Four Years of Speckle Interferometry at the WIYN Observatory

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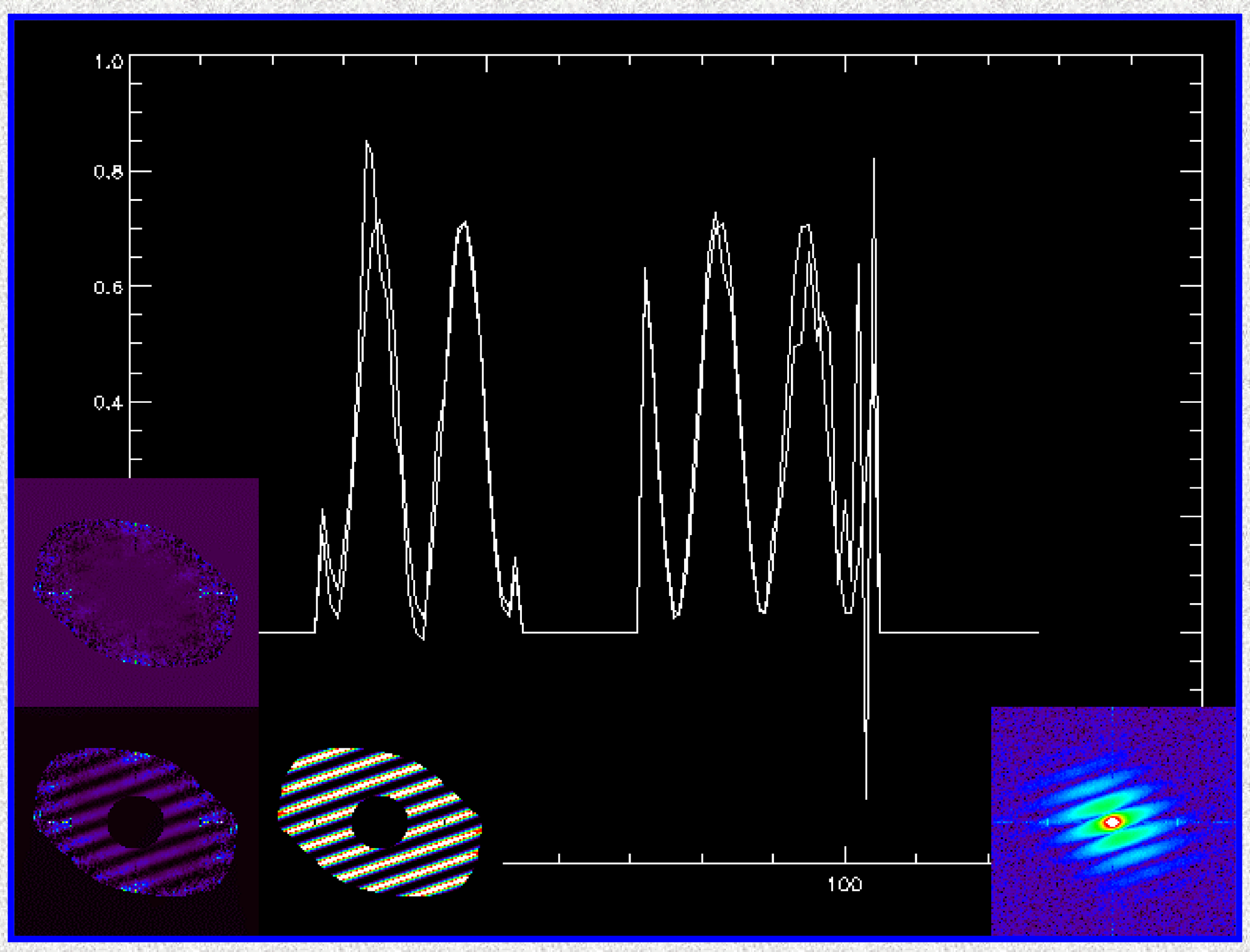
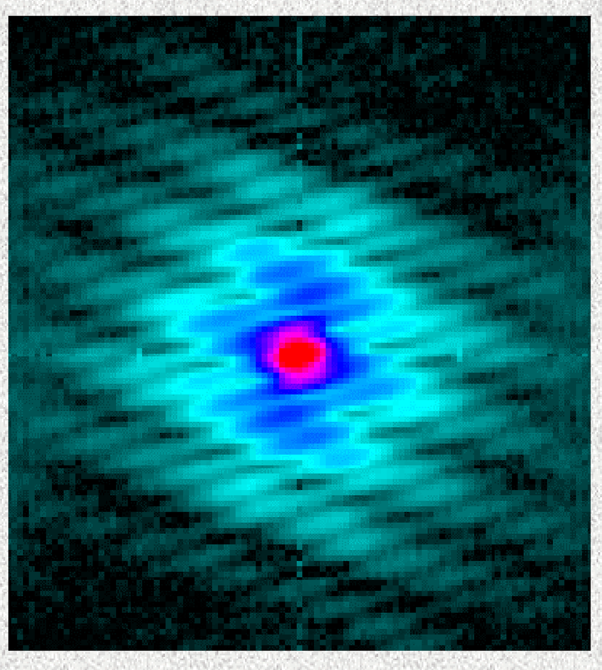
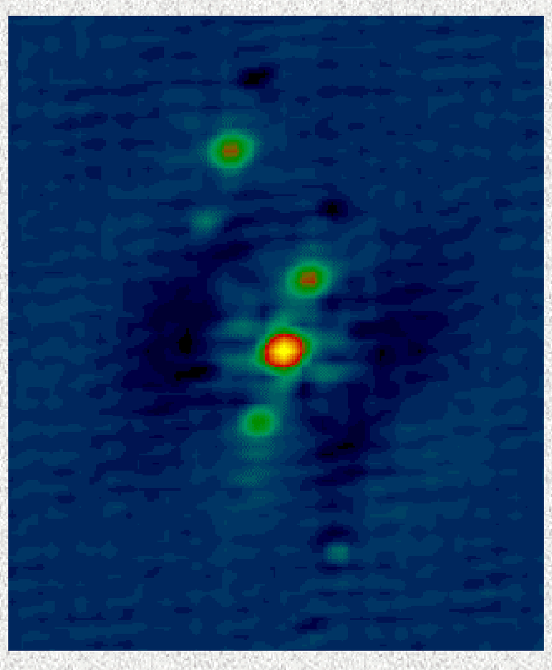
Current Projects

Classic Visual/Speckle Binaries

Observations of classical visual and speckle objects aided us in investigating the reliability and precision of WIYN data at the beginning of the program, but they also have been taken in order to refine the main sequence mass-luminosity relationship. Horch, Ninkov and Franz (AJ 121, 1583) showed reliable magnitude differences are possible with speckle interferometry. The promise for even better results from WIYN is high, due to the excellent seeing conditions at WIYN. R.M. and E.H. are currently studying the photometric precision of this data set. In addition to addressing Pop. I systems with WIYN, E.H. plans to study the mass-luminosity relationship of Pop. II systems with HST. Pictured below the reconstructed image and power spectrum of the triple system BU 1295. Note the double set of fringes in the power spectrum image, which indicate two companion stars. The orbits of the components of BU 1295 have been well documented, but only recently has it been possible to begin measuring the magnitude differences between the three stars.





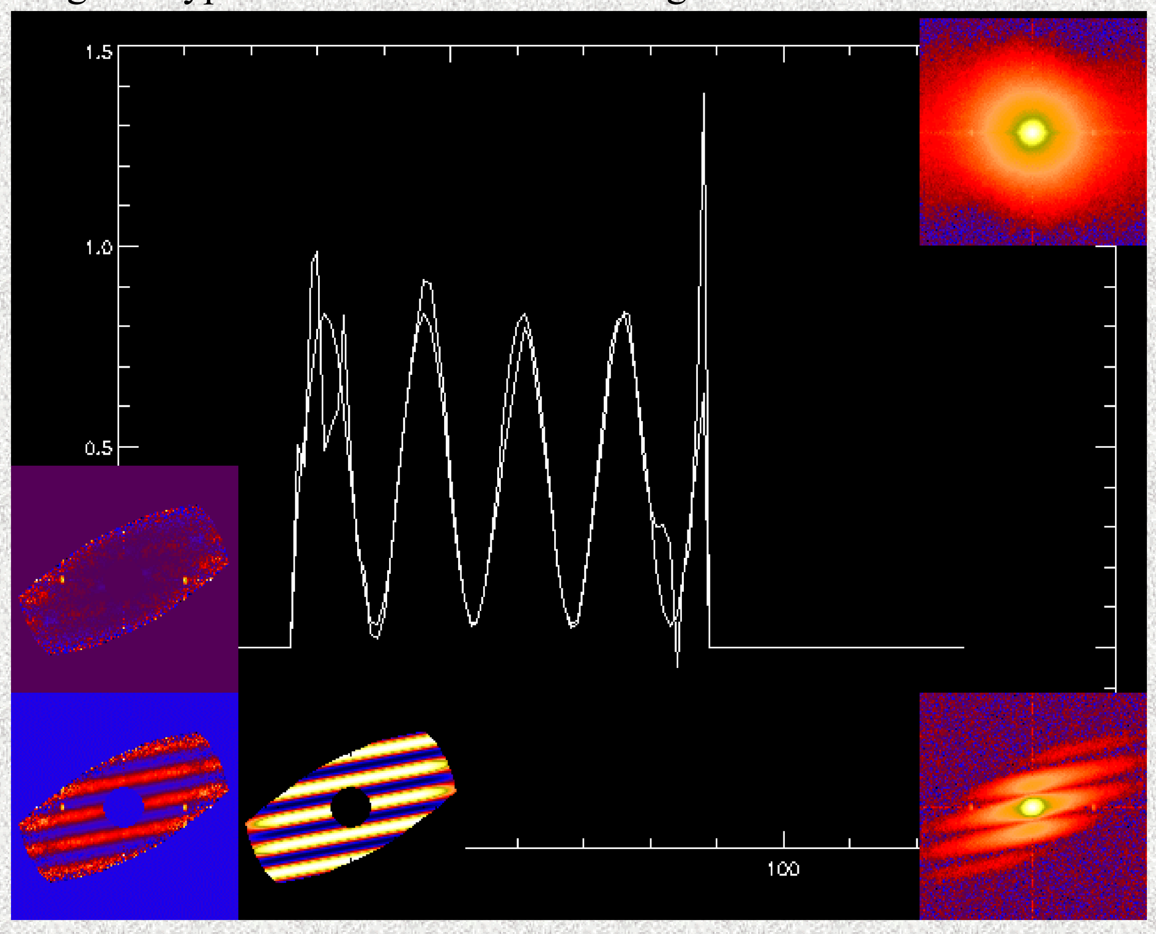


Hipparcos Double Stars

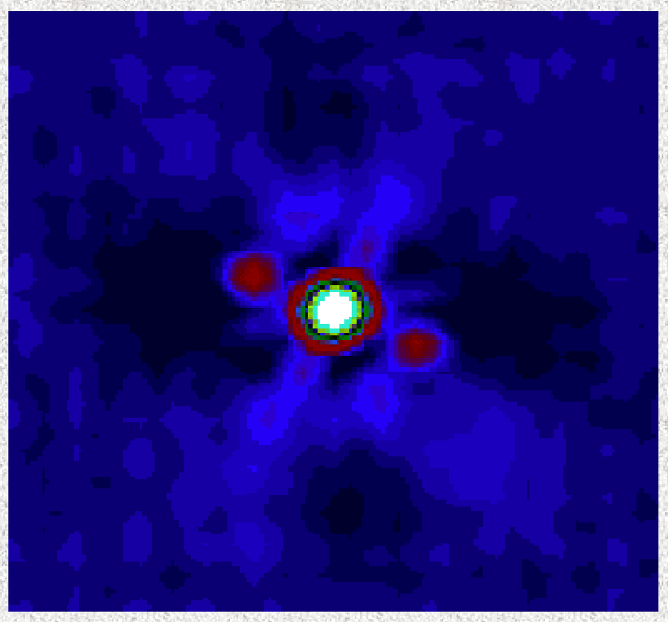
In addition to determining the trigonometric parallaxes for 118,000 stars, the Hipparcos satellite also discovered approximately 3400 previously unknown double star systems and flagged thousands of other objects as "suspected double." Since its inception, the WIYN speckle program has been surveying these stars. The main goal of this project is to obtain the necessary relative astrometry to determine which pairs are gravitationally bound. For those systems that are gravitationally bound, we plan to take spectroscopic observations to obtain the mass fraction. Two of us (E.H. and R.M.) are now working on deriving component magnitudes from the speckle observations (for the method, see Horch, Ninkov & Franz, AJ, 121, 1583 -- reprints below) which lets us investigate the evolutionary stage of the component stars. WIYN is well suited to following up on the suspected Hipparcos doubles since it has a significantly larger aperture than that of the satellite. In 1999 and 2000, we observed 281 Hipparcos doubles at WIYN and obtained astrometry of a binary companion for 131 systems. Out of 53 Hipparcos suspected doubles, 2 have shown secondary peaks indicating binarity; these objects are listed under the new discoveries heading. Pictured above is a model of the interference patterns in HD 222104 = Hip 116578, observed on 10/05/00.

Space Interferometry Mission

In collaboration with S. Urban, B. Mason and others at the USNO (see BAAS 31, 1440), we have used WIYN to obtain data on objects from the Navy's list of candidate stars for the SIM grid. Two main ideas emerged concerning the makeup of the candidate list; the Navy favored nearby A5 to G5 stars, while others argued for a distant grid in order to minimize the parallax of the grid stars. It now appears that the SIM grid will be composed mostly of objects more distant than those on the Navy list, but these stars can still be used as a proxy sample to give insight into the overall duplicity statistics for the final grid. We have analyzed images of 244 SIM targets observed between 11/19/99 and 10/05/00, of which 5 showed multiplicity (data from 10/06 and 10/07/00 still need to be evaluated). Final results of the SIM study will be submitted for publication later this summer. Below is a fit to the fringe patterns of newly confirmed double H 17895, a SIM target as well as Hipparcos suspected double. In the upper right corner of the image is the power spectrum of H 11873, a point source whose lack of fringes is typical of most of the SIM targets we observed.

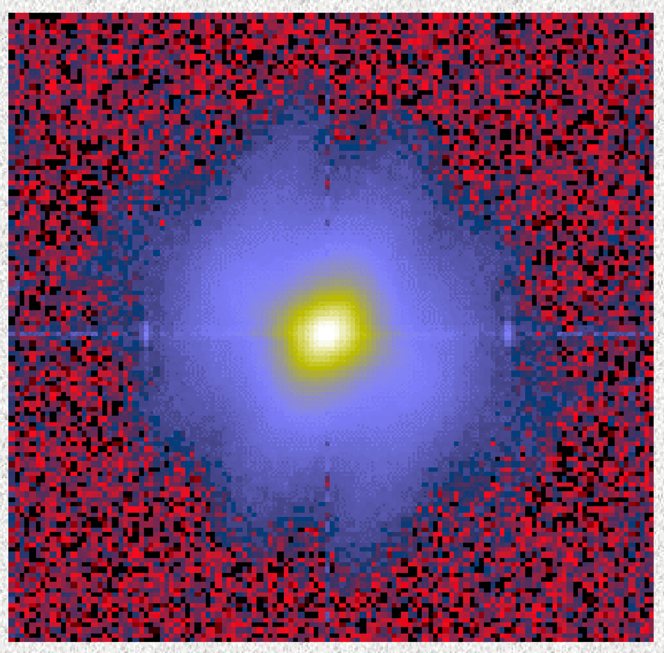


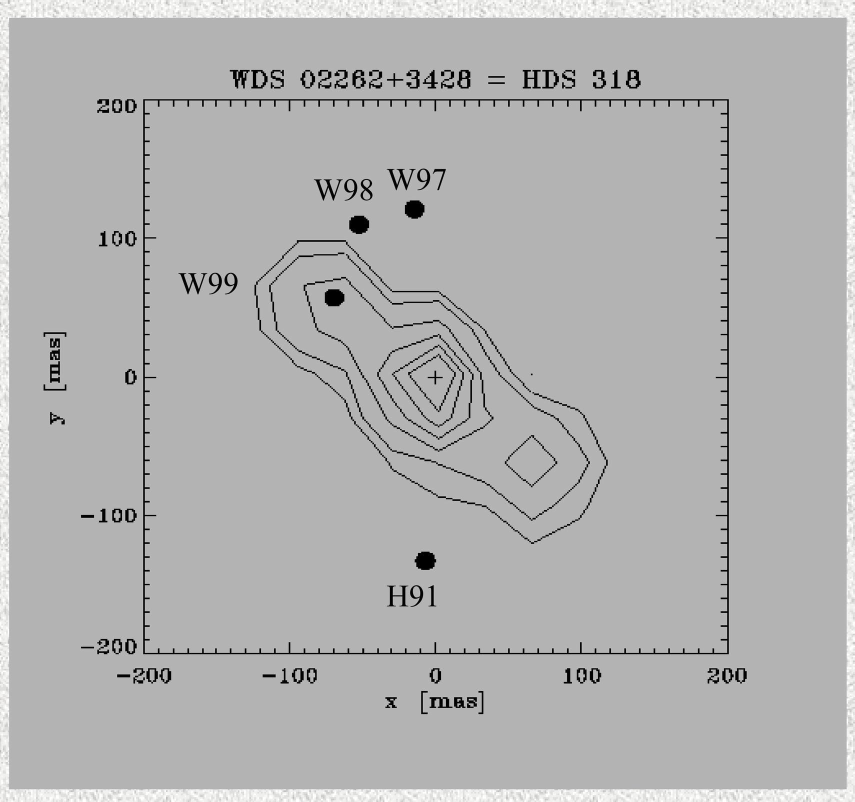
Latest Discoveries

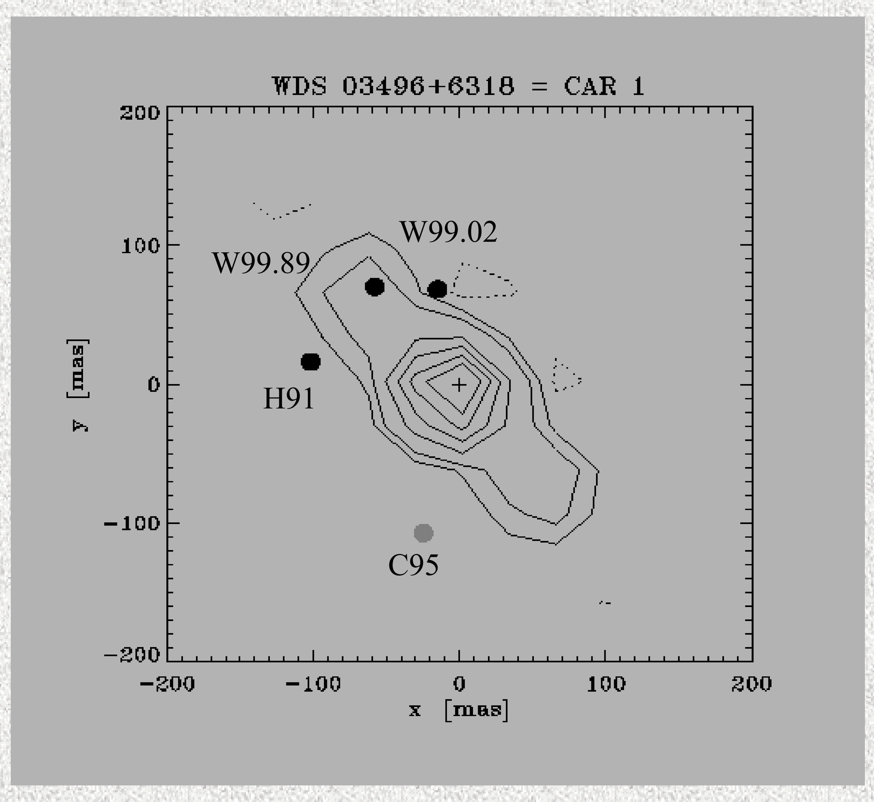


New Companion Stars

In 1999 and 2000, we were able to detect multiplicity in 5 previously undiscovered apparent binary systems from the SIM list. We also confirmed the multiplicity of 2 Hipparcos suspected doubles. Pictured at left are the reconstructed image (with ghost peak artifact of "quick and dirty" secondary quadrant determination) and power spectrum of T342, whose companion star was first observed on 11/20/99 at a position angle of 245.9° and 181 mas. We will continue to observe these recent discoveries in order to calculate the orbits, and eventually the masses, of the component stars. Below is a list of the speckle binaries discovered from November 1999 to Oct 4, 2000 (S denotes SIM target and H denotes Hipparcos suspected double).







Recent Discoveries

Project	Obs. Date	Name	θ (°)	ρ(mas)	Δm
S	11/20/99	T 030	289.2	542	3.67
S	11/20/99	T 342	245.9	181	2.17
S	11/22/99	T 097	86.4	417	2.76
H	11/22/99	H 115279	282	122	0.88
S	2/23/00	H 58661	162	51	0.11
H	10/4/00	H 16930	71.9	124	1.41
S	10/5/00	H 17895	9.9	277	0.56

The Next Step: Orbit Determination

Pictured above are orbits of two true Hipparcos binaries. After successfully resolving the secondary star, the next step is to make sure the two objects are gravitationally bound. Both systems pictured above show an elliptical path for the secondary star that can only be explained by gravitational binding between the two components. Because these objects have a small angular separation between components (and therefore short orbital period), we expect to be able to calculate orbits after another few speckle observations. The points indicating the orbit of the secondary star are overlaid on a contour plot of the system's reconstructed image at the time of the first WIYN observation. The contours show 3 peaks on each image, which correspond to the primary star, the secondary and a ghost peak opposite the secondary, which our "quick and dirty" quadrant determination does not remove.

Unique Features of WIYN Speckle Program

Detection System and Seeing Conditions

By using the RIT large-format fast readout CCD, which has performed as well as expected (see Horch, Ninkov and Franz, 1999AAS…194.0904H), we are able to record images over the entire surface of the detector before readout, greatly improving the overall observing efficiency. The 0.8 arcsec median seeing conditions at WIYN and the linear response of the fast-readout CCD have allowed us to collect distinctly high quality data. In a typical night, we observe around 100 binaries, and speckle observing is interspersed with Hydra multiobject spectrograph observations in order to maximize the time spent on science targets. Currently, each speckle observation is compared with a point source image taken at about the same time, but R.M. is working on a method to eliminate the need for point source comparisons and therefore increase the time available for observations of binaries.

Magnitude Differences

E.H. and R.M. are currently studying the quality of the differential photometry obtainable from the WIYN speckle data. Horch, Ninkov and Franz (AJ 121, 1583) showed reliable magnitude differences are possible with speckle interferometry using a data set obtained using the Helen Sawyer-Hogg Telescope and the Lowell-Tololo Telescope at CTIO, Chile. WIYN data are higher quality, so they should enable more accurate differential photometry than CTIO data. In 1999-2000, we successfully resolved a 5 systems with Δm > 4, including 1 with Δm=5.3.

Pictured at right: aerial view of WIYN observatory (image from http://www.noao.edu/wiyn/wiynis.html).