A New World of Possibilities

Using Solar Telescopes to do Double Star Speckle Interferometry

Richard Harshaw and Jimmy Ray

Phoenix, Arizona

Seriously into double stars!

What Started it All

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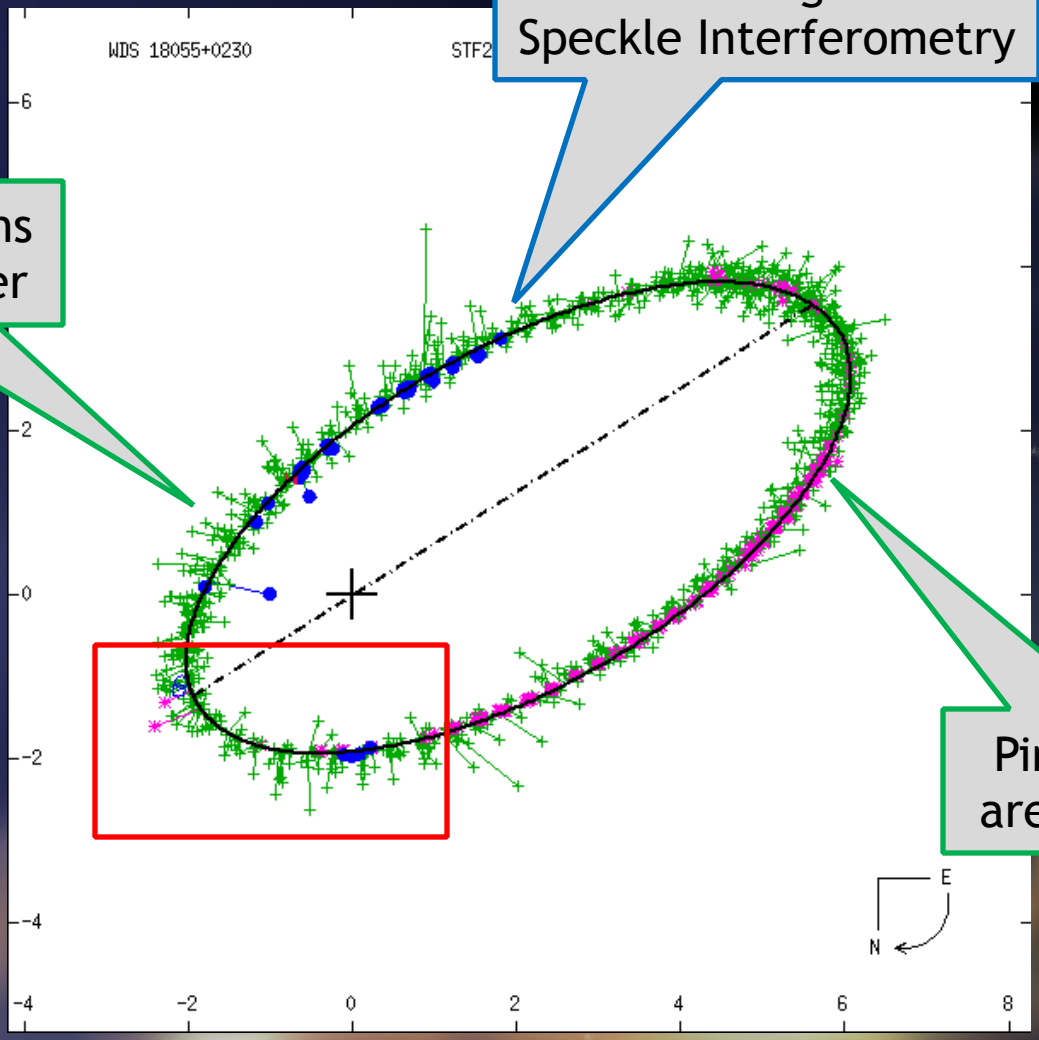
Another Statistical Tool for Evaluating Binary Stars

Richard Harshaw

Brilliant Sky Observatory
Cave Creek, Arizona

Abstract: Down through the years, astronomers have proposed many ways to estimate the number of binary and optical pairs in a given section of sky. In this paper, I propose a simple test to determine whether a given pair of stars is binary or optical based on the proper motions of the two stars. It will be shown that there is a very high correlation between binary status and common proper motion and optical status and different proper motions.

I Had Stumbled Upon Short Arc Binaries

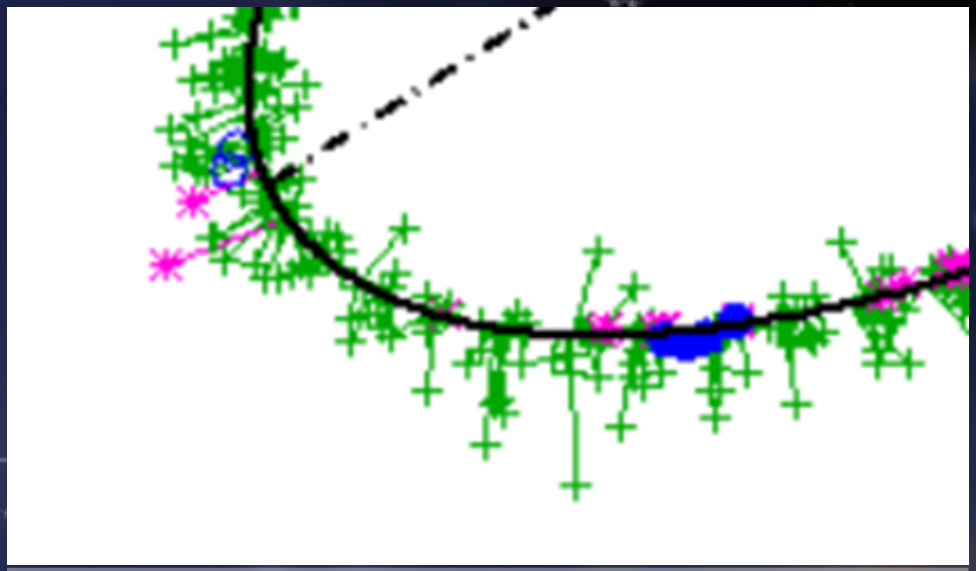


Blue“●” signs are Speckle Interferometry

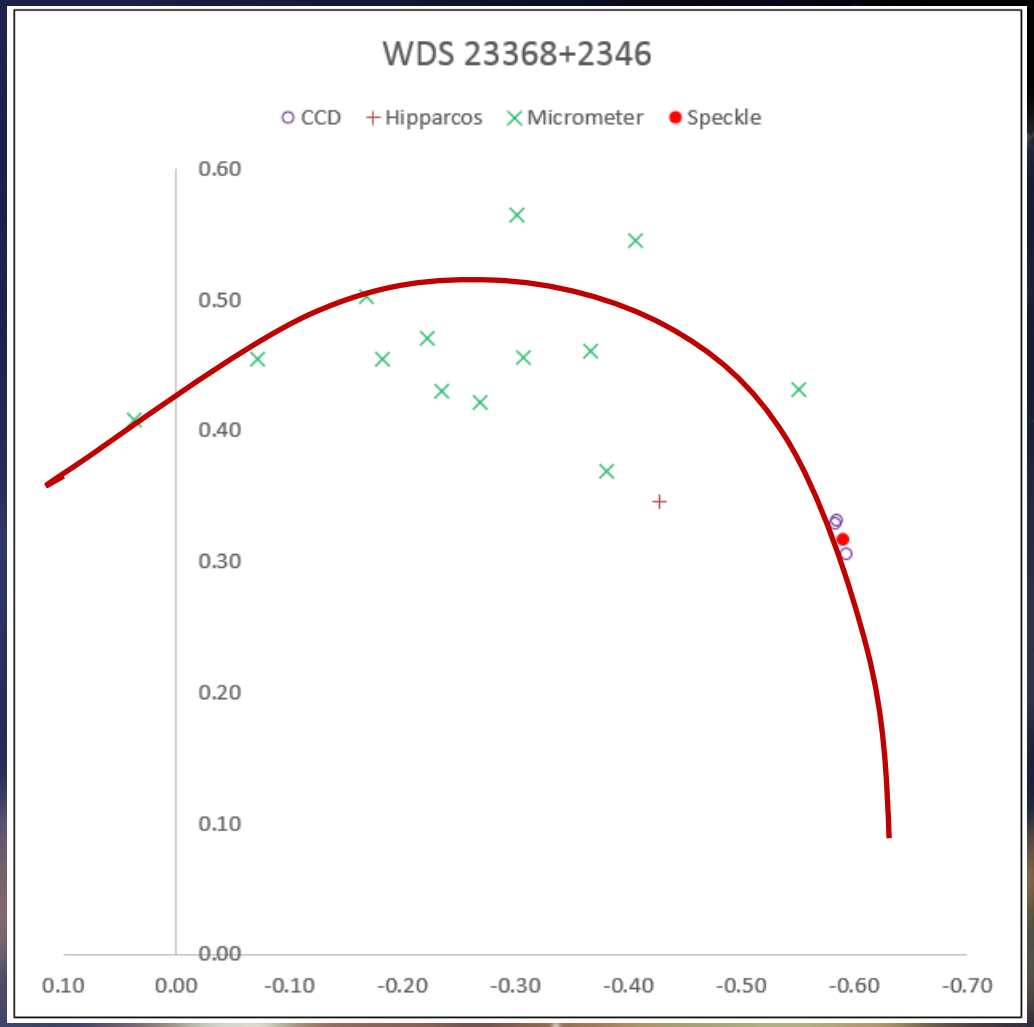
Green “+” signs are Micrometer

Pink “●” signs are Photograph

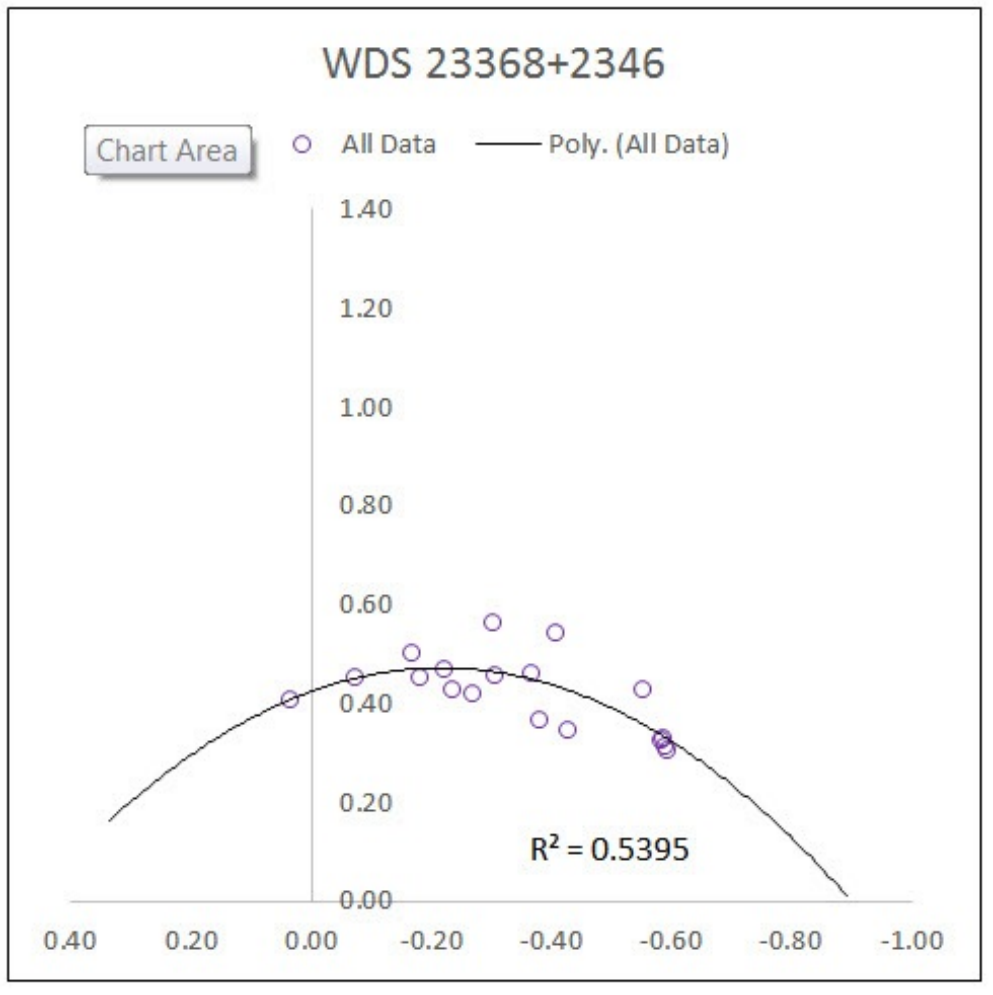
What a Short Arc Looks Like



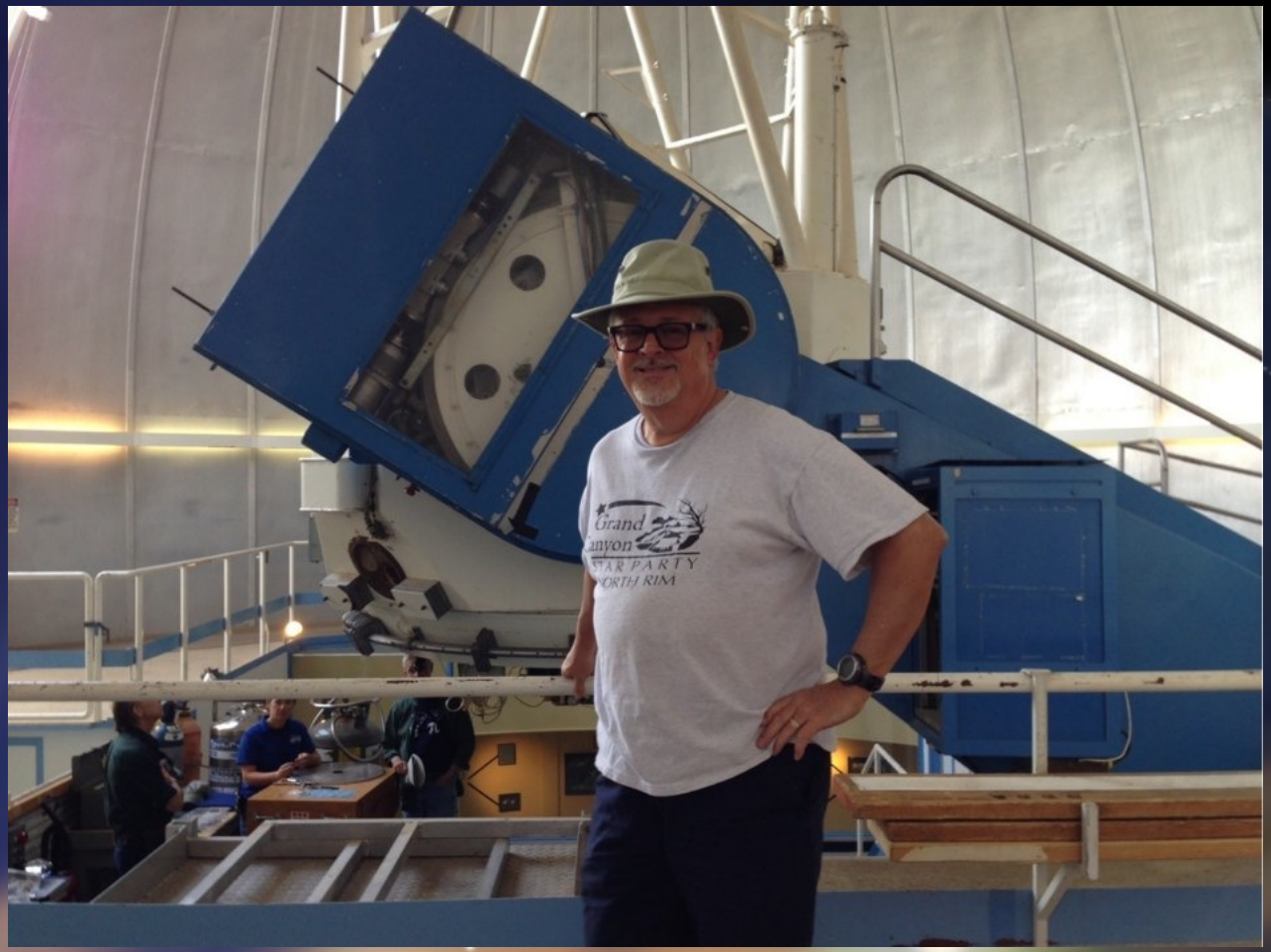
Classic Example



A Case Using Trendlines

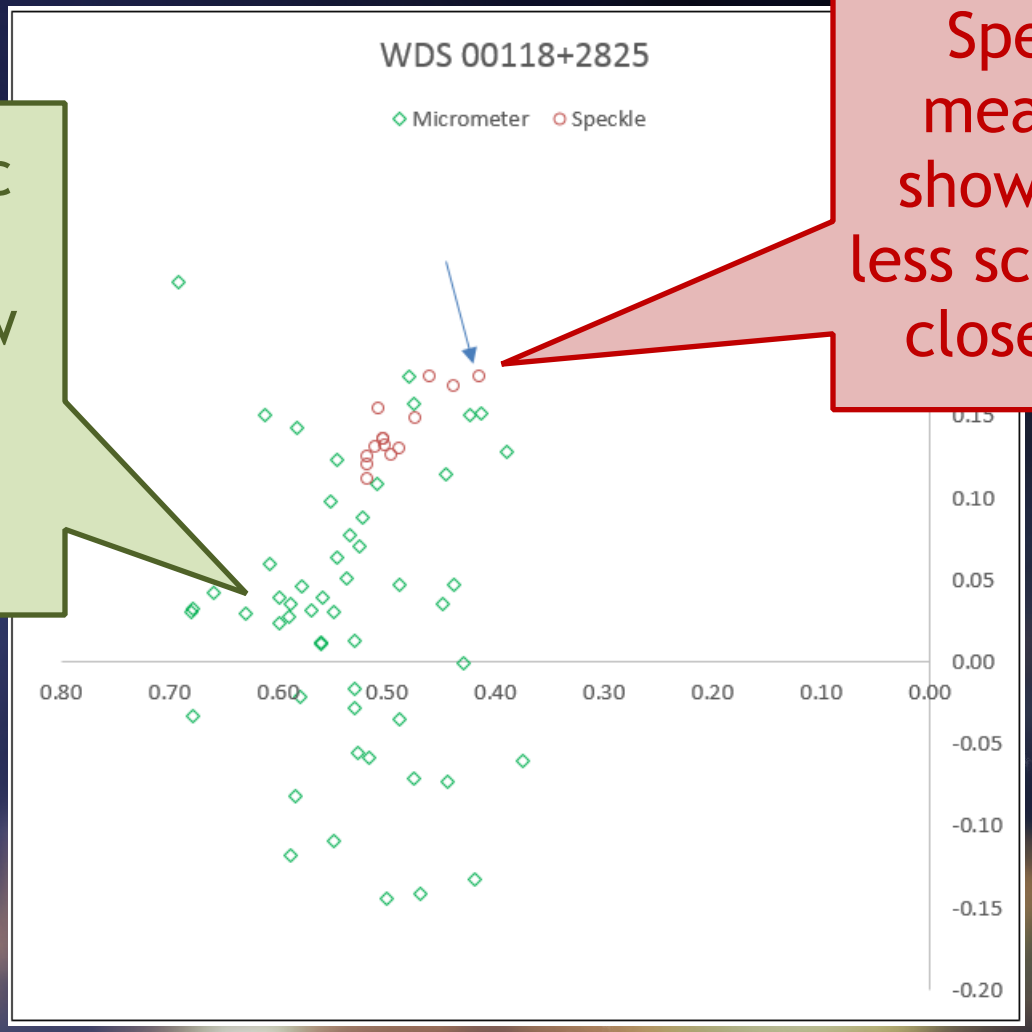


Invitation to Kitt Peak



Why Speckle Is Important

Micrometric measures always show significant scatter on close pairs



Speckle measures show much less scatter on close pairs

The Most Interesting Binaries

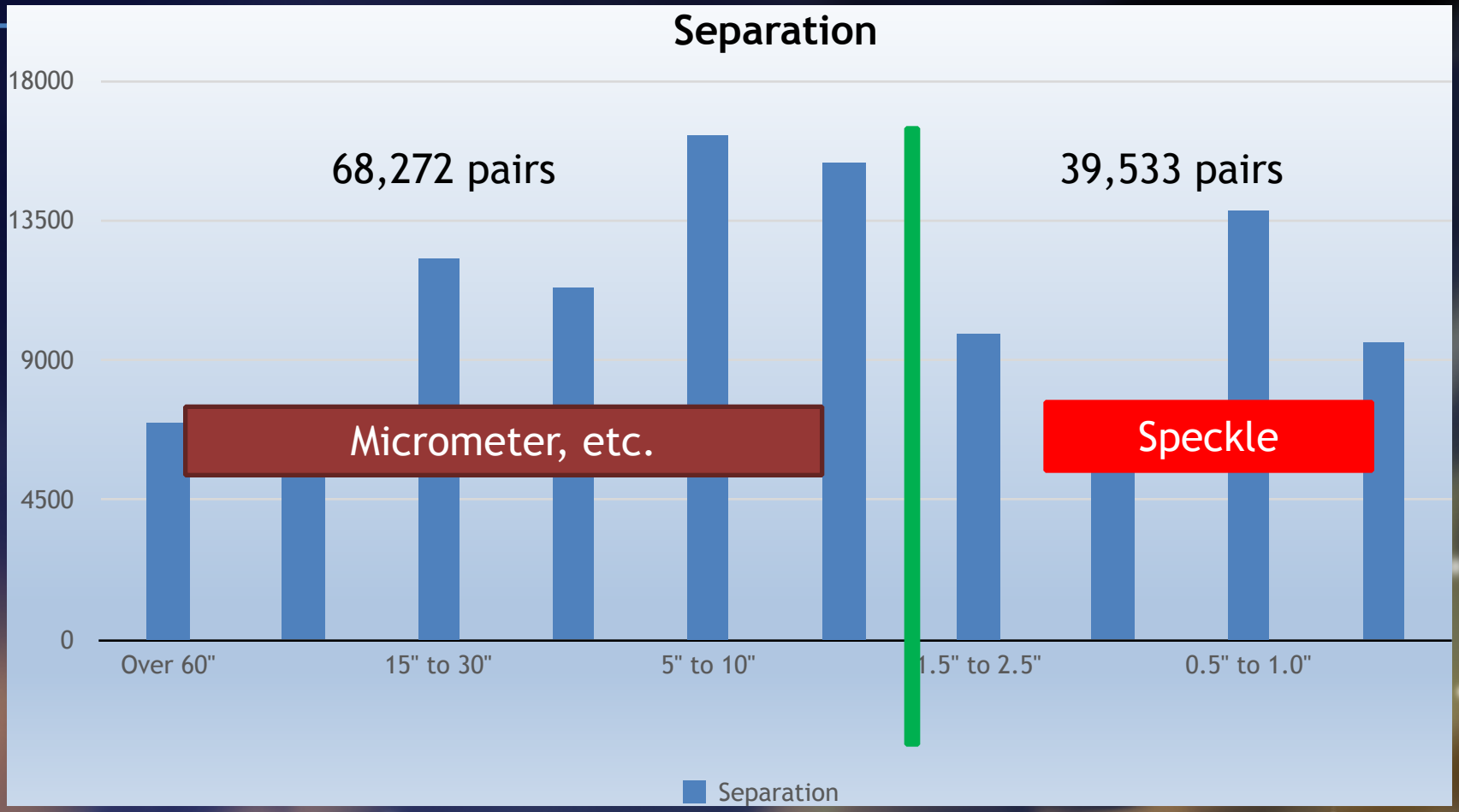
Need to have relatively short periods so we can "weigh" the stars

This in turn lets us fine-tune the H-R Diagram

Short periods imply very close separations

Wide pairs may take up to a million years to orbit; it may take millennia to gather enough data to solve the orbit

The Stats on the WDS



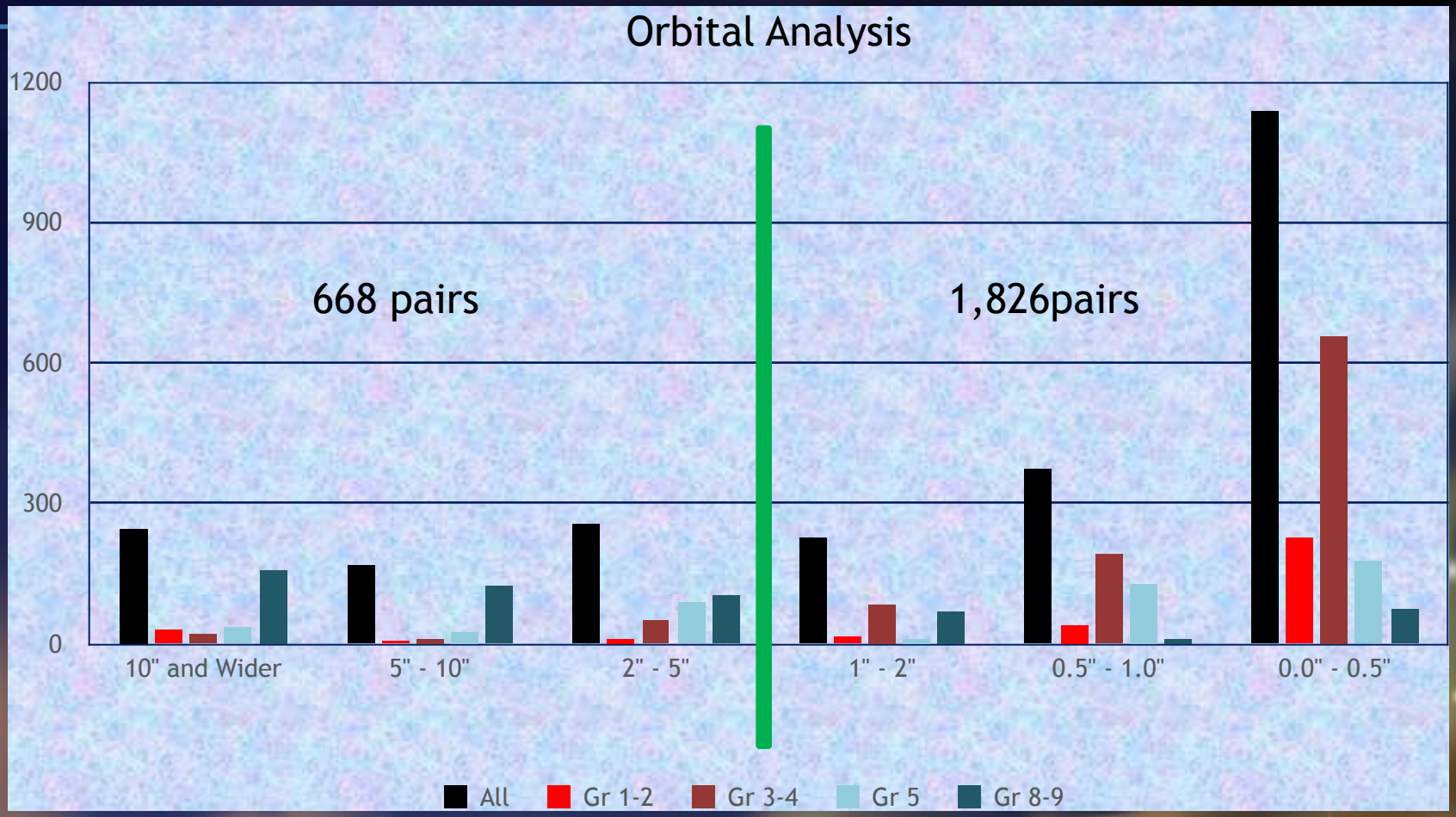
The 6th Catalog of Orbital Elements

2,494 Orbits

Masses computed on 4,988 stars

Orbits are graded from 1 (very good) to 9 (very iffy)

The 6th Catalog of Orbital Elements



Speckle Interferometry (Harshaw)

The WDS shows 1,702 total records of double star measurements by Heliometer

- Mean separation of 30.619”
- Median separation of 10.475”
- Leans towards much wider pairs!

Up to 2014, Heliometer systems had never been used for EMCCD Speckle Interferometry

The Physics of Convolution

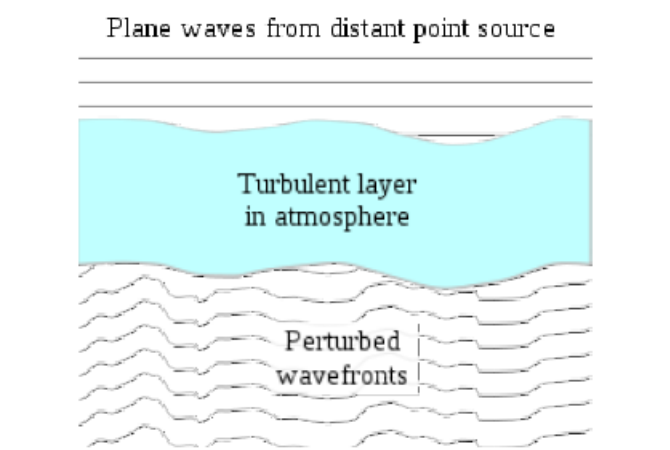


Figure 1
How the atmosphere distorts seeing at ground level. Diagram from Wikipedia.

David Fried, "Fried cells"

Kolmogorov

Enter Antoine Labeyrie (1970) (Father of Speckle Interferometry)

Attainment of Diffraction Limited Resolution in Large Telescopes by Fourier Analysing Speckle Patterns in Star Images*

A. LABEYRIE
Observatoire de Meudon

Received January 23, 1970

In the more realistic case of a single telescope, the proposed technique seems capable of giving useful astronomical data on star features, with a resolution reaching 0.02″. Its application requires the largest possible telescope and sensitive image receivers such as image intensifiers or electronographic cameras. The technique appears to be limited to objects brighter than $m = 7$ and it does not seem possible to use it for discriminating faint stars against the sky background.

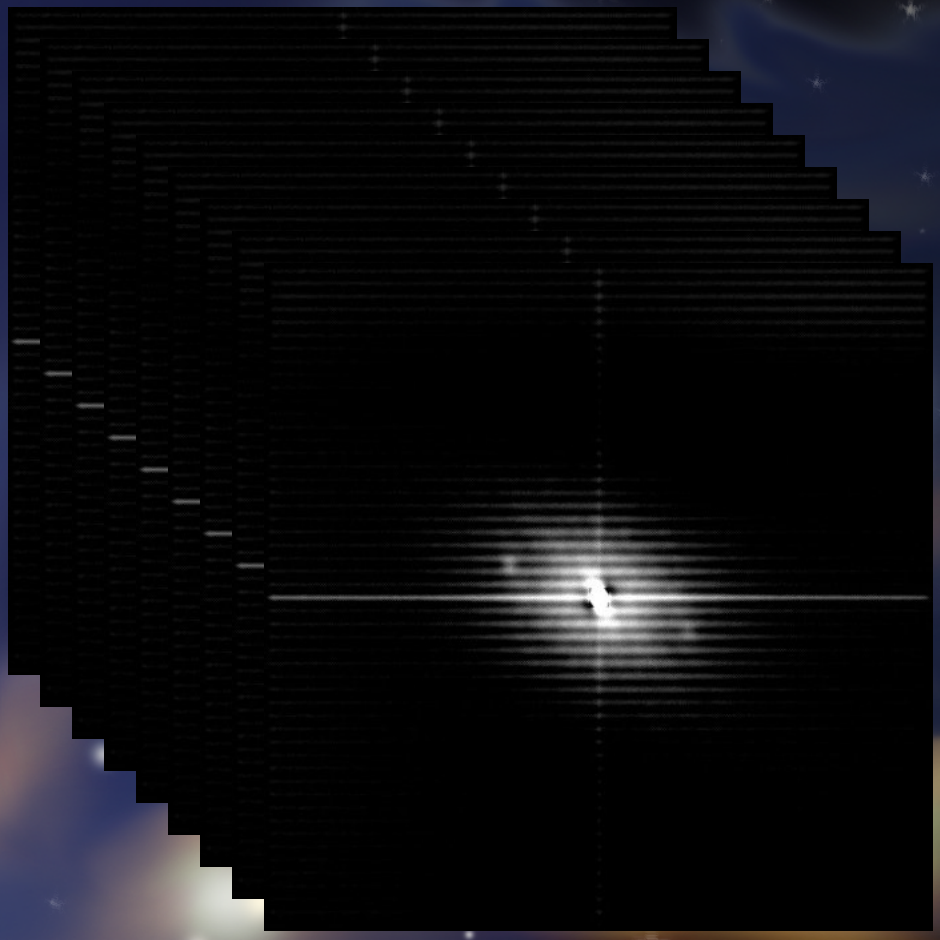
What We See at f50 (Yes, f50!)

Super Fast EMCCD Cameras

Up to 11,000 frames per second!

Composition of a FITS Cube

FITS = Flexible Image Transport System



Data Reduction

Trims out bad data and computes standard deviations, etc.

Solving With Plate Solve 3- No Deconvolution WDS 13491+2659

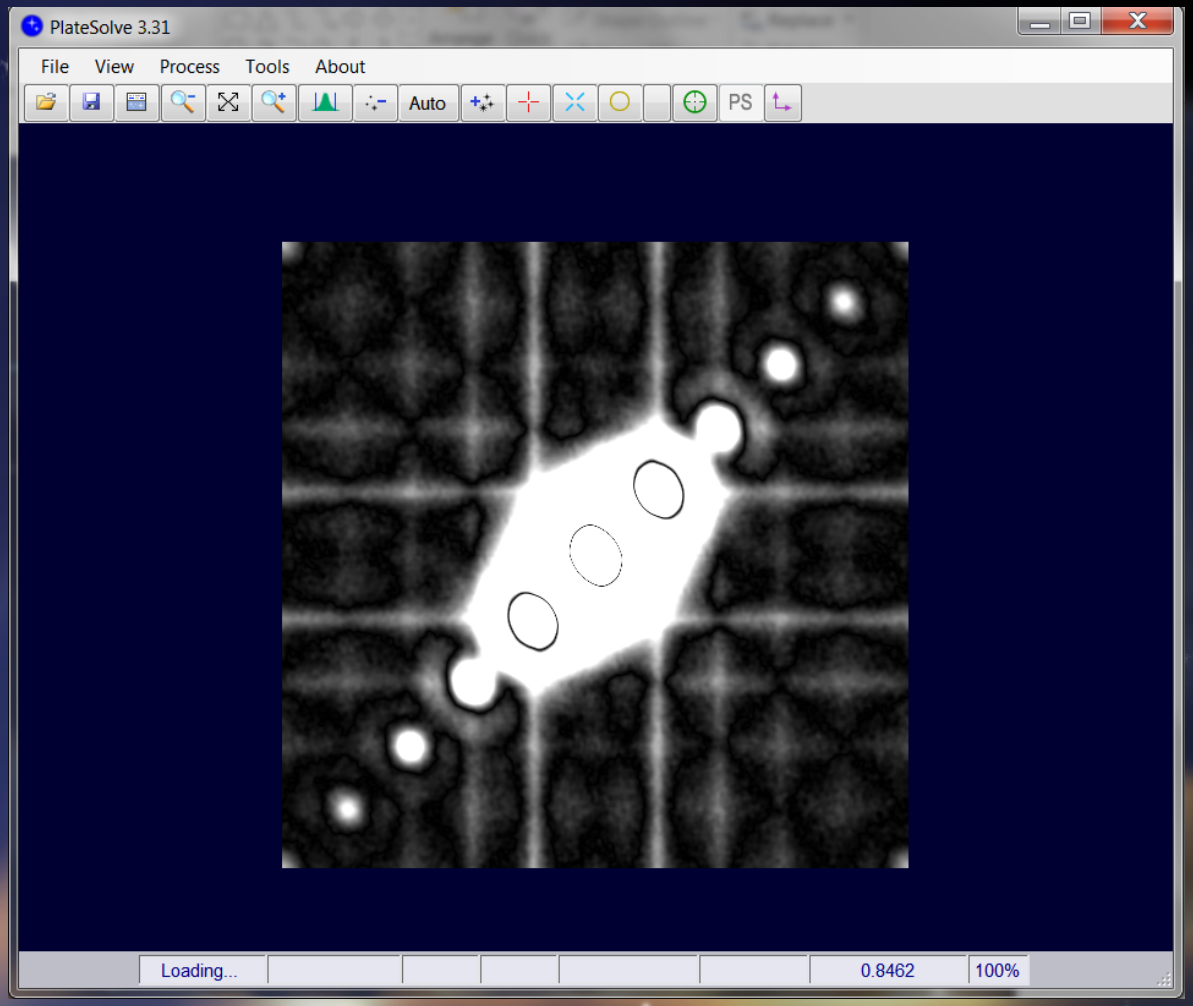
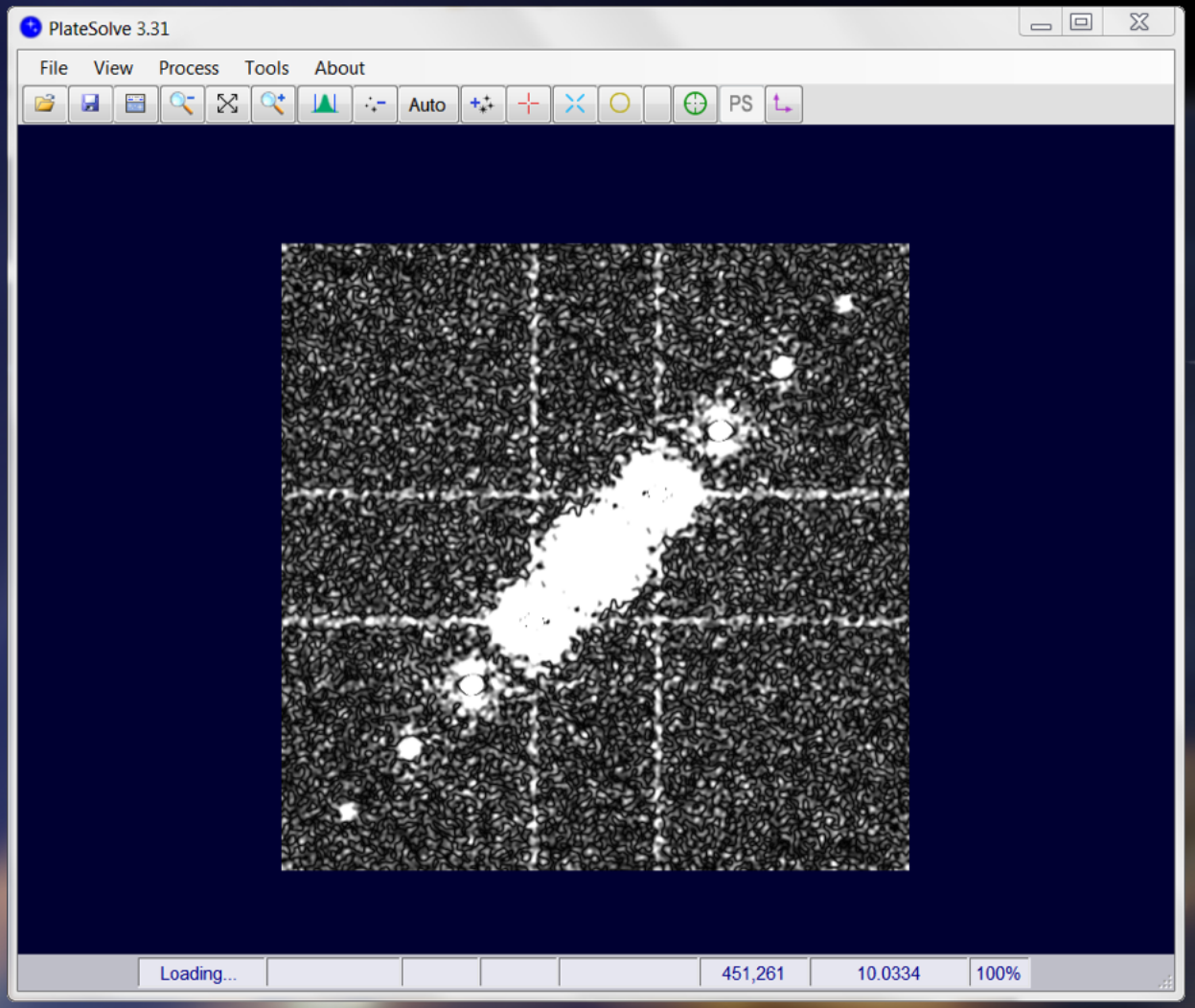
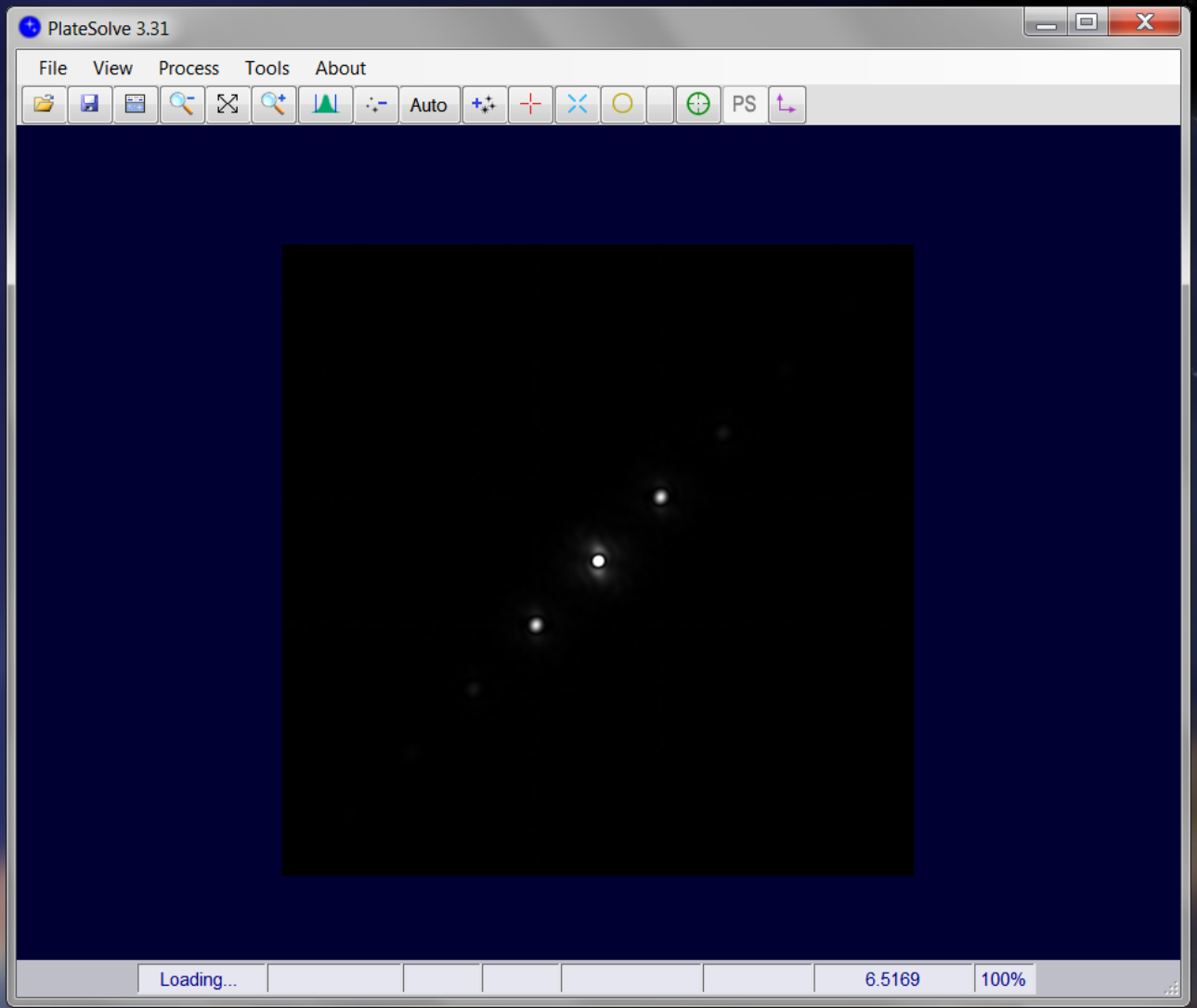


Plate Solve 3 With Deconvolution



After Cleanup

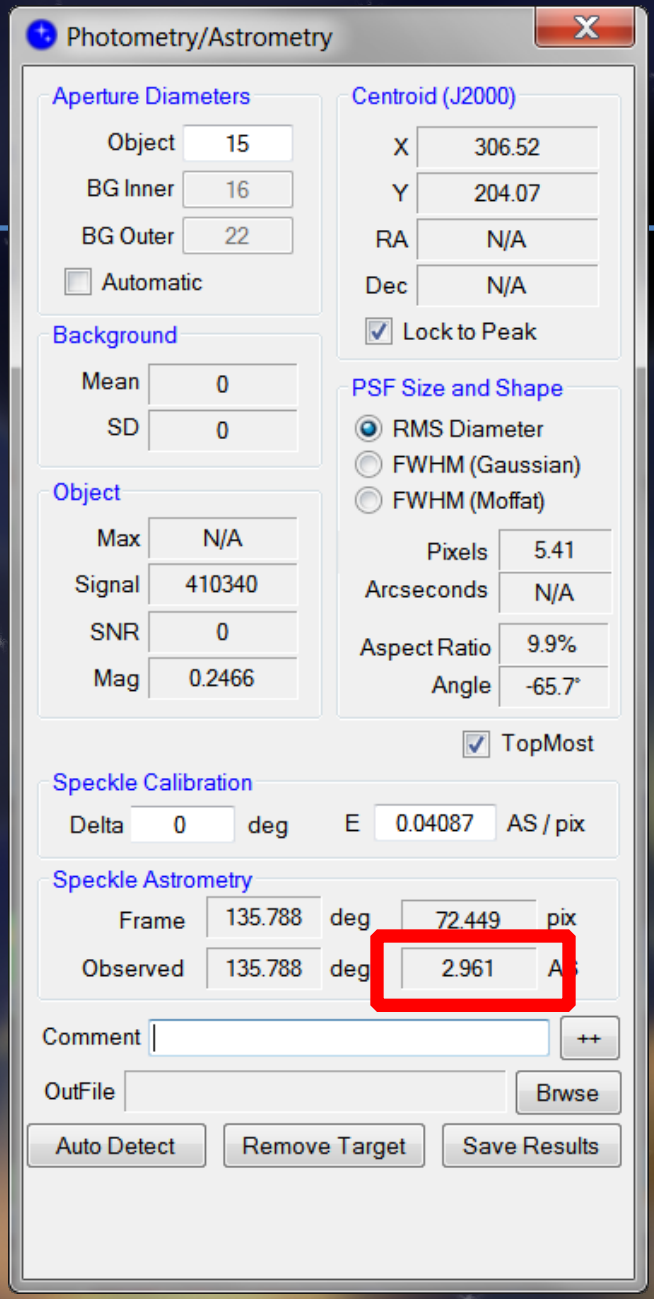


The Solution

On this night, this Grade 2 Orbit had a separation of 2.963” and position angle of 184.8°.

We are within 0.002” of arc on rho and ~50° off on theta, but then we did not correct for field rotation yet.

Accuracy ~ 1,000 x micrometer!



Conclusions

- ☆ Solar telescopes / heliostats CAN be used for speckle if properly collimated
- ☆ With most solar telescopes in heavy use during the day and mostly idle at night, a whole new instrument world opens for astronomers (both professional and lay) to do serious binary star research