Speckle Interferometry at SOAR

Andrei Tokovinin

Speckle interferometry is an observing technique that reaches diffraction-limited resolution in the visible, for relatively bright targets. This method has a well-established niche between long-baseline interferometers (higher resolution on even brighter stars), adaptive optics in the near-infrared, and the Hubble Space Telescope. Nearly all modern observations of visual binaries are done with speckle.

Two successful speckle runs have been completed at the SOAR 4.1-meter telescope in October 2008 and April 2009. A very simple camera (Tokovinin & Cantarutti, 2008, PASP, 120, 170) with electron-multiplication CCD, interfaced to a standard PC via USB (figure 1) was used to acquire a series of short-exposure images where individual photon events stand above the readout noise. The pixel scale is 15 milliarcseconds. With narrowband filters, binaries of V = 10 magnitude are easily accessible. The software developed by R. Cantarutti has the full functionality required for operating this instrument and, most importantly, a built-in quick-look image processing to evaluate the result immediately after taking the data.

Accumulation of the data cube takes only a few seconds. With optimized strategy, more than 100 stars per night can be observed, beating in productivity current adaptive optics systems and resolving binaries down to a 20-milliarcsecond separation. Hundreds of binaries were measured during two SOAR runs. A dozen new components or sub-systems were discovered, changing our view of nearby multiple stars. Owing to its high dynamic range, our camera detects close companions that are five magnitudes fainter than their primary stars. It delivers relative astrometry accurate to one milliarcsecond, as well as relative photometry of close binaries.

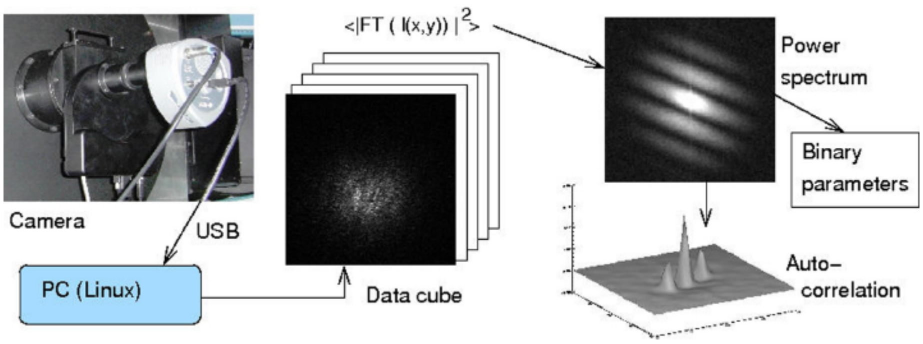

Figure 1: Data flow from telescope through image processing to final result. The binary FIN 334Aa illustrated here had separation of 0.102 arcseconds.

The speckle camera has been developed for work with the SOAR Adaptive Module (SAM). The number of photons per speckle is inversely proportional to the cube of the image size, so a gain of two times in resolution translates to eight times in sensitivity. We shall further boost the sensitivity by using wider filters (this is prevented now by the lack of an atmospheric dispersion corrector) or a better detector. While SAM by itself will not reach the diffraction limit in the visible (especially with a laser guide star), its combination with the speckle camera will bridge this gap, opening a unique science opportunity. Figure 2 illustrates this future capability with the data taken under 0.5-arcsecond seeing in April 2009. Meanwhile, the stand-alone speckle camera can be used as a "visitor instrument" at SOAR.

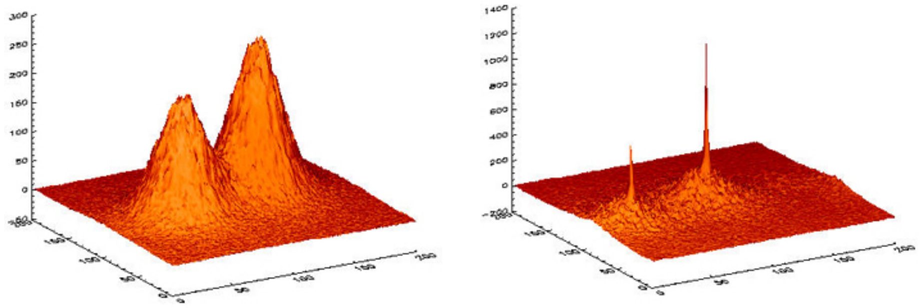

Figure 2: Short-exposure images of the 1.08″ binary star were co-added with re-centering on the global centroid (left), or on the brightest pixel, selecting the sharpest 10 percent of images (right). The latter method, recently dubbed "lucky imaging," is slowly gaining popularity. Here it is applied at the SOAR 4.1-meter telescope at a 540-nanometer wavelength under very good seeing. Similar performance will be achieved routinely by pre-compensating images with SAM, as was already demonstrated at the Palomar 5-meter telescope.

Final Integration & Testing of the SOAR Adaptive Module (SAM) Preparing for Commissioning in NGS Mode

The SAM Team

After a successful first integration & testing round, the SOAR Adaptive Module (SAM) was disassembled to permit last modifications and improvements, products of the analysis of the instrument performance during the testing. The main module was anodized in our shops, and is now colored a distinguished gray on the outside, while the inside is painted black. In mid-April the main module returned to the laboratory where SAM will be re-assembled, aligned, and tested during the coming months. SAM is on schedule to be taken to the SOAR 4.1-meter telescope for the first commissioning run in August, during which the instrument will operate in Natural Guide Star mode.

During the break in testing for modifications and anodizing, Roberto Tighe and Andrei Tokovinin made extensive laboratory tests on the recently received 10-Watt ultraviolet laser, which has passed all requirements successfully. This will permit the design of the laser box to proceed.

For updates and pictures on the integration of SAM, go to: *www.ctio.noao.edu/new/Telescopes/SOAR/Instruments/SAM/*.

Andrei Tokovinin and Roberto Tighe working in the Optics Laboratory with the Laser Test Set-up.

WHAM Installed on Cerro Tololo

Matt Haffner & Ron Reynolds (University of Wisconsin)

After an extremely successful eleven years surveying the northern sky from Kitt Peak, the Wisconsin H-Alpha Mapper (WHAM) began operation from CTIO in March. A smooth port arrival and two-week installation was made possible by outstanding help from CTIO and AURA Observatory Support Services staffs. Final testing and commissioning of WHAM's fully-remote observations are progressing with full operation expected by mid-year.

WHAM will devote much of its first two years at Cerro Tololo to finishing an all-sky Balmer-alpha spectroscopic survey of the diffuse ionized gas of the Milky Way. However, its multi-wavelength, wide-field Fabry-Perot spectrometer has proved to be an extremely powerful tool for a variety of astronomical and aeronomy projects. In particular, from its new southern location, WHAM will not only be exploring the unique features of the southern Galaxy, but will also be able to study the extended ionized environment of the Magellanic Clouds, Bridge, and Stream.

WHAM being tested during full moon at Cerro Tololo with the Blanco 4-meter telescope in the background. (Image credit: Alex Hill)

More information about the project can be found at: *www.astro.wisc.edu/wham/*