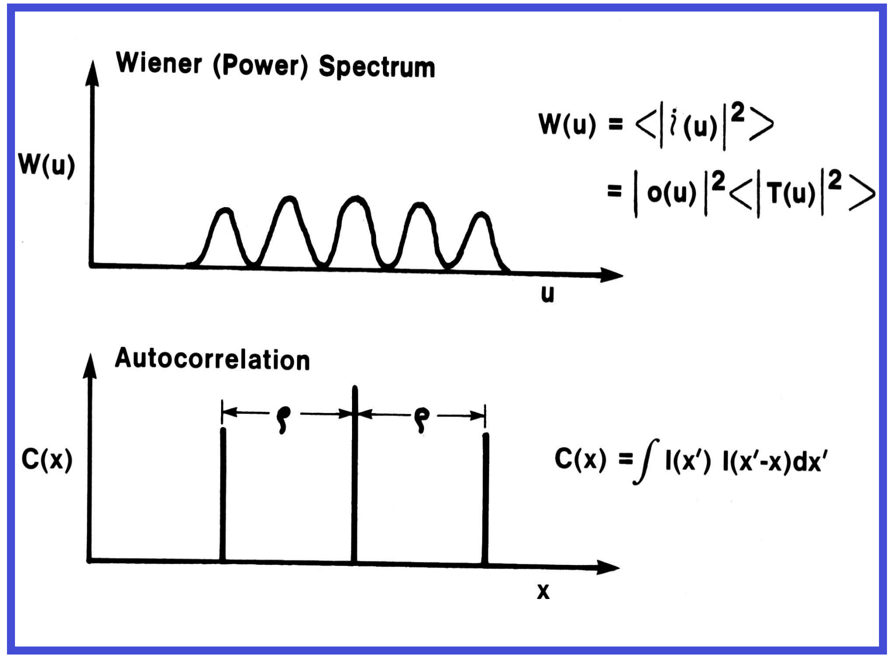
Fourier Analysis

Formation



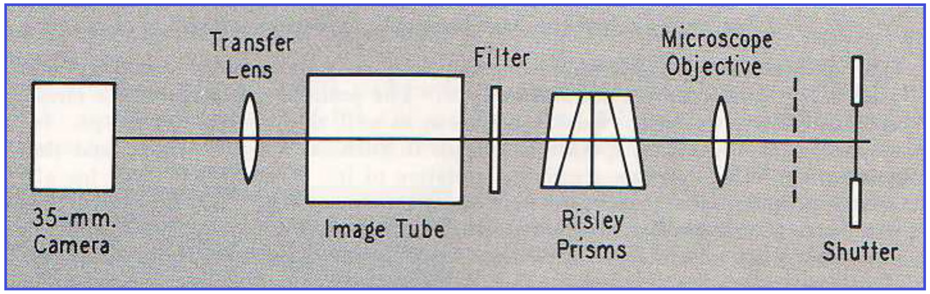
Each “speckle” is a noisy Airy disk

Analysis

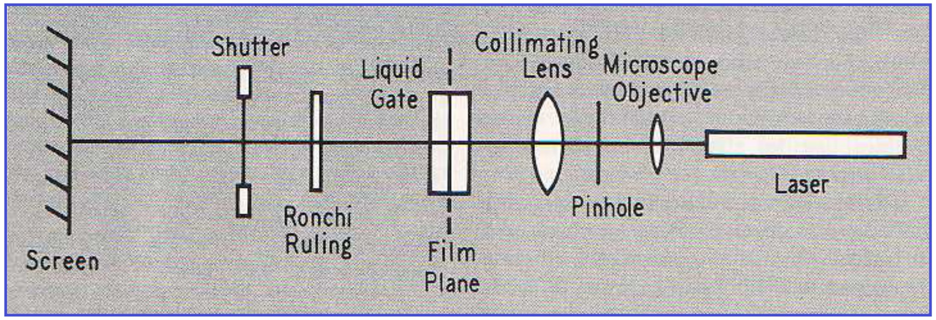


Speckle Interferometry

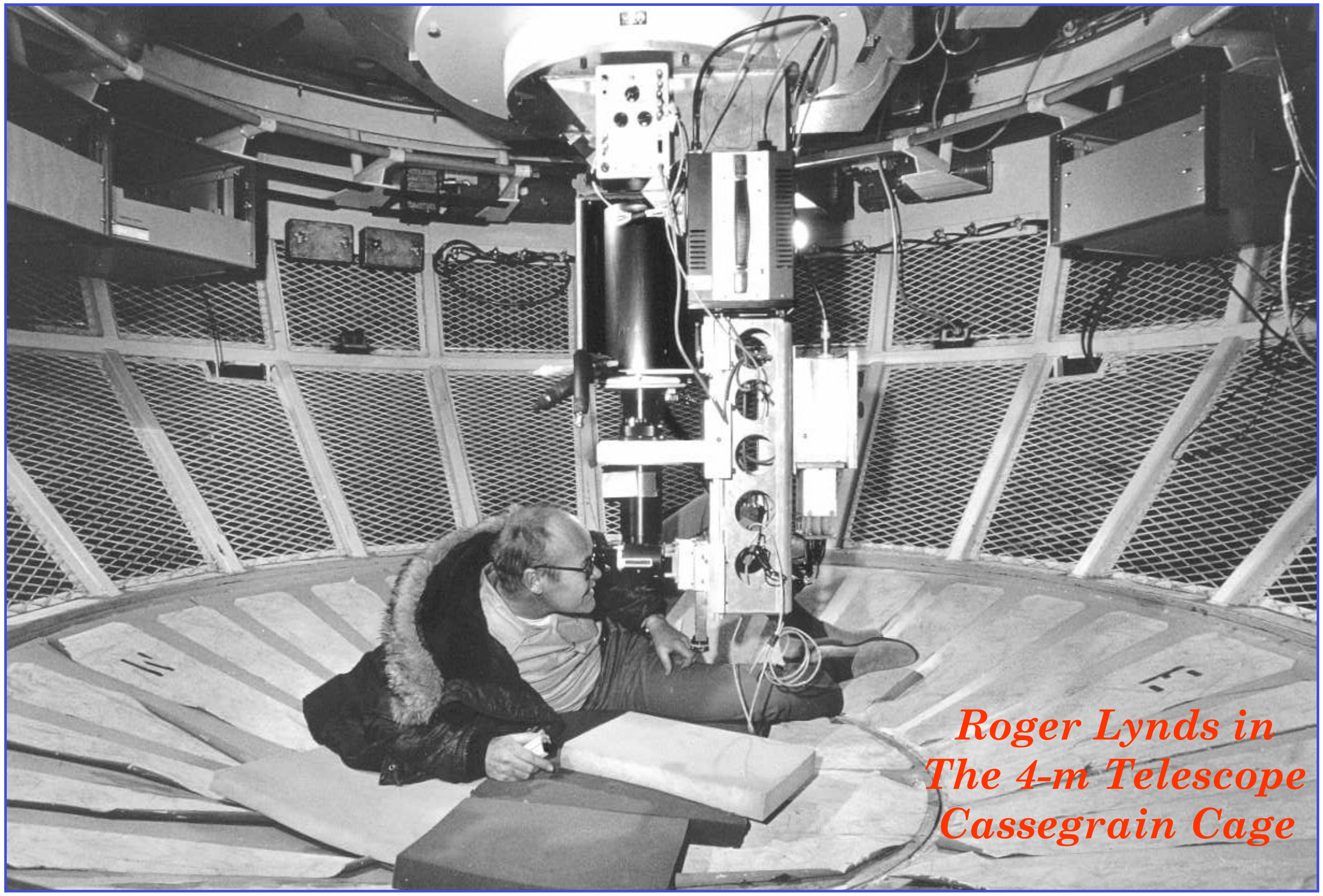
Recording and Processing Film Data



The basic requirements for recording speckle images are: short exposure times to freeze atmospheric turbulence, restricted spectral bandwidth to prevent blurring of speckles, and (for larger telescopes) compensation for atmospheric dispersion. The film data could be Fourier processed using the apparatus shown below.

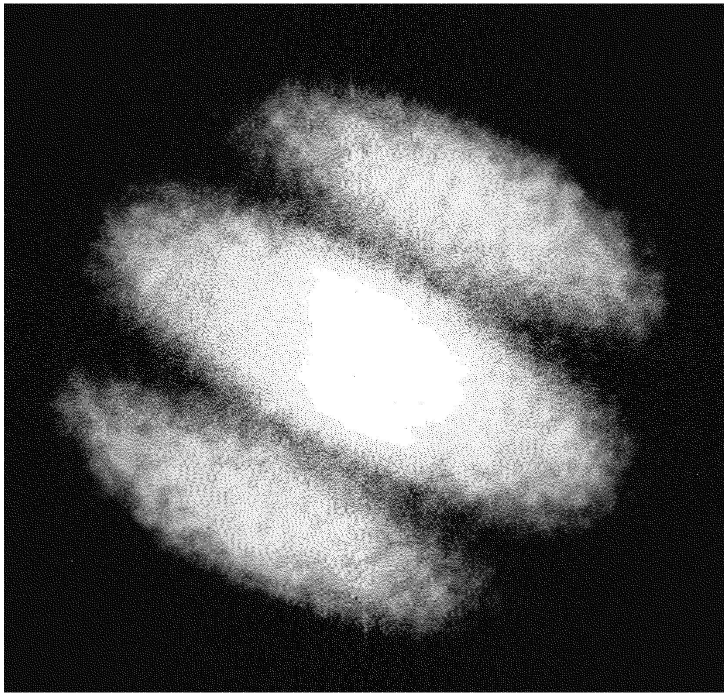


Speckle Interferometry on Kitt Peak, c. 1975

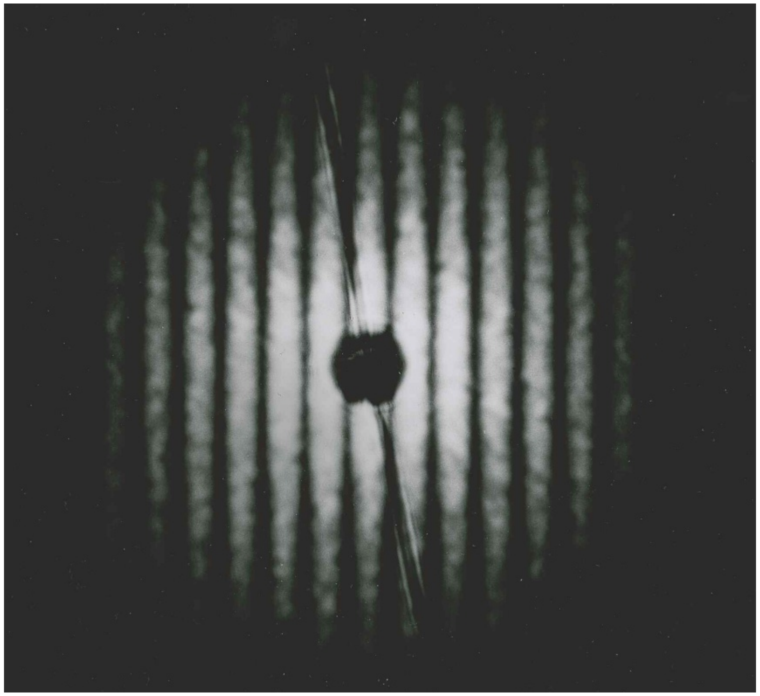


Power Spectra of Close and Wide Binaries

Fringe Spacing is Inversely Proportional to Angular Separation



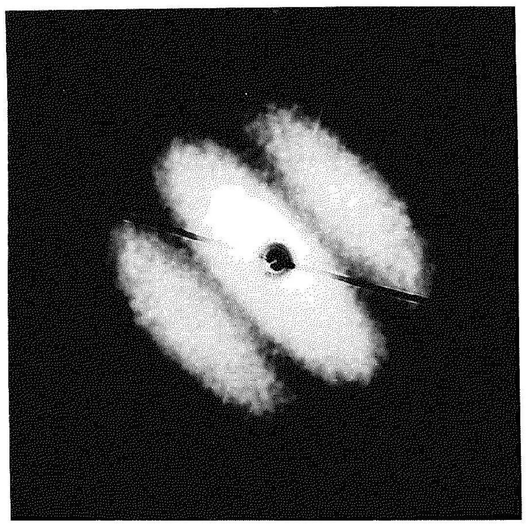
$\rho \approx 0.05$ arcseconds

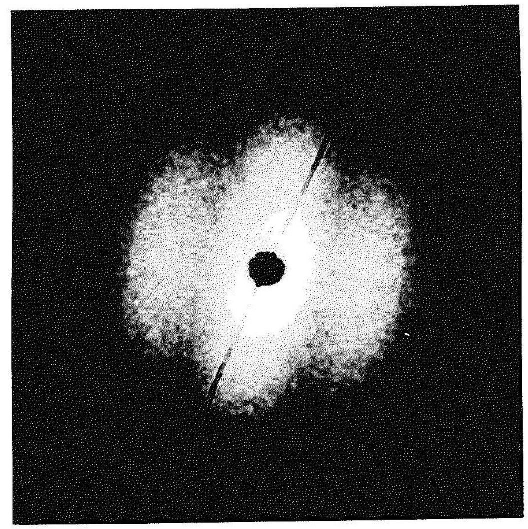


$\rho \approx 0.25$ arcseconds

Orbital Motion in 12 Persei (HR 788)

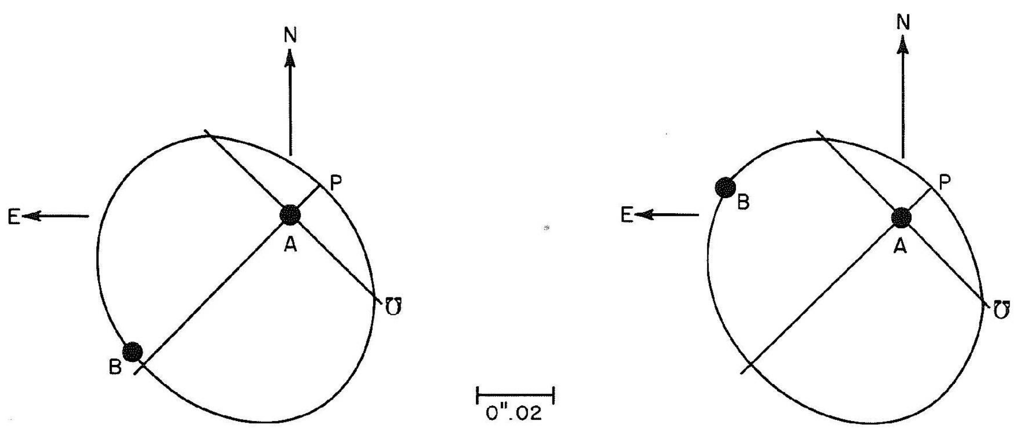
Remember - Fringe Spacing is Inversely Proportional to Angular Separation





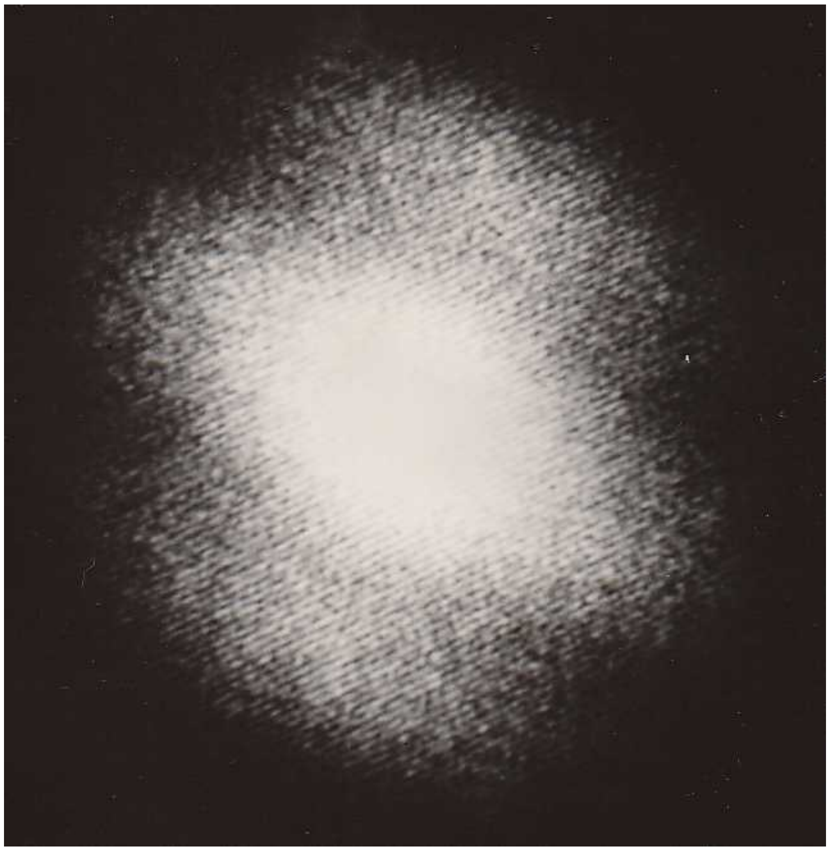
1975.713: ρ = 0.053” θ = 132.8º

1975.960: ρ = 0.048” θ = 85.6º

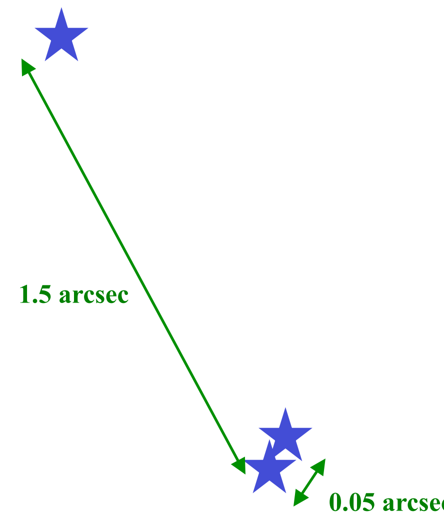


Power Spectrum of Speckle Images of η Orionis

From ~100 speckle frames taken at the KPNO 4-m telescope in 1976

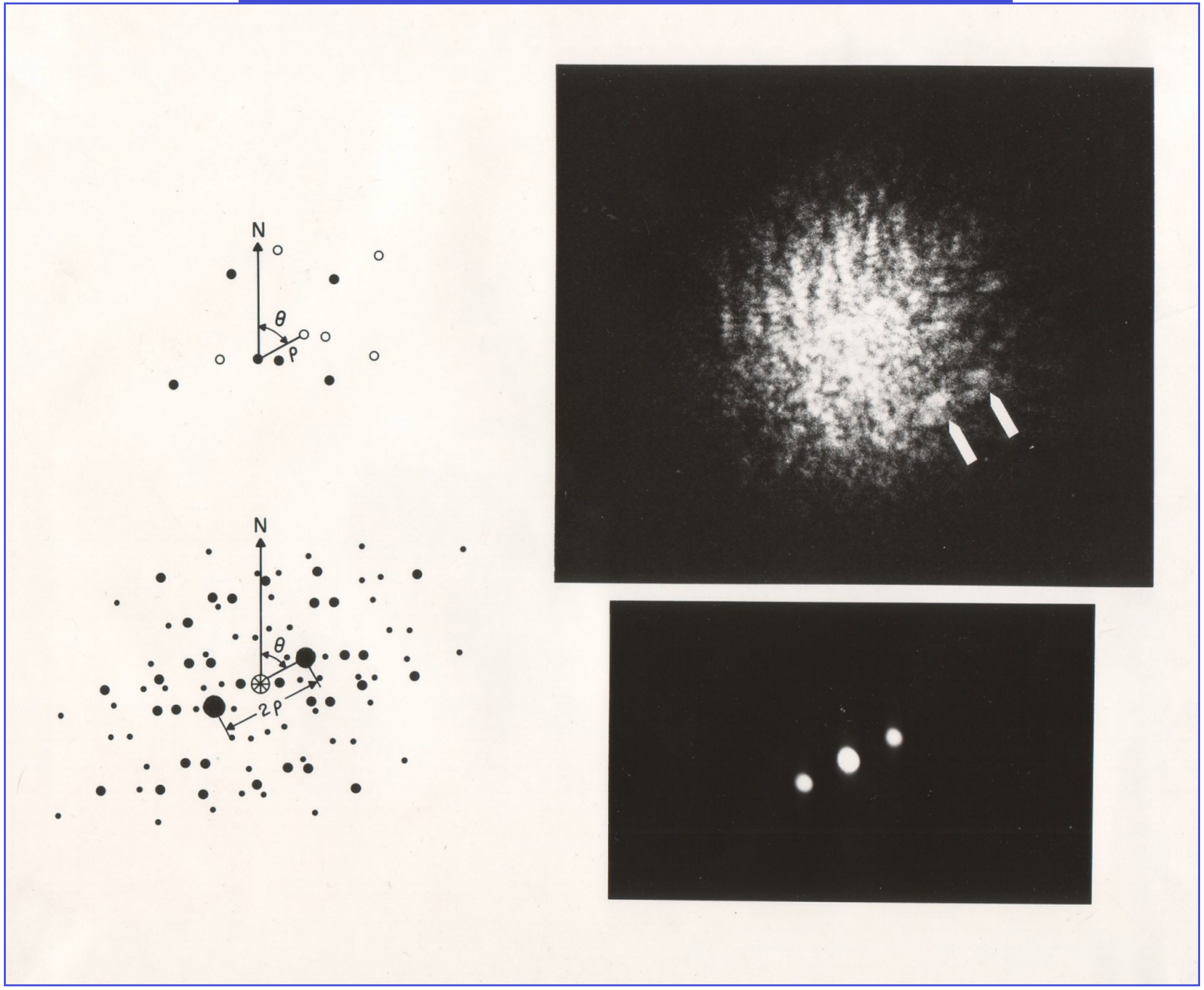


Note that there are two sets of fringes indicating that this is a triple star having the geometry shown below:



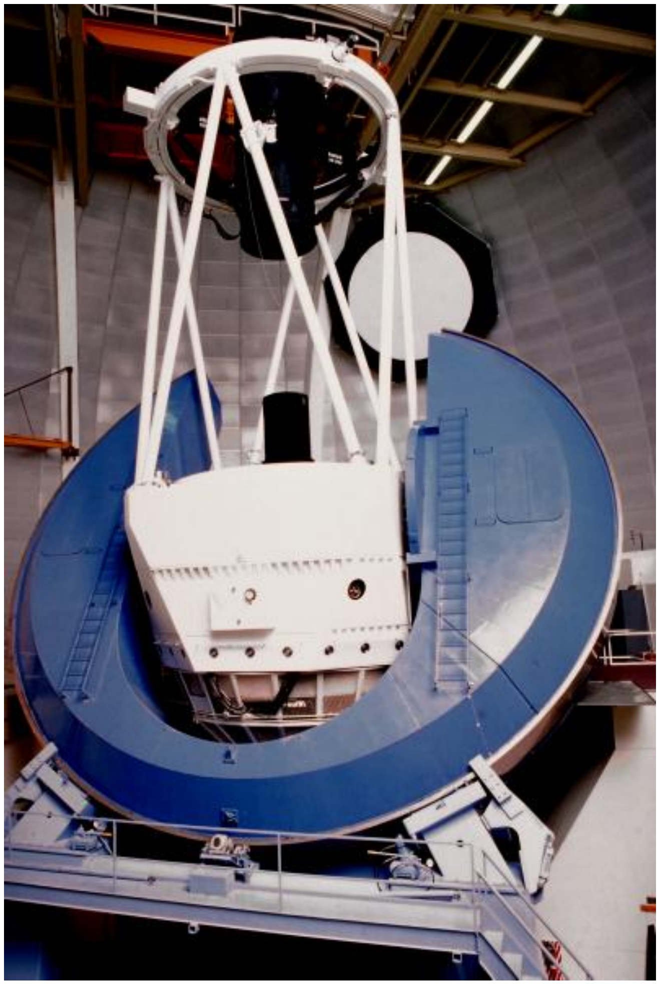
Speckle Interferometry

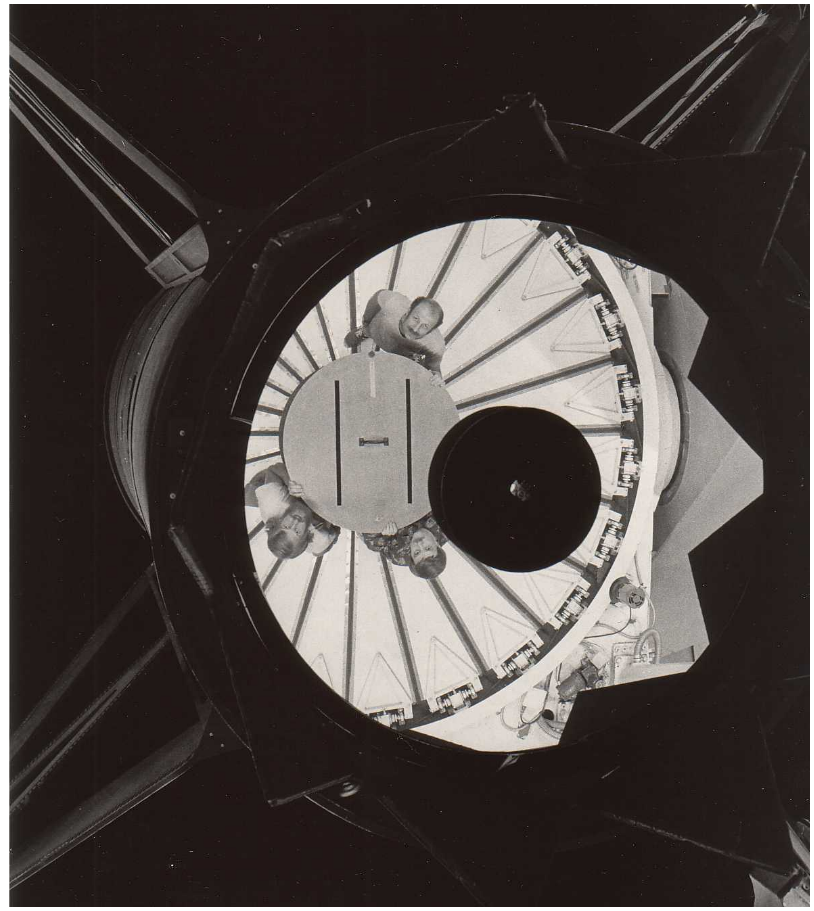
Analog Vector-Autocorrelation



Calibration of Speckle Data at KPNO 4-m Telescope

A double slit mask turns telescope into simple Michelson interferometer (c. 1977)



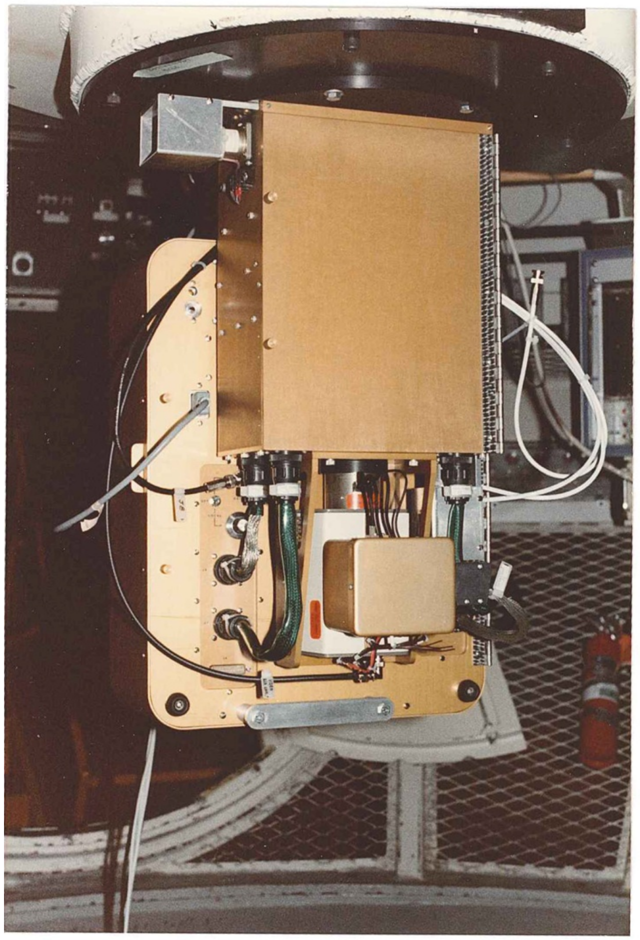


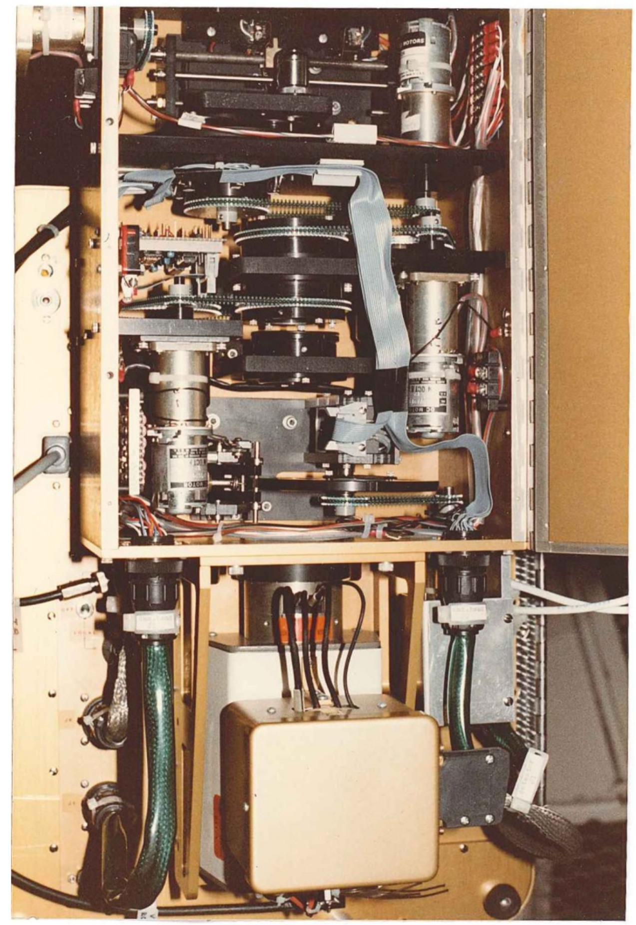
Frank Fekel, Dean Ketelson and Hal McAlister standing on the primary mirror cover looking up into secondary with calibration mask in place.

The CHARA Speckle Camera

An Intensified CCD Replaced Film as the Detector

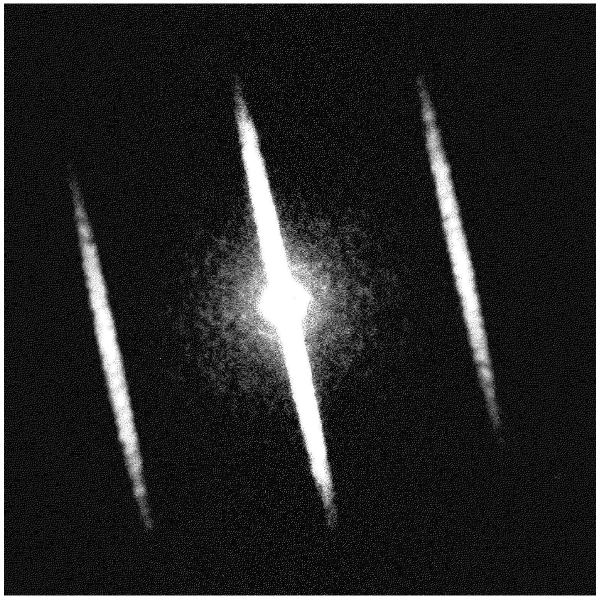
& No more riding in the cage!



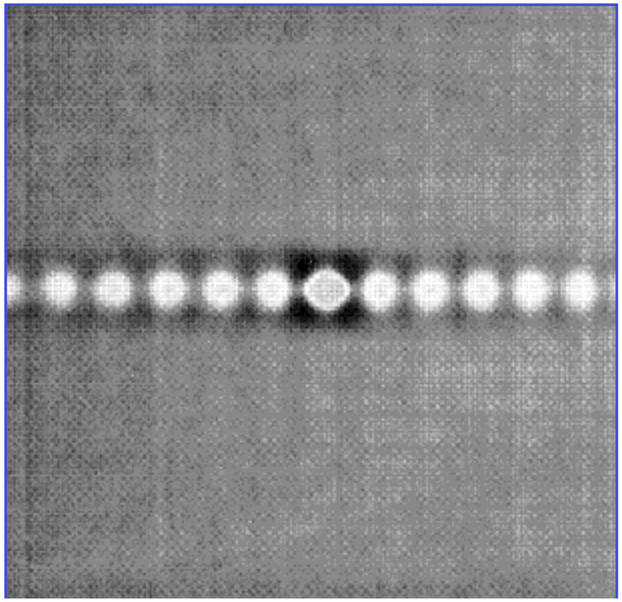


Remotely Controlled Camera Mounted at the KPNO 4-m Cassegrain Focus

Double-Slit Mask Calibration of Speckle Data



Photographic power spectrum of mask data



Digital vector-autocorrelation of mask data

The spacing between peaks in the VAC at left is determined by the slit spacing projected onto the telescope entrance pupil (which means one must know the distance of the mask from the focal plane) and the wavelength of the observation. By measuring the focal length of telescope, one can then determine the scale on the VAC's in arc/sec per pixel.

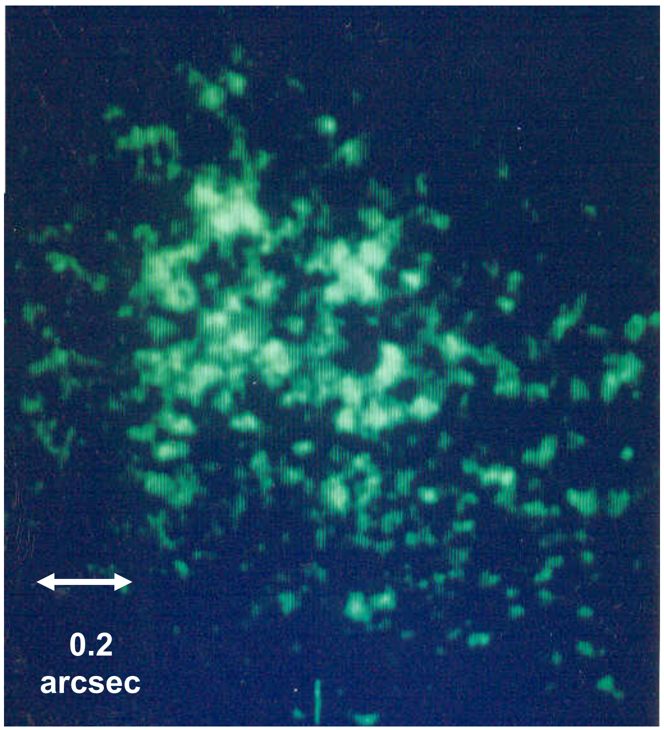
To determine the direction to north, one knows that the peaks in the VAC at left are perpendicular to the long axis of the mask slits. By taking a photographic image at the telescope focal plane of the diffraction pattern from the slit and then trailing a star across the plate with the telescope drive turned off, one can measure by how much the mask deviates from a north-south orientation.

These procedures allowed the calibration of 4-m data to about +/-0.5% in angular separation and +/-0.1 degree in position angle.

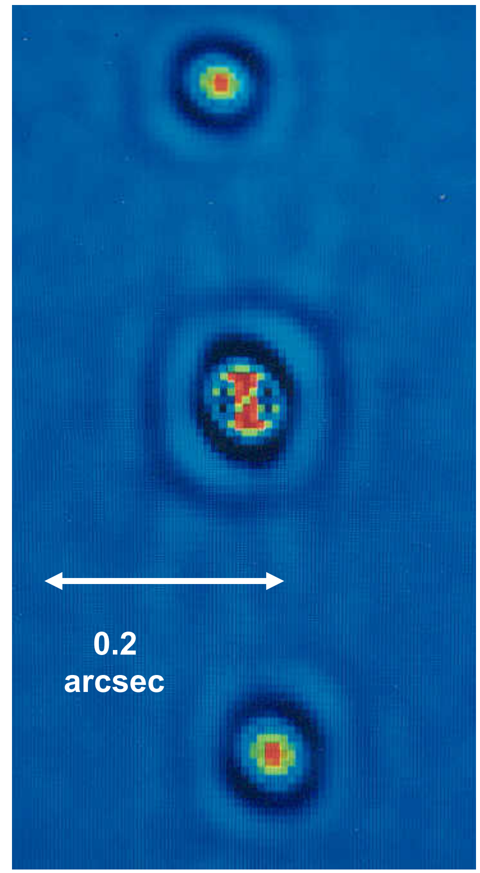
Speckle Interferometry

Digital Processing

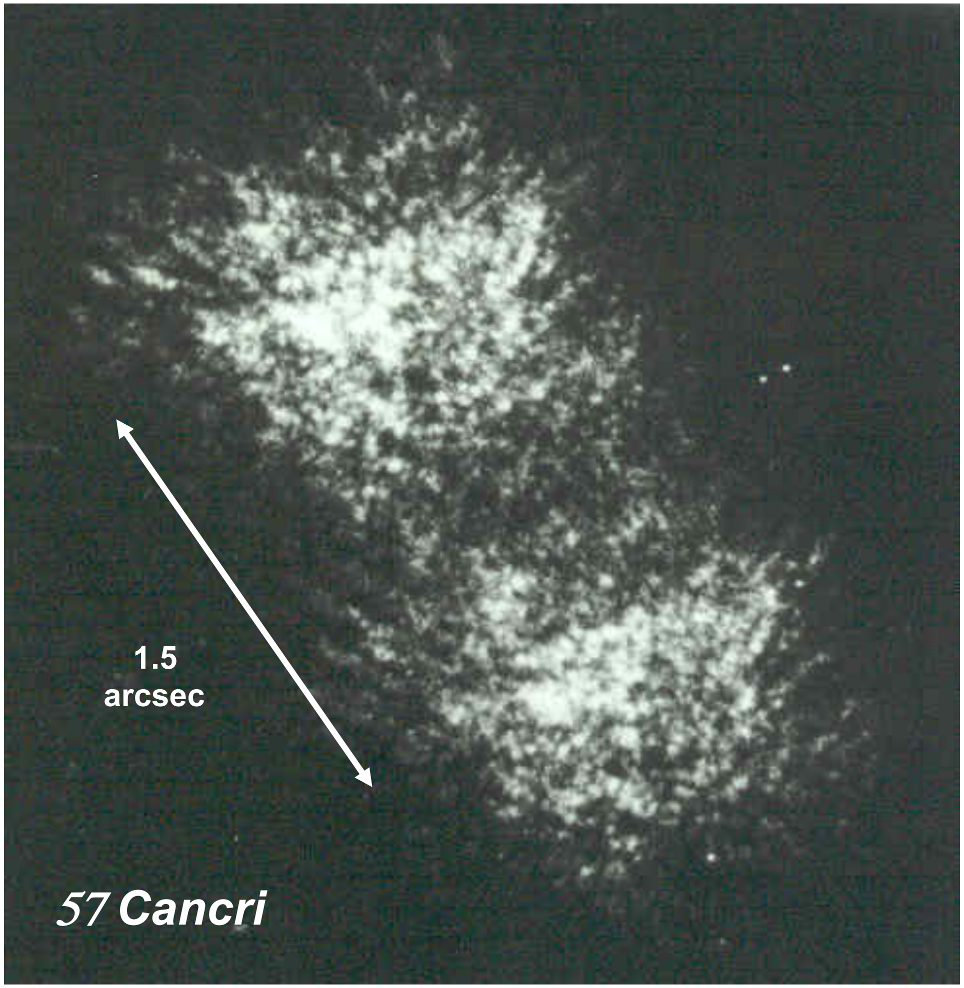
Speckle Frame



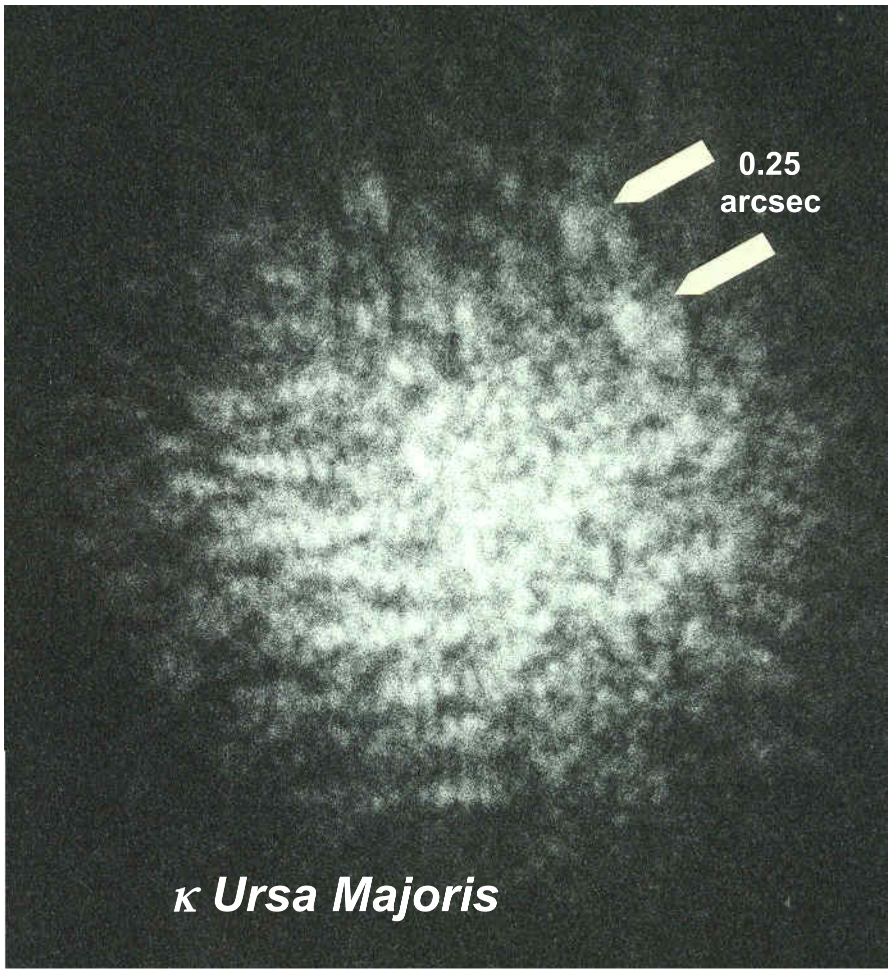
VAC

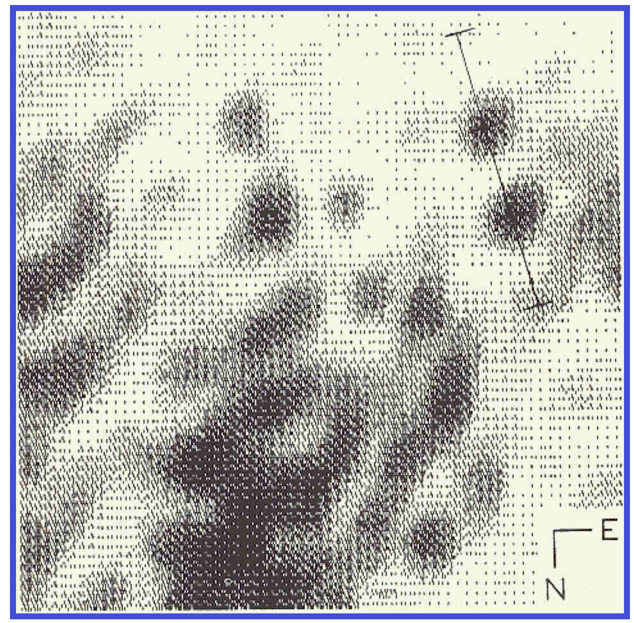


Speckle Image of a “Wide” Binary



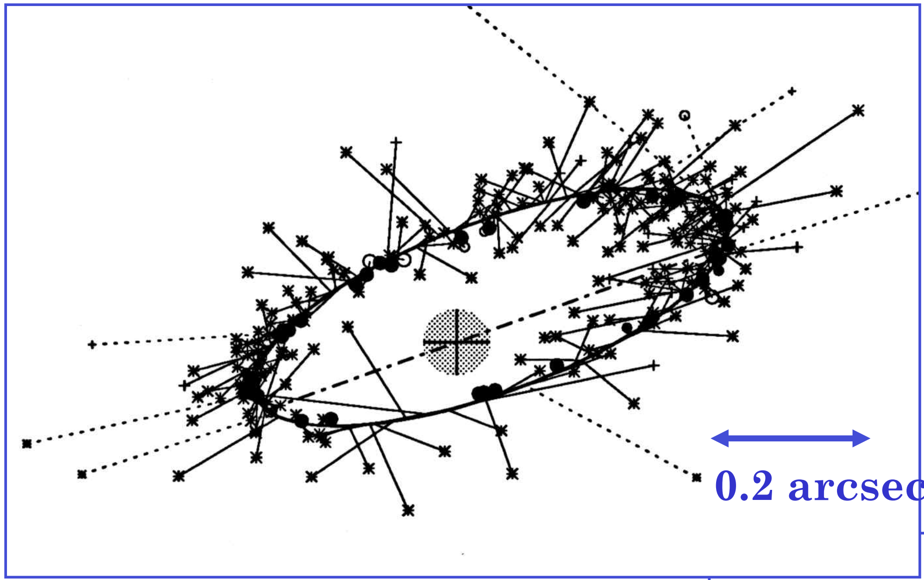
Speckle Images of "Close" Binaries



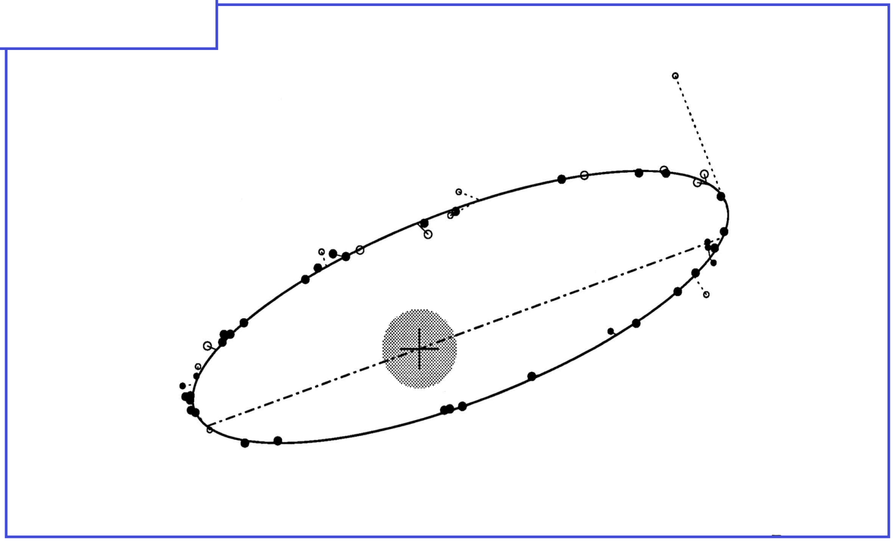


Capella – 0.05 arcsec

Enhanced Measurement Accuracy

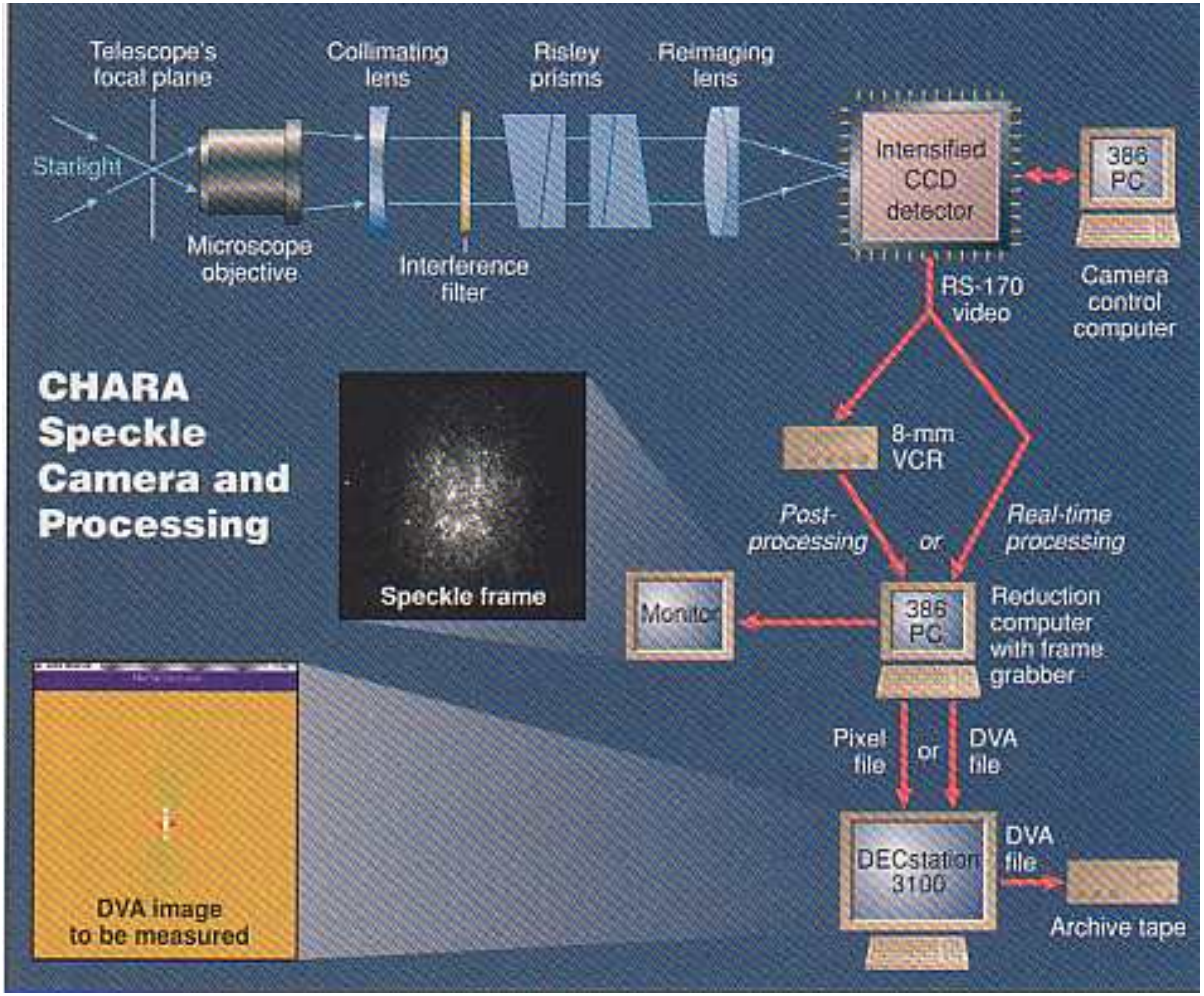


Micrometer Observations of κ Pegasi



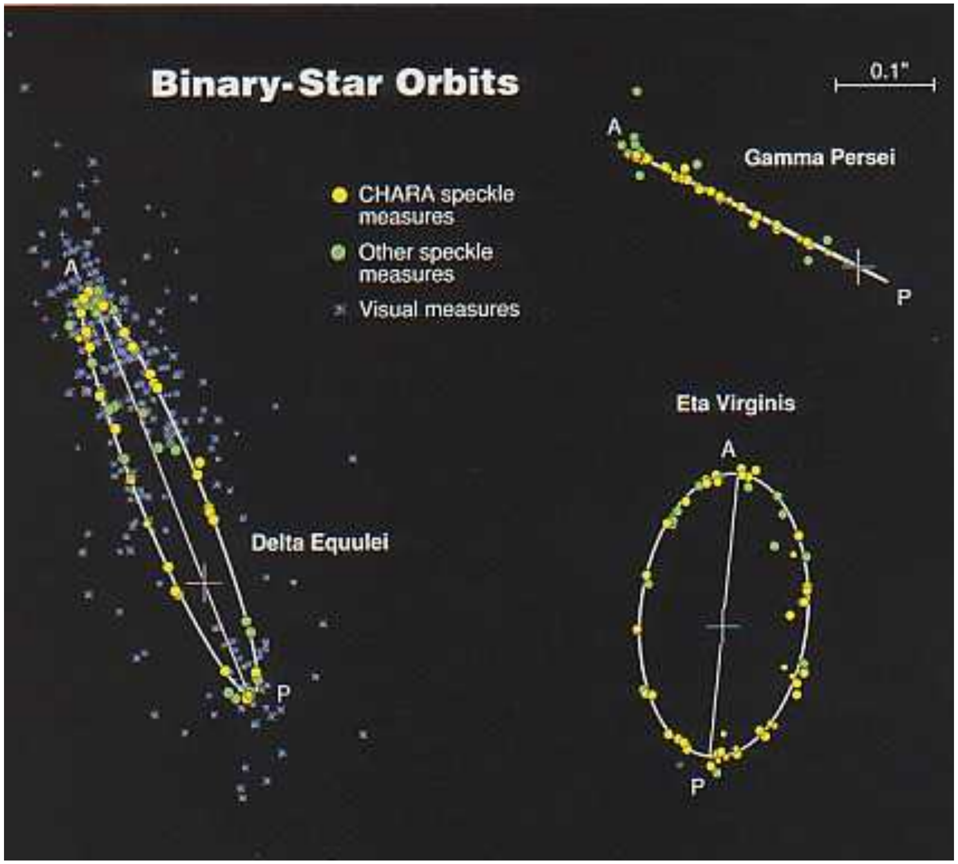
Speckle Observations of κ Pegasi

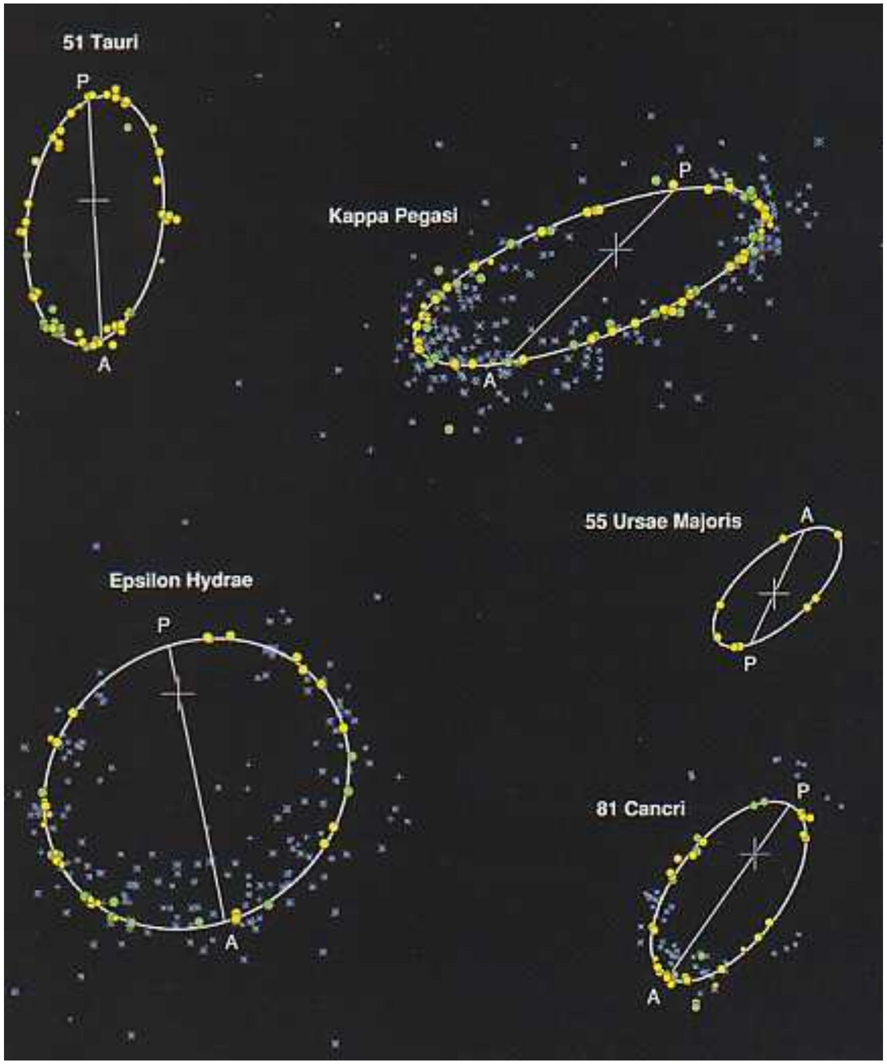
Data Collection & Processing Pipeline



McAlister, Sky and Telescope, 92, No. 5, 28, Nov. 1996.

Some CHARA Speckle Orbits





McAlister, Sky and Telescope, 92, No. 5, 28, Nov. 1996.

χ Dra – A Resolved Spectroscopic/Astrometric Binary I.

McAlister AJ, 85, 1265, 1980.

A 280-day spectroscopic binary discovered by Wright in 1898 and subsequently measured as an astrometric binary by Alden (1936). It was first resolved with SI by Labeyrie et al. (1974). Breakiron & Gatewood (1974) refined the astrometric orbit and Bonneau & Foy (1980) produced the first speckle orbit.

TABLE III. Speckle interferometric observations of χ Dra.

Obs. No.	Epoch 1900.0 +	p.a.	Sep.	Aper. (m)	Reference
1	73.2080	240°5 ± 2°0	0″096 ± 0″010	5.0	Labeyrie *et al.* (1974)
2	73.4520	70.5 ± 3.0	0.077 ± 0.008	5.0	Labeyrie *et al.* (1974)
3	73.7580	218.5 ± 5.0	0.115 ± 0.010	5.0	Labeyrie *et al.* (1974)
4	75.7151	63.6 ± 3.0	0.090 ± 0.009	4.0	McAlister (1977)
5	76.2991	242.0 ± 2.0	0.078 ± 0.008	4.0	McAlister (1978)
6	76.4494	53.2 ± 2.0	0.088 ± 0.010	4.0	McAlister (1978)
7	76.4548	53.9 ± 2.0	0.082 ± 0.009	4.0	McAlister (1978)
8	77.4818	194.3 ± 3.0	0.053 ± 0.005	4.0	McAlister (1979)
9	77.4872	189.9 ± 3.0	0.057 ± 0.006	4.0	McAlister (1979)
10	77.7411	226.9 ± 0.6	0.136 ± 0.001	4.0	McAlister and Fekel (1980)
11	78.3935	224.6 ± 5.0	0.119 ± 0.010	1.9	Bonneau and Foy (1980)
12	78.3945	221.6 ± 5.0	0.116 ± 0.010	1.9	Bonneau and Foy (1980)
13	78.5410	229.6 ± 1.0	0.124 ± 0.005	4.0	McAlister and Fekel (1980)
14	78.6147	244.5 ± 3.0	0.071 ± 0.007	4.0	McAlister and Fekel (1980)
15	79.3628	237.9 ± 2.0	0.094 ± 0.009	4.0	McAlister (unpublished)
16	79.5321	54.4 ± 2.0	0.094 ± 0.009	4.0	McAlister (unpublished)

χ Dra – A Resolved Spectroscopic/Astrometric Binary II.

McAlister AJ, 85, 1265, 1980.

TABLE V. Orbit residuals for χ Dra.

Obs. No.	Breakiron and Gatewood (1974) $\Delta\theta$	$\Delta\rho$	Bonneau and Foy (1980) $\Delta\theta$	$\Delta\rho$	This paper $\Delta\theta$	$\Delta\rho$
1	−7°9	−0″027	+3°7	−0″031	+5°9	−0″003
2	−28.7	−0.027	+7.9	−0.004	+5.7	−0.001
3	+12.2	−0.057	+1.6	+0.013	−0.1	+0.005
4	−17.5	−0.017	+11.0	+0.020	+4.9	+0.000
5	−13.2	−0.027	+3.6	−0.042	+5.0	−0.005
6	−12.1	−0.015	+17.9	+0.048	−0.7	−0.002
7	−14.0	−0.022	+14.3	+0.037	−0.8	−0.008
8	+13.7	−0.083	+16.9	+0.008	−1.7	+0.001
9	+7.8	−0.081	+8.7	+0.010	−8.2	+0.002
10	−2.8	−0.033	−3.5	−0.002	−1.5	+0.003
11	+14.0	−0.059	+4.8	+0.008	+3.9	−0.000
12	+10.8	−0.062	+1.7	+0.004	+0.7	−0.003
13	−6.4	−0.030	−3.2	−0.013	−0.9	−0.001
14	−16.7	−0.022	+5.0	−0.044	+5.4	0.000
15	−13.5	−0.020	+0.6	−0.030	+2.3	+0.003
16	−15.9	−0.011	+12.6	+0.045	−1.0	+0.003
⟨$\Delta\theta$⟩	−5°6 ± 13°4		+6°5 ± 6°6		+1°1 ± 3°8	
⟨$\Delta\rho$⟩	0″037 ± 0″025		+0″002 ± 0″029		−0″001 ± 0″003	
			Predicted separations			
1975.6250	0″067		0″043		0″050	
1976.3970	0.071		0.039		0.055	
1979.7725	0.131		0.041		0.046	

χ Dra – A Resolved Spectroscopic/Astrometric Binary III.

McAlister AJ, 85, 1265, 1980.

1268 H. A. McALISTER: CHI DRACONIS

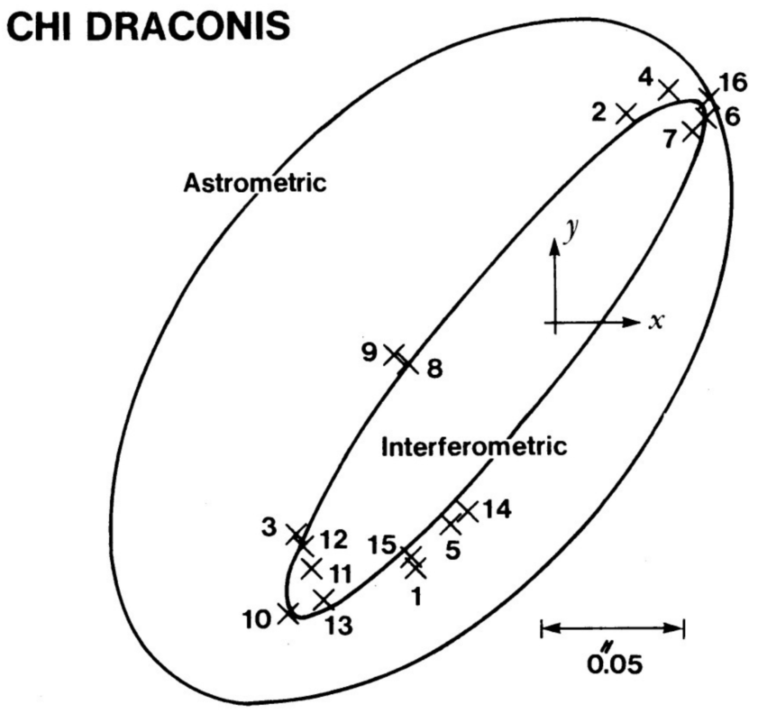


FIG 1. All available speckle observations of χ Dra are shown as crosses with an identification number for reference to Table III. Also plotted for comparison are the astrometric orbit of Breakiron and Gatewood (1974) and the newly determined interferometric orbit.

Discrepancy between astrometric and visual orbits is apparent, particularly in inclination for which astrometry gave $i = 56.0 \pm 2.1^{o}$ while speckle yielded $i = 79.9 \pm 0.9^{o}$

χ Dra – A Resolved Spectroscopic/Astrometric Binary IV.

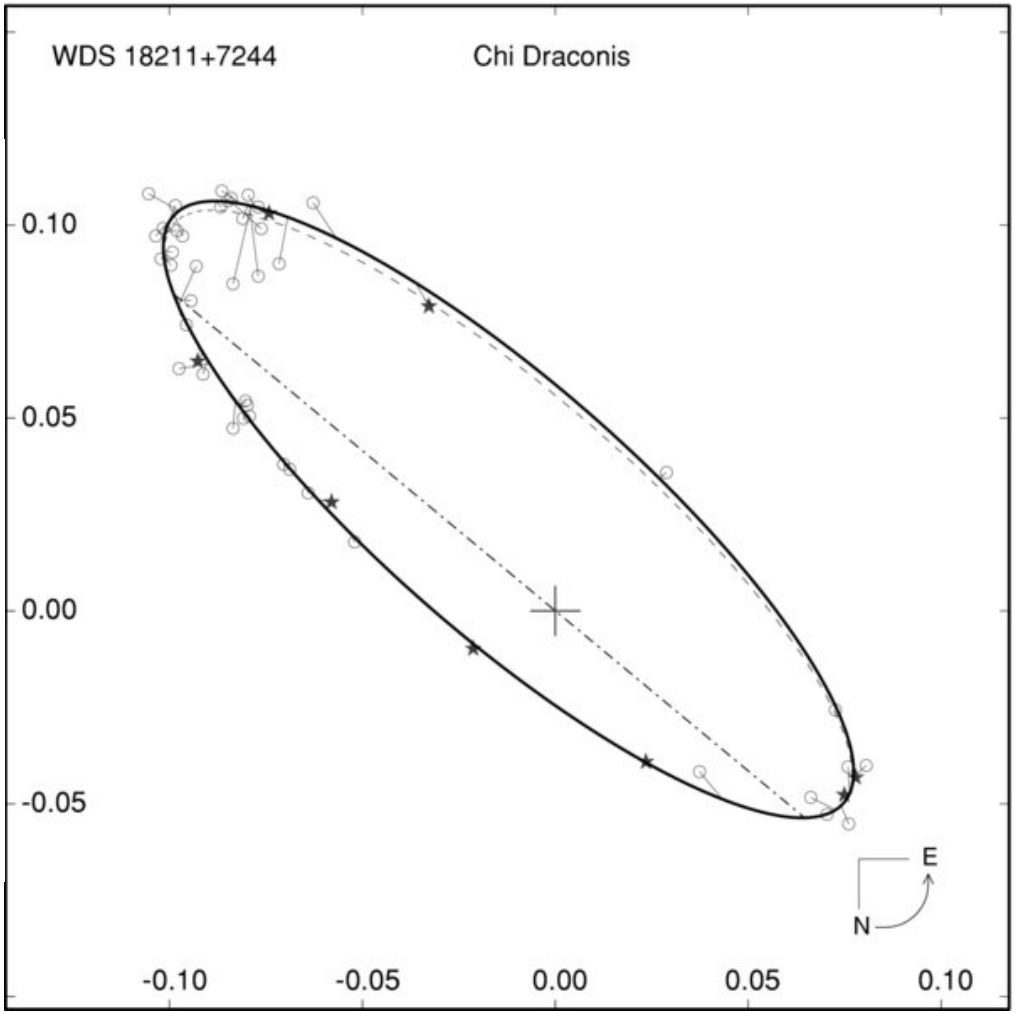
Farrington *et al.* AJ, 139, 2308, 2010.

Modern long-baseline interferometry using the CHARA Array has refined the orbit significantly.

The system's deduced masses (compared with those of McAlister) in solar units are:

M_A = 0.96±0.03 (0.88±0.09)

M_B = 0.75±0.03 (0.67±0.05)



The Remarkable Case of Tweedledum & Tweedledee I.

Mason, Hartkopf & McAlister AJ, 140, 242, 2010.

The wide binary was first discovered in 1825 by Struve and in 1953, W.S. Finsen found that A and B were both binaries with remarkably similar pairs.

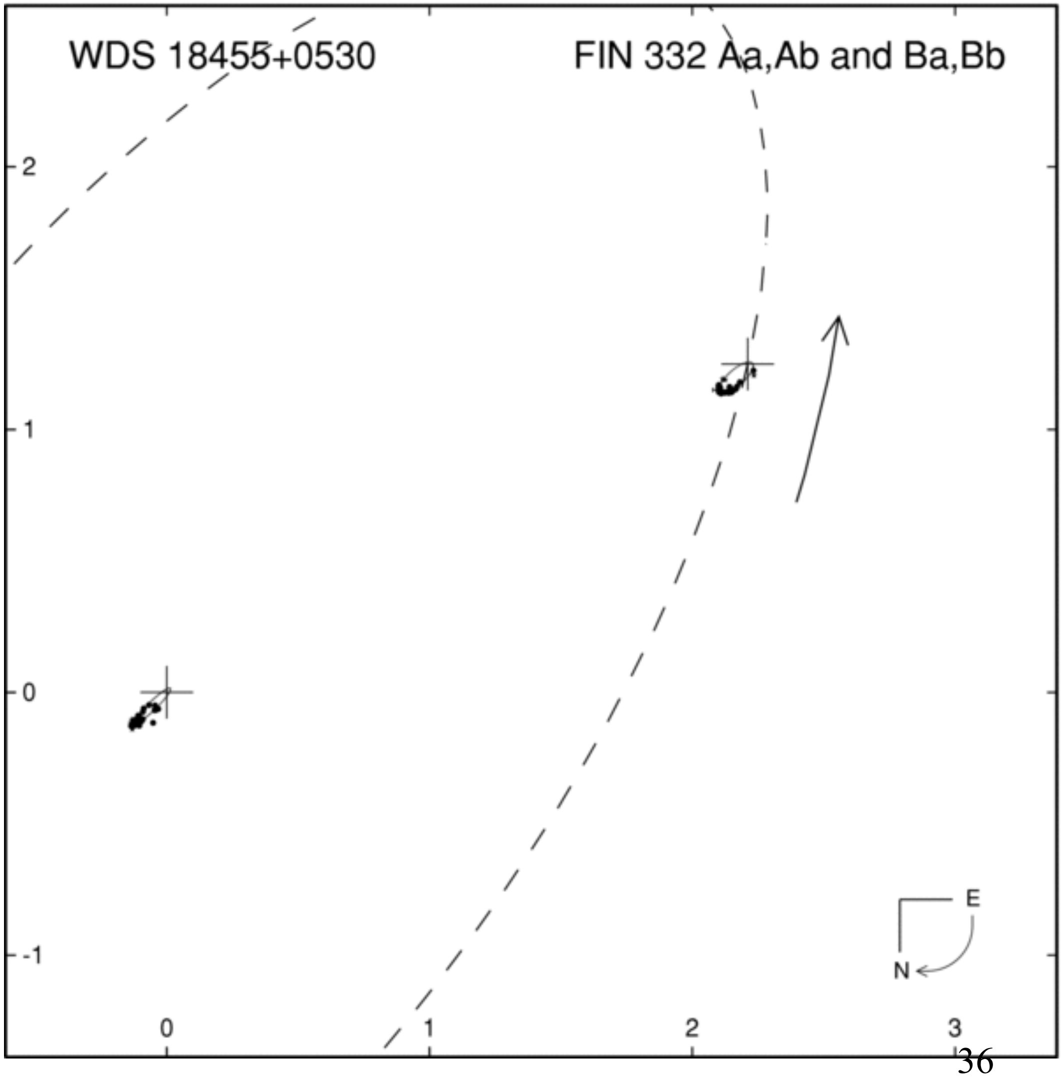
Finsen's first measurements:

Aa,Ab

ρ = 0.153" θ = 316.5º

Ba,Bb

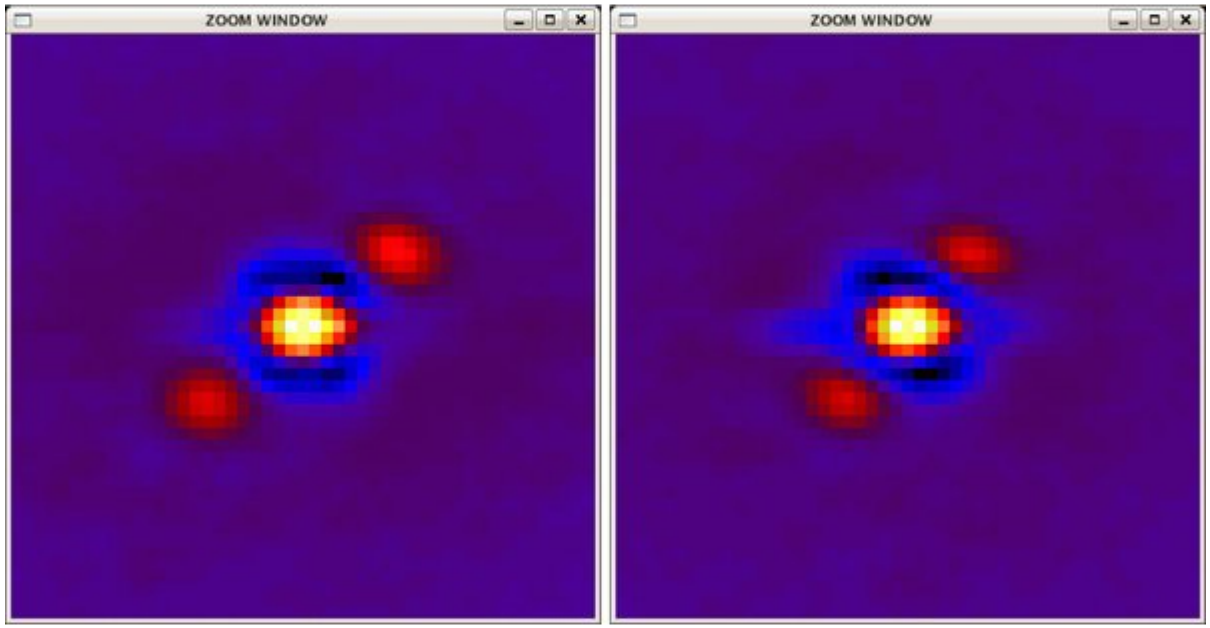
ρ = 0.148" θ = 315.3º



The Remarkable Case of Tweedledum & Tweedledee II.

Mason, Hartkopf & McAlister AJ, 140, 242, 2010.

Directed Vector Autocorrelegrams of Aa,Ab and Ba,Bb from 1982.765



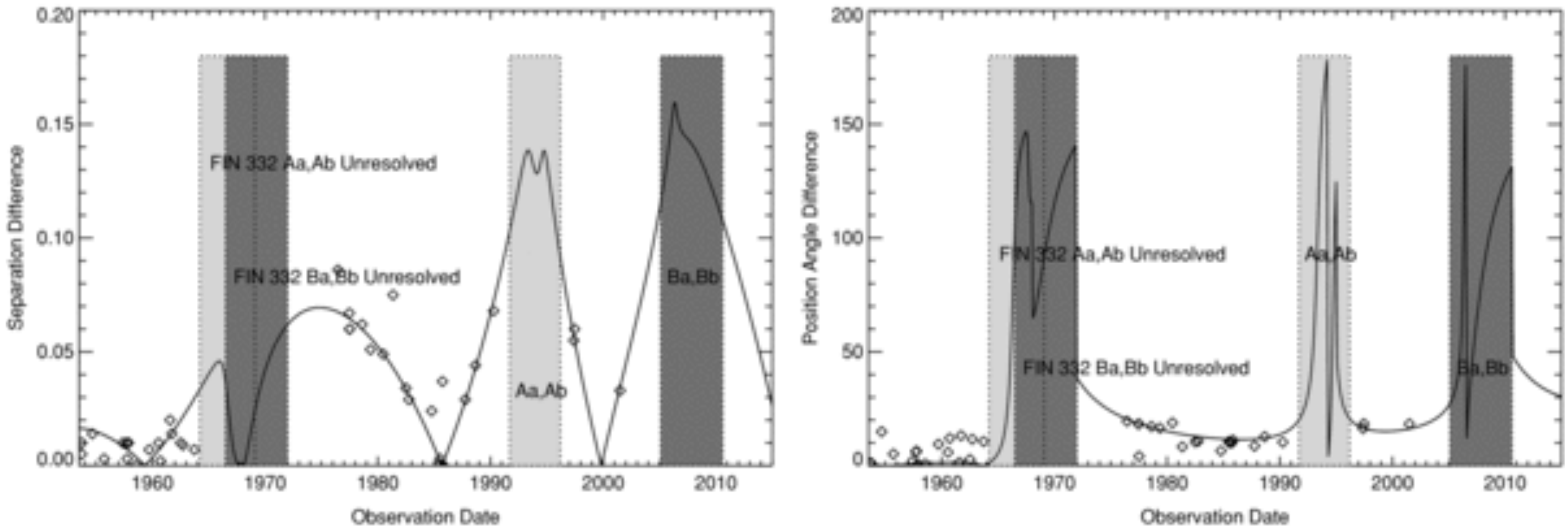
Orbital Elements:

	Aa,Ab	Ba,Bb
P (yrs)	27.03	38.6
a”	0.094	0.105
e	0.79	0.87
i	106	117
T	1994.2	1967.9
ω	10	311
Ω	136	112

The Remarkable Case of Tweedledum &Tweedledee III.

Mason, Hartkopf & McAlister AJ, 140, 242, 2010.

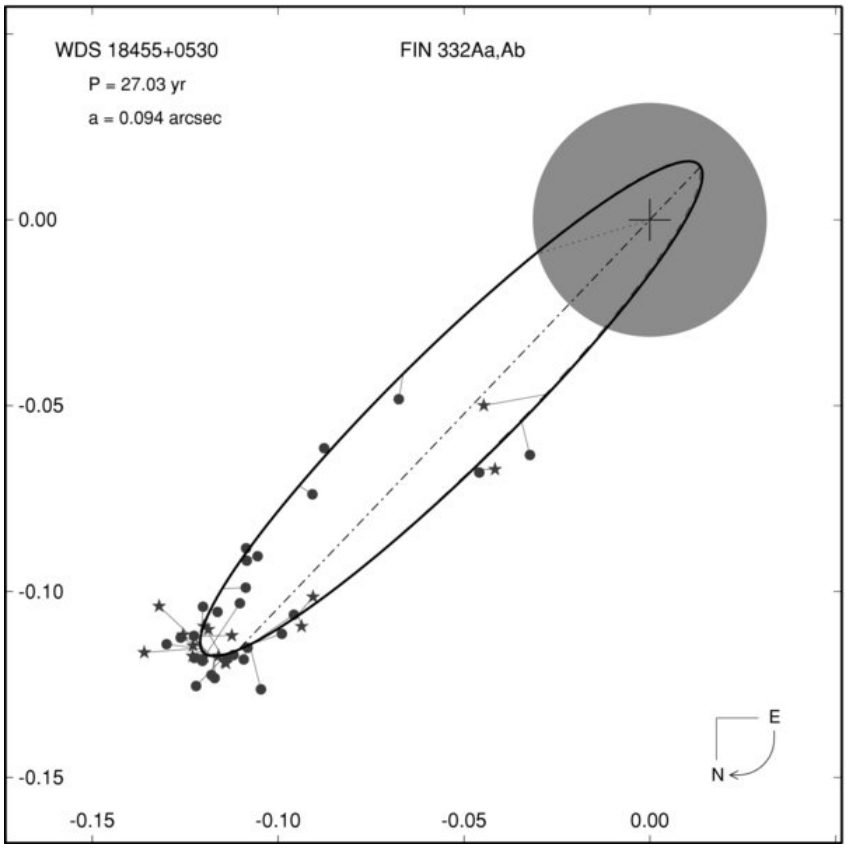
The lighter shaded areas from 1964.2 to 1969.1 and 1991.7 to 1996.2 are dates when Aa, Ab is predicted to be closer than 0.05 arcsec. The darker shaded areas from 1966.5 to 1972.0 and 2005.1 to 2010.6 indicate the range of dates when the orbit predicts Ba, Bb to be closer than 0.05 arcsec.

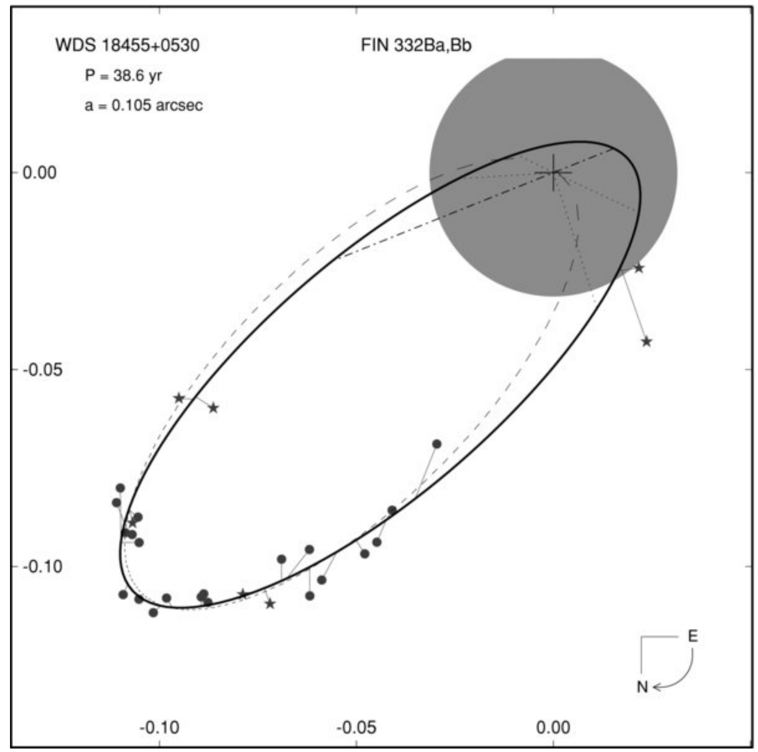


The Remarkable Case of Tweedledum & Tweedledee IV.

Mason, Hartkopf & McAlister AJ, 140, 242, 2010.

The two orbits reveal their difference in inclinations which lead to a angle of mutual inclination of 25º or 49º depending upon Ω.





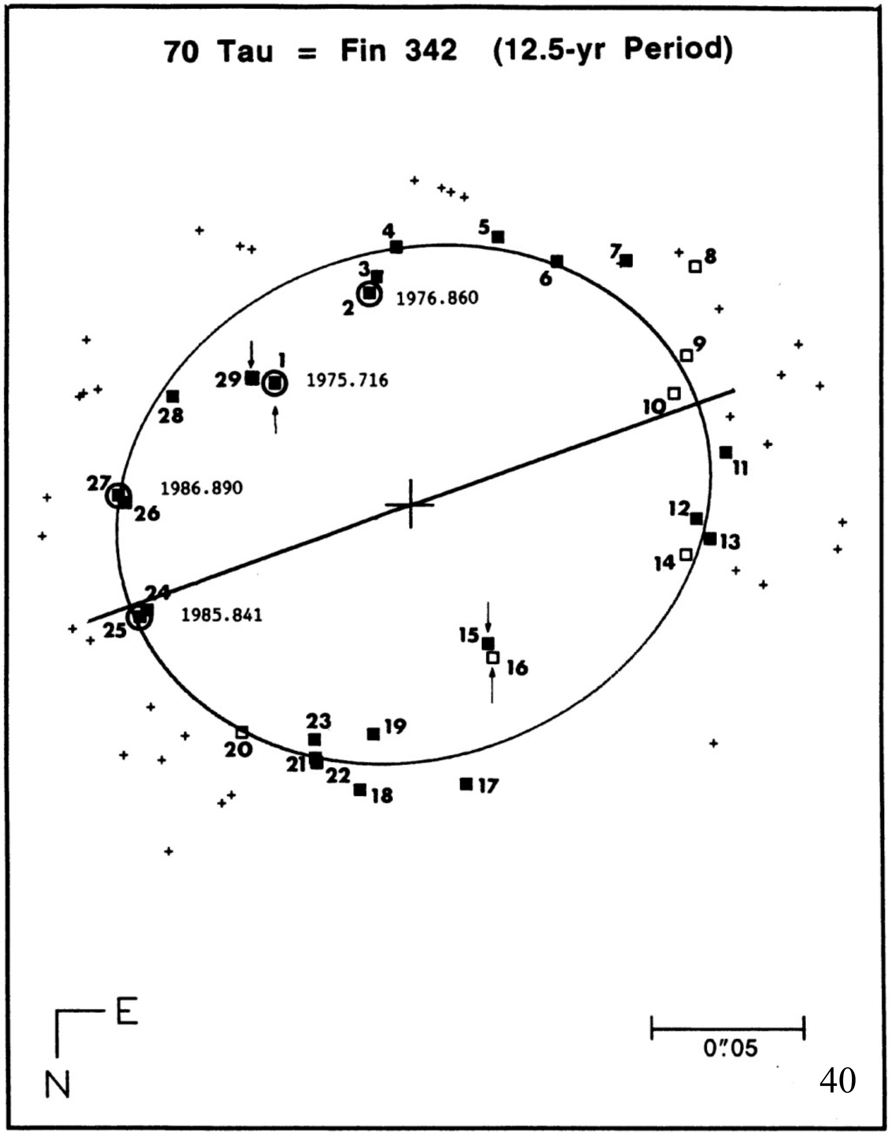
Another Interesting Finsen Binary - Φ 342 I.

McAlister *et al.* AJ, 96, 1431, 1988.

The star in the Hyades was discovered as a binary by W.S. Finsen using visual interferometry in 1959, and ensuing observations implied an orbital period of ~ 12 years.

This plot show Finsen's observations along with CHARA and other speckle observations as filled and open squares, respectively.

Notice the "pinched" appearance perpendicular to the line of nodes.

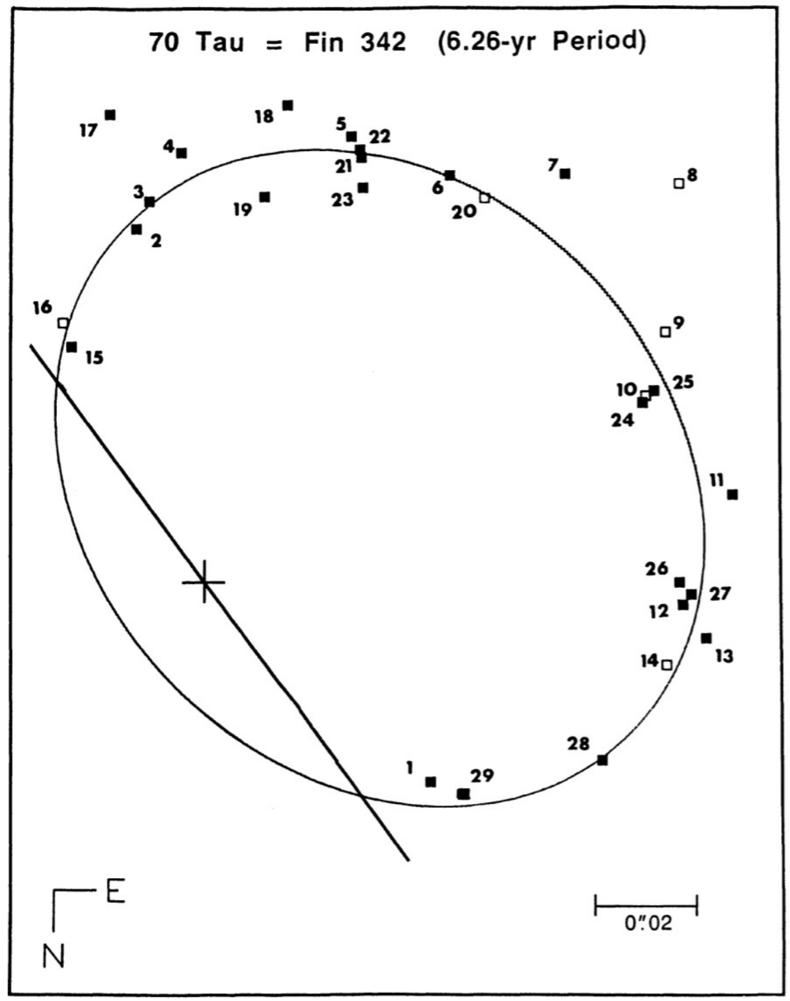


Another Interesting Finsen Binary - Φ 342 II.

McAlister *et al.* AJ, 96, 1431, 1988.

The DVA method for speckle interferometry was able to determined several true quadrants which led to quadrant reversals and a re-determination of the orbit .

Rather than being a long-period, nearly-circular orbit, the true solution is one having an eccentric orbit with half the period.



A Few More Goodies I.

Cole *et al.* AJ, 103, 1357, 1992.

In a spectroscopic and speckle interferometric investigation of the triple system HR 266 = ADS 784, the high accuracy of SI clearly shows the astrometric signature of an otherwise unseen companion to component B for which spectroscopy shows an orbital period of 1769 days.

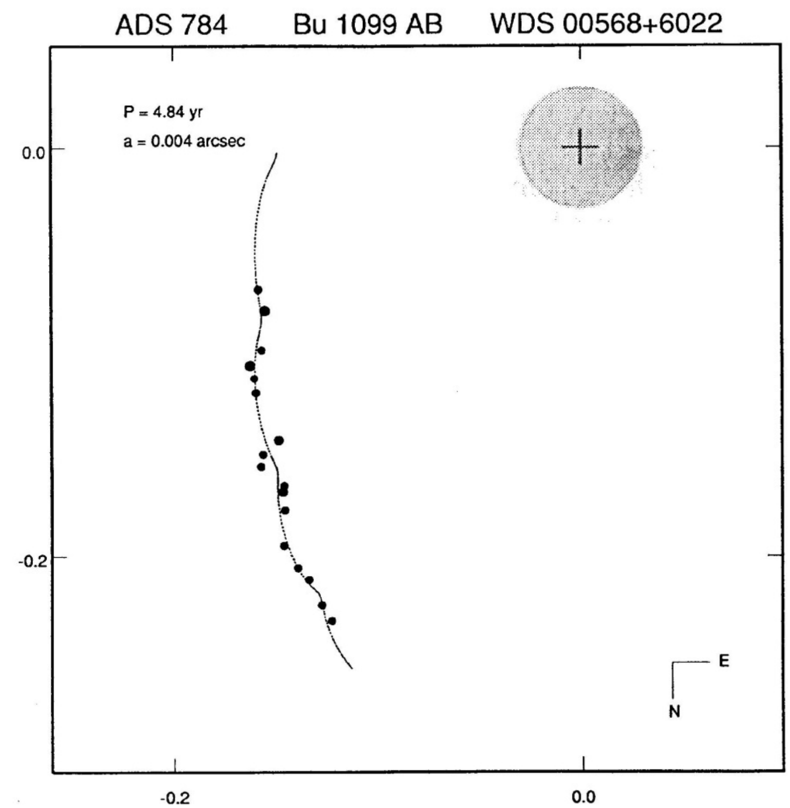
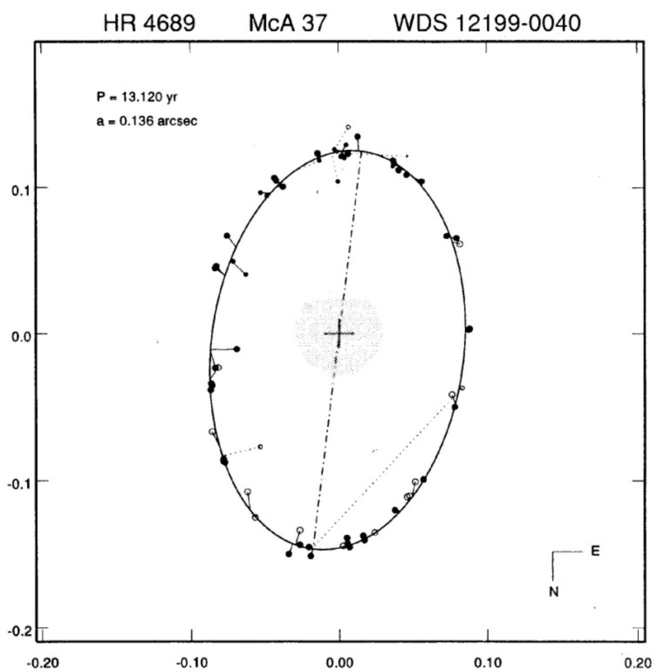


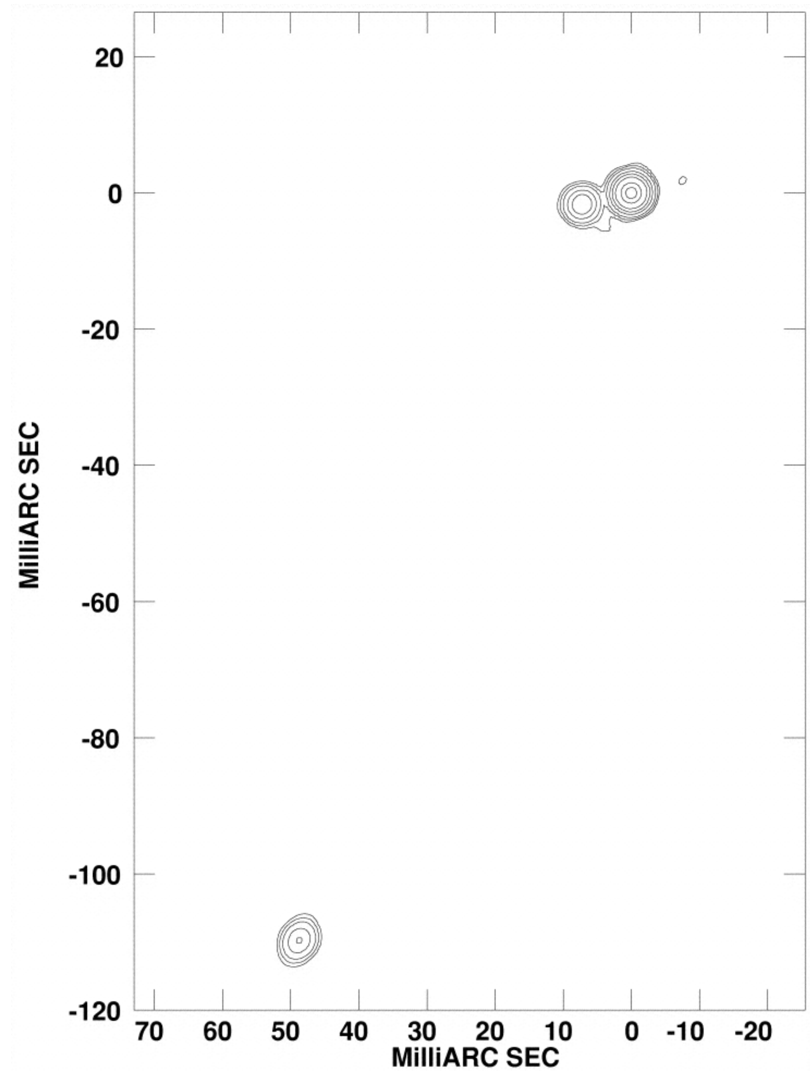
FIG. 7. A portion of the long-period orbit, perturbed by the 5 yr astrometric orbit. Speckle "normal" points are indicated by filled circles. P_I, T_I, e_I, and ω_I for the intermediate-period orbit were adopted from the spectroscopic solution. Thus, the period, phase, and general shape of the perturbation are fixed. Axes are in seconds of arc.

A Few More Goodies II.

Hartkopf *et al.* AJ, 103, 1976, 1992 and Hummel *et al.* AJ, 125, 2630, 2003.

The components of the 13.1 yr orbit in HR 4689 = η Vir shown below were beautifully imaged at right with the Navy Prototype Optical Interferometric which also resolves the inner 72-day short period component not resolvable by speckle interferometry.





A Few More Goodies III.

McAlister *et al.* AJ, 112, 1169, 1996.

In a brief survey of duplicity of white dwarfs, the stars GD 294, GD 140, GD 319 and HZ 43 were examined for companions. No new companions but the known companions to GD 319 and HZ 43 were detected. The former was shown to exhibit rectilinear motion indicative of an optical pair while that of HZ 43, the brightest EUV source in the sky, was shown to be physical. The companion is probably an early-type M dwarf in a 2000+ year orbit.

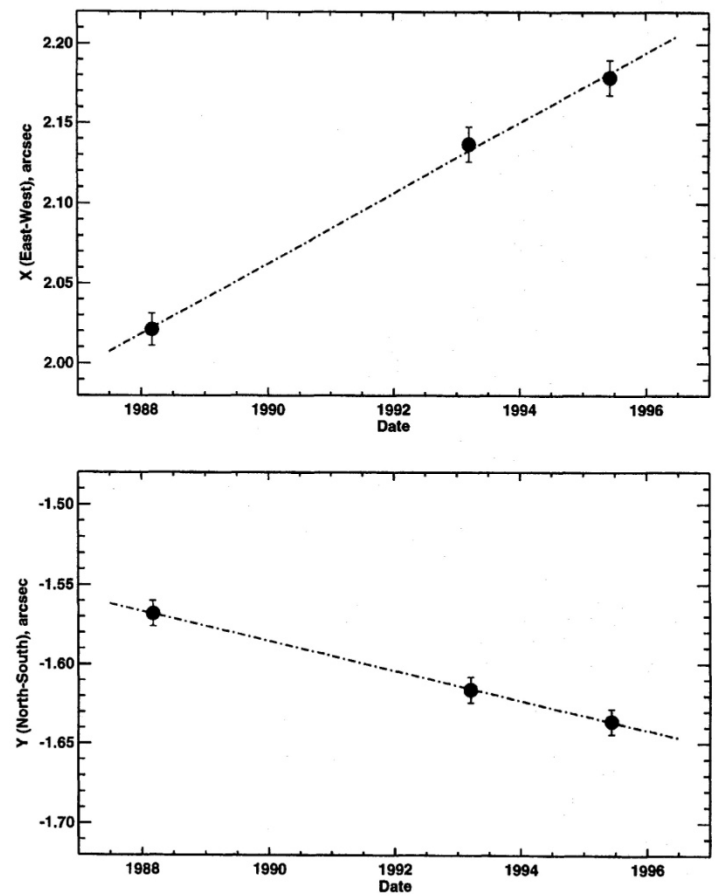
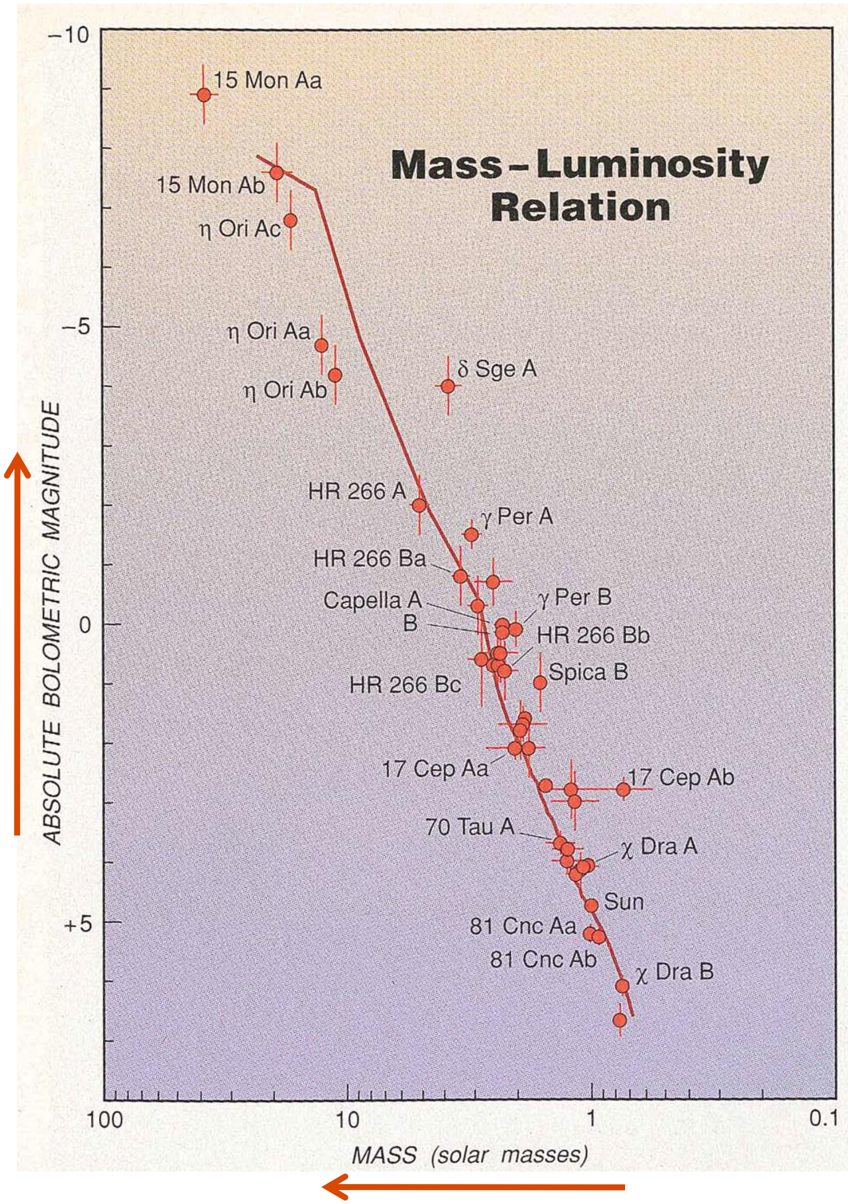


FIG. 1. The relative motion of the red companion to GD 319 with respect to the white dwarf primary is shown for three epochs. The X (east-west) and Y (north-south) components of motion are both well represented by linear fits, and there is no evidence of any curvature that would indicate orbital motion.

CHARA Placements on the Mass-Luminosity Relation



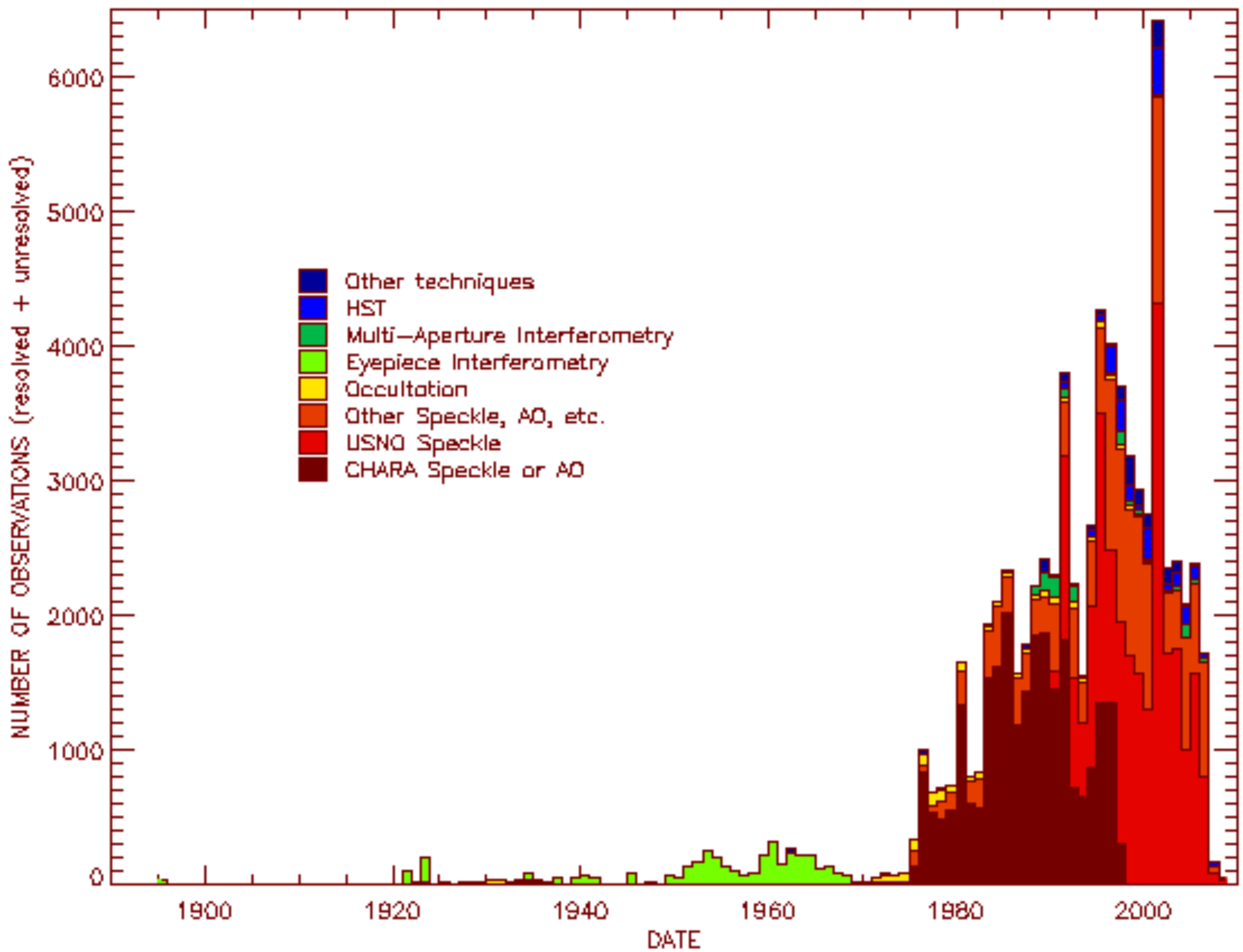
CHARA Speckle Interferometry Papers

From 1975 - 2000

Photographic Speckle	9
Digital Speckle	21
Unresolved Systems	3
Individual System Studies	26
Bulk Orbits (85 orbits)	5
Surveys (bright stars, cluster members, asteroids, O stars)	5
Miscellaneous	25
Total Number of Published Papers	94

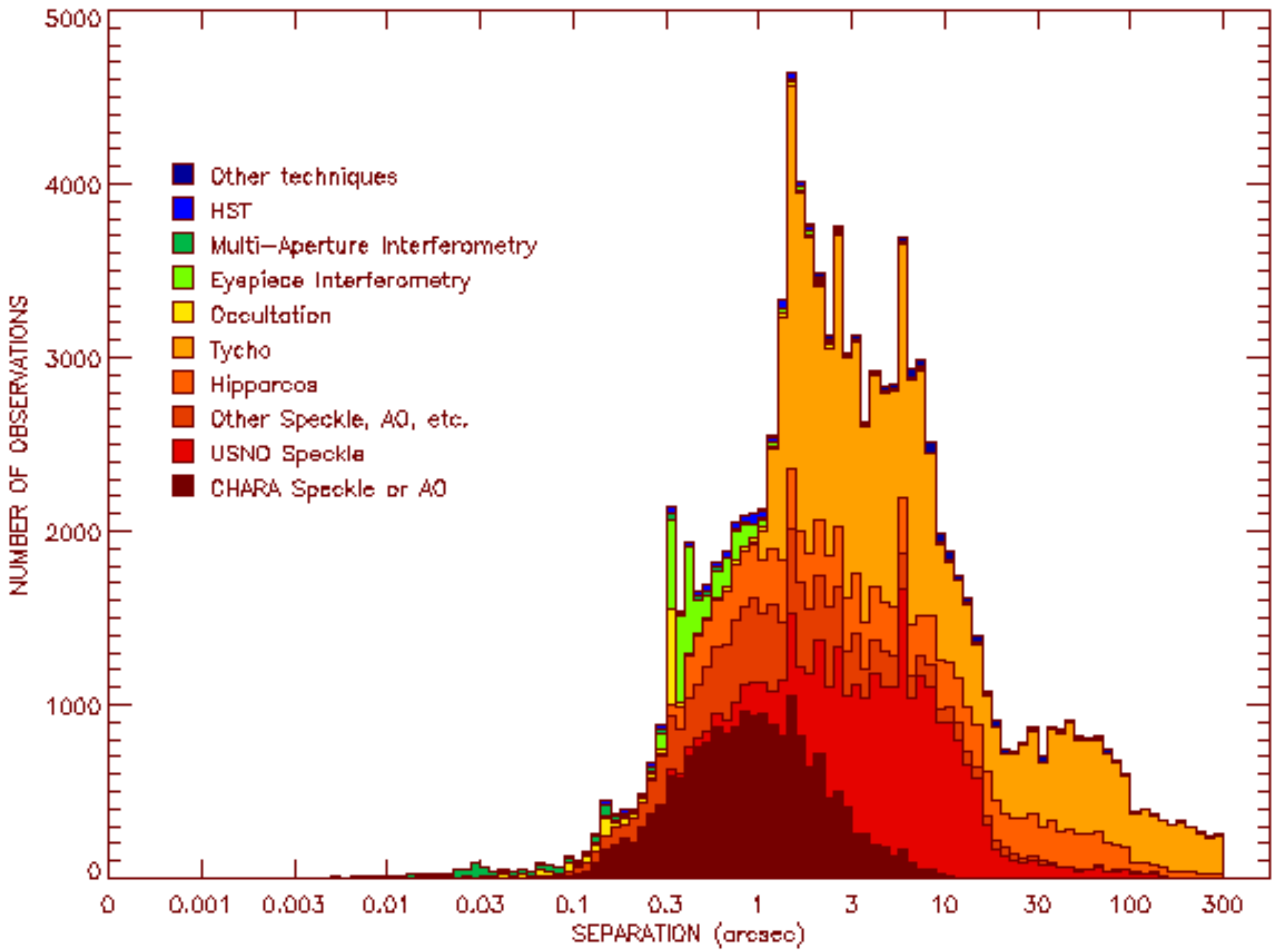
Summary of High Angular Resolution Results I.

(As of Jan 2010– from *Fourth Catalog of Interferometric Measurements of Binary Stars,* Hartkopf *et al.*)



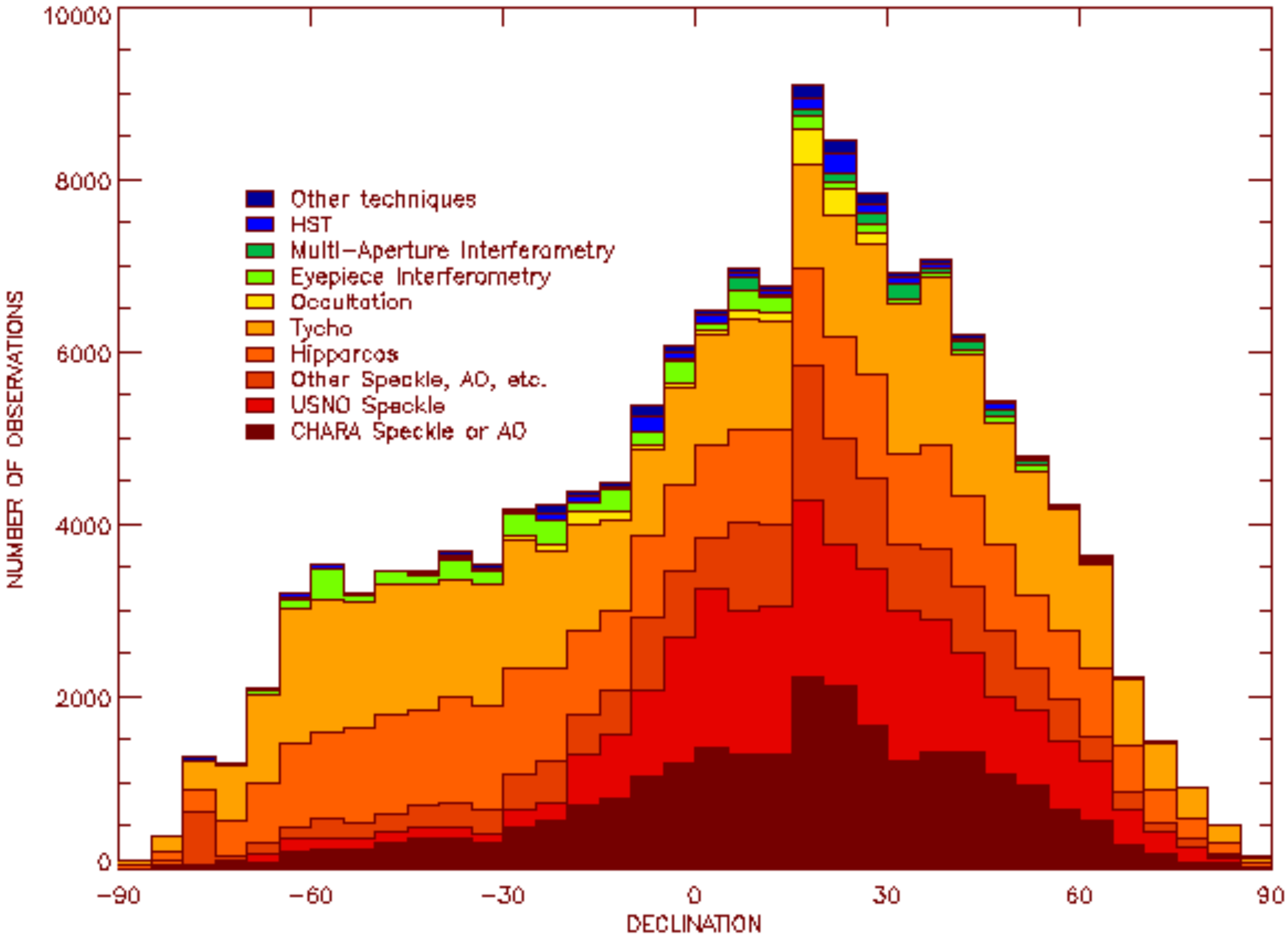
Summary of High Angular Resolution Results II.

(As of Jan 2010– from *Fourth Catalog of Interferometric Measurements of Binary Stars,* Hartkopf *et al.*)

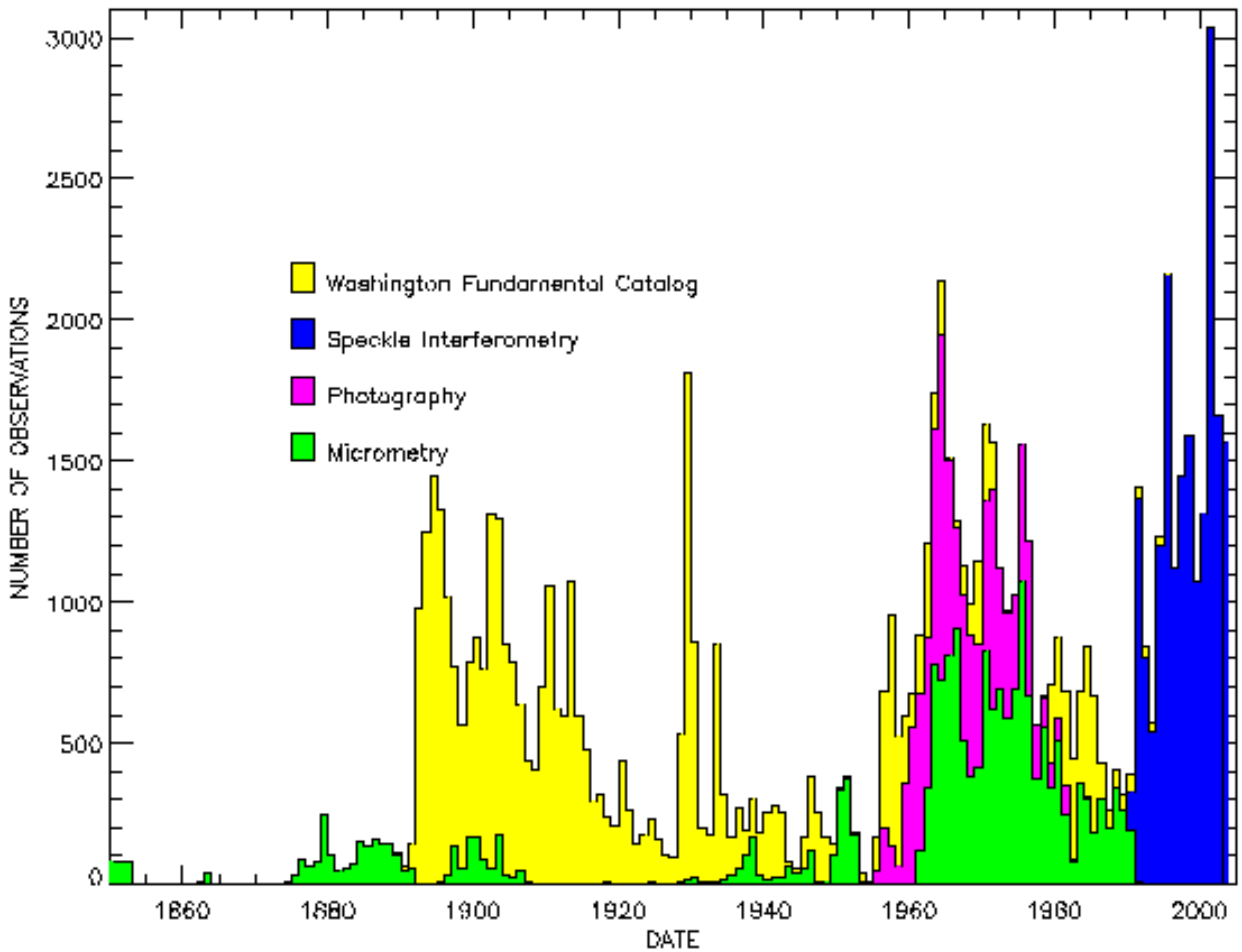


Summary of High Angular Resolution Results III.

(As of Jan 2010– from *Fourth Catalog of Interferometric Measurements of Binary Stars,* Hartkopf *et al.*)



Progression of Techniques for Visual Binaries at the U.S. Naval Observatory



Currently Active Speckle Programs

- **U.S. Naval Observatory (B. Mason & W. Hartkopf) – 26-in Washington refractor and miscellaneous large reflectors.** **(ad.usno.navy.mil/wds/ds_history.html)**
- **Special Astrophysical Observatory/Russia (Y. Belaga) – 6-m SAO telescope near Zelenchukskaya, Russia.** **(www.sao.ru/mavr/index.htm)**
- **Southern Connecticut State University (E. Horch) – 3.5- m WIYN telescope on Kitt Peak.**
- **Max Planck Institut fur Radioastronomie Infrared Group (G. Weigelt)– 6-m SAO and VLT.** **(www.mpifr-bonn.mpg.de/div/ir-interferometry/)**
- **CHARA's program began in 1977 and was carried out primarily at the NOAO 4-m telescopes. The effort was retired in 1998 to turn full attention to long-baseline interferometry.** **(www.chara.gsu.edu/CHARA/speckle.html)**
- **For more about speckle interferometry, see *Sky and Telescope*, May 1977 and November 1996.**

system developed by the Mount Wilson Institute for the 100-inch telescope is pro- feasibility of accurately measuring brightness and color differences in close visual lete. Not much chea

Amateur Speckle Interferometry

INEXPENSIVE CCD cameras and computers have made it feasible for amateurs to put together their own speckle-interferometry systems — assuming they have access to a moderately large telescope.

The resolution limit for binary-star measurements with such a system is 5.4/*d* arcsecond, where *d* is the telescope aperture in inches. Thus a 20-inch telescope could measure binaries as close as a quarter of an arcsecond. Individuals and clubs with scopes this size or larger should seriously consider acquiring speckle capability. Few professional astronomers devote time to speckle measurements of binaries, so amateurs can make a substantial contribution!

A speckle camera is very simple. You need a detector that can take snapshots short enough to freeze the atmospheric seeing. A commercial video CCD camera taking the standard 30 frames per second works quite well, except occasionally when the seeing is very "fast." To resolve individual speckles well, you need to magnify the image so the telescope's resolution limit is about 5 pixels wide on the CCD. For measuring double stars much wider than the telescope's diffraction limit, a scale of only 2 pixels or less covering the Airy disk would do the job — and would show fainter stars. Such high magnifica-

tions are easily obtained using m
You also need a filter to limit
observed spectral bandpass is
speckles blur out.
And that's about it. If the tele
inches, you must also compensat
The usual approach is to use Ris
plication that is unnecessary on
To run the camera you need a
ber and a digitizer board, both
computer can be used to process
To prove that low-cost speckle
gia State graduate students Nils T
gether a system on the 16-inch tel
Creek Observatory 50 miles east
microscope objective and a 535
from Edmund Scientific for und
camera for $440, and a Catenary
image-processing library for $49
$1,000, not counting the compute
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Left: Nils Turner inserts his amateur speckle interferometry camera into Georgia State University's 16-inch telescope. *Below:* The camera is simple. In the box at right is a commercial CCD video camera, and the tube at left goes into the telescope's focuser. Between them fit a microscope objective to provide high magnification and a color filter to sharpen the speckles.

34 Sky & Telescope November 1996

Amateur Speckle Interferometry is a Reality

See also Nils Tuner's Chapter on "Speckle Interferometry for the Amateur" in <u>Observing and Measuring Visual Double Stars</u>, ed. By Bob Argyle, (Springer), 2004.

Amateur Speckle Interferometry is a Reality

OBSERVACIÓN

Medición astrométrica de STF2744 mediante la técnica de interferometría speckle

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En este trabajo presentamos la medición de la binaria orbital STF2744 empleando el telescopio de 0,4 metros del Observatorio Astronómico de Cantabria. Se empleó la técnica de interferometría speckle mediante el uso de diferentes programas informáticos. Se estudiaron los residuos con respecto a la órbita y se analizaron los resultados de los diferentes programas informáticos. También se calculó el límite de resolución para el instrumental usado.

In this paper we present the measurement of the STF2744 binary system by using the telescope of 0.4 meters of the Observatorio de Cantabria. We used the speckle interferometry method by means of several specialized software packages, and we include a discussion above the results. The residuals were studied with regard to the orbit. Also, the limit of resolution of the optical train used was calculated.

Introducción

NO CABE DUDA de que en los últimos años los amateurs están consiguiendo realizar trabajos de gran calidad (ver la sección *Introduction* en el artículo de Rica (2008)). Precisas y numerosas mediciones mediante

medición y estudio.

Afortunadamente las técnicas observacionales evolucionan de forma importante y actualmente los amateurs disfrutamos de técnicas que no hace mucho sólo estaban al alcance de los profesionales. Nos estamos refiriendo a las técnicas “lucky imaging” y a la

from El Observador de Estrellas Dobles, No. 6, 2011.
http://www.infoastro.com/dobles/oed6.pdf

Vol. 4 No. 3 Summer 2008 Journal of Double Star Observations Page 111

Estimation of Double Star Parameters by Speckle Observations Using a Webcam

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Abstract: For many years accessible to the professional astronomer only, nowadays speckle interferometry benefits also the double star amateur community, thanks to the introduction of affordable CCD detectors and powerful computers. Following some seminal papers, a description is given of a method to estimate double star parameters from speckle images captured using a webcam. Results show that diffraction-limited measurements are indeed obtained even with a relatively small telescope under moderate seeing conditions. An application has been developed to perform all the required speckle analysis presented here.

Introduction

Seeing effects due to the atmospheric turbulence limit the resolution of ground-based telescopes. Even for small apertures (0.2—0.3 m), the seeing disk,

Image acquisition is performed with a Philips ToUcam Pro PCVC 840K color webcam, with a CCD chip made of an RGB matrix of 640x480 squared pixels (5.6 microns). Once fitted to the focal extender, the webcam is then connected to a laptop computer by a USB

from Journal of Double Star Observations, Vol. 4, 111, 2008.
http://www.jdso.org/volume4/number3/caloi.pdf

Binary Star Speckle Interferometry Summary

- **Provides enhanced resolution over classical techniques.**
- **Provides enhanced accuracy over classical techniques.**
- **Provides non-subjective measures less susceptible to personal bias.**
- **Begins to bridge the gap between visual and spectroscopic binaries**
- **Extremely efficient of valuable large telescope time.**
- **While speckle methods can be generalized to imaging problems, they are ideally suited to binary star studies.**