Portable Speckle Interferometry Camera Checkout at Kitt Peak

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The National Optical Astronomy Observatory (NOAO) Time Allocation Committee (TAC) awarded eight nights on the 2.1m telescope at Kitt Peak National Observatory for double star speckle interferometry using a portable camera. As described in the proposal, binary orbits, when combined with parallaxes, yield dynamical masses, while photometry of the components restrains astrophysical models. Both are vital to understanding stellar evolution. Speckle interferometry, which is telescope resolution limited as opposed to seeing limited, allows observation of close, short-period binaries. A portable, low cost, EMCCD-based speckle camera will be used to observe several hundred binaries. The run will confirm Hipparcos/Tycho double star discoveries as candidates for new binaries, classify new pairs by determining if their motion is curved (gravitationally-bound binary) or linear (mere optical double), add high-accuracy speckle observations that will allow the first determination of orbits, refine existing orbits by extending orbital coverage with speckle observations, and obtain precise photometry of binary components to link photometric with dynamical masses.

The run was set for 15th-23rd October 2013. Tuesday the 15th was set aside for test and engineering, while the remaining nights were dedicated to observations. To fully utilize this large block of time and accommodate the largest number of students, the observing was split into two four-night sessions, with separate teams for each session. Team A used the 16th-19th (Wednesday-Saturday), while the 20th-23rd (Sunday-Wednesday) was used by Team B. Speckle observations require intense, fast-paced coordination between a telescope operator, a speckle camera operator, and a session director that selects targets, logs data, etc. An additional observer to reduce data on the fly is also helpful. The run will feature a number of undergraduate and graduate student observers as full team members.

Figure 1. Russ in front of the dome of the 2.1-meter telescope.

The 2.1-m / 84-inch telescope is on the south end of the Kitt Peak summit complex, conveniently close to the dining room. Construction began in 1959, with first light in 1964. In Figure 1, Russ stands by the “Beware of Snakes” sign. Hillary Mathis opened the dome slit slightly (pointing north) to let in light for camera installation.

Figure 2. Looking north from the porch of the 2.1-m is a view of the 4-m Mayall and several other telescopes.

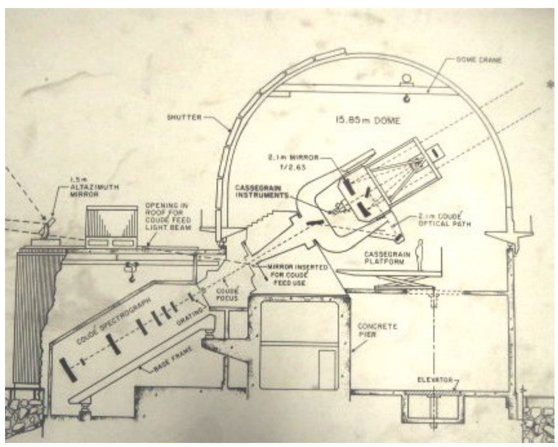

Figure 3. Cutaway of the 2.1-m telescope.

The Coude feed from the auxiliary 0.9-meter telescope is still operational (Figure 3). The Cassegrain platform is very useful for removing and installing instruments, although instrument operation is conducted from the warm room.

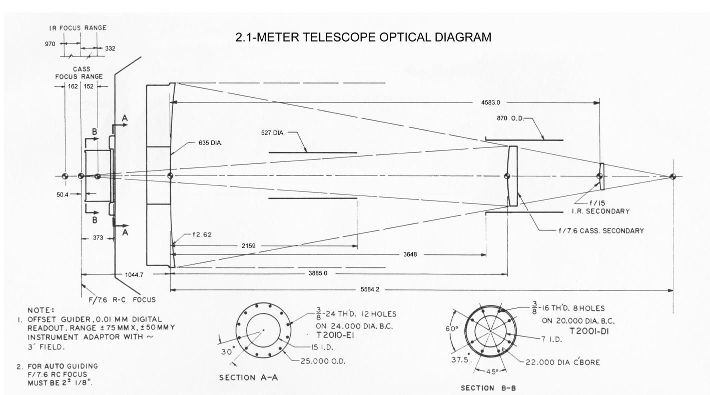

Figure 4. Optical layout of the 2.1 m telescope.

With the F/7.6 secondary in place, the effective focal length of the telescope is 16,200 mm. Our speckle camera has a magnification of about 8x, providing an overall effective focal length of about 129,600 mm and F/ratio of 61.7. This gives a plate scale of about 1.6 arc seconds/mm or 0.016 arc seconds/pixel (10 micron pixels in our Andor Luca-S EMCCD camera). With the Acquisition/Guider unit installed there is only 2 inches of back focus. Our camera is really lightweight, so Hillary Mathis installed lead counterweights to balance the telescope (Figure 5).

Figure 5. Hillary Mathis installing counterweights on the telescope.

Figure 6. Thomas Smith attaching speckle camera to the Kitt Peak-provided plate.

Tom Smith fastened our camera with its 12x12-inch, ¼-inch thick aluminum plate to a larger, round, ½-inch thick aluminum Kitt Peak plate (Figure 6) that had been used to interface an earlier visitor instrument. This "used" plate saved us from making and transporting a large, heavy plate to Kitt Peak. Hillary and Brent then installed the Kitt Peak plate with our speckle camera fastened to it (Figures 7, 8).

Figure 7. Installing the camera assembly on the telescope.

Figure 8. Hillary and Russ check the speckle camera connections.

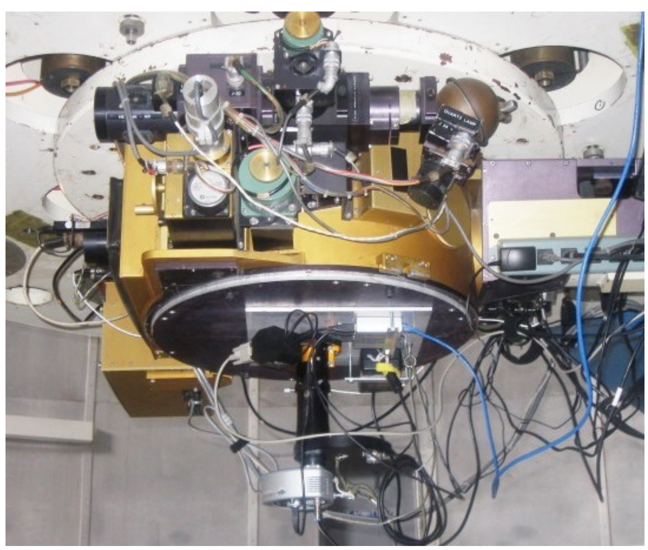

Figure 9. Speckle camera installed.

Figure 9 shows our camera mounted onto the acquisition/guider unit which has three 45° mirrors in the system. Two face toward the guide camera, while the other faces toward the wide-field camera. The guide camera and wide field camera are mounted 180-degrees apart (although the power switches for the two cameras are actually next to each other). The thru position is between the two mirrors that face the guide camera. The "idt" position centers one of the guide mirrors. The "widefield" position moves the slide further along its travel to put that last mirror into position.

A Moonlite motorized focuser allowed us to be parfocal with the 2.1-m telescope's acquisition camera. As there was only 2-inches of back focus (and ¾ inch was used up by their ½ inch thick plate and our ¼ inch thick plate), we placed a negative lens (taken from an OPT 2-inch Barlow) that extended from our focuser up into their Acquisition/Guider to extend the back focus. This lens also provided some of our required magnification. Moonlite Telescope Accessories added set screws on the bottom of our focuser's draw tube to fasten the negative lens. The lens conveniently unscrewed from the 2-inch OD, 2X OPT Barlow. Also mounted on our plate were an Icron Ranger USB extender and the power supply for our Andor Luca-S EMCCD camera. Inserted into the Moonlite focuser were a 4X Tele Vue Powermate, an Orion seven-position filter wheel (Johnson Cousins BVRI, Sloan r'i', and H-alpha filters), and the Andor Luca-S EMCCD camera. A 50-foot Category-5 cable connected the speckle camera to the camera-control laptop in the warm room.

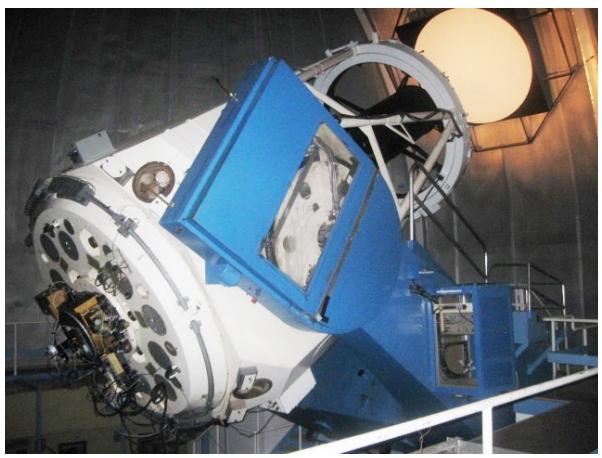

Figure 10. 2.1-meter telescope with speckle camera.

Our speckle camera was dwarfed by the 2.1-m telescope. Figure 10 shows the telescope pointed at the dome flat position. We turned on the flat lights distributed around the top ring of the telescope.

Figure 11. Russ at the telescope operator's station.

Although NOAO has provided 2.1-m telescope operators in the past, users now operate the telescope themselves after reading the instruction manual *(http://www-kpno.kpno.noao.edu/2m-manual/)* and receiving instruction (Figure 11). Two panels (A behind Russ and B with the two round position readouts) are used in conjunction with two computer monitors with GUIs to control the telescope. An additional monitor displays the telescope's position and other key information, while video monitors display the output from the acquisition and guide camera.

Figure 12. The control room. From left to right: Dave Summers, Kent Clark, Tom Smith, and Paul Wren.

Dave Summers taught us how to run the 2.1-m telescope. We took turns operating the three positions: telescope control, camera control, and session director. In Figure 12, Kent Clark is operating the telescope, Tom Smith is operating the speckle camera, while Paul Wren is the session director selecting the next target and keeping the detailed log. Although our checkout was in the middle of the monsoon season and, not unexpectedly, it was cloudy, we still pointed the telescope at the stars and went through all the procedures. These included loading our targets (supplied by Eric Weise) into the telescope's cache, acquiring our targets, fine-positioning the telescope and camera's Region of Interest (RoI), etc.

Besides learning how to open and close the observatory and operate the telescope, we developed and checked procedures for preloading our targets into the telescope's cache and for transferring data from the telescope control system to our data log. We also developed a written procedure for coordinating the operation of the three operating positions, and made notes for improving the master spreadsheet the session director uses to select the next target to observe.

Figure 13. Russ and Di Harmer.

Di Harmer paid us a visit during our checkout (Figure 13). Di is a good friend of Bob Argyle, the double star expert at Cambridge University.

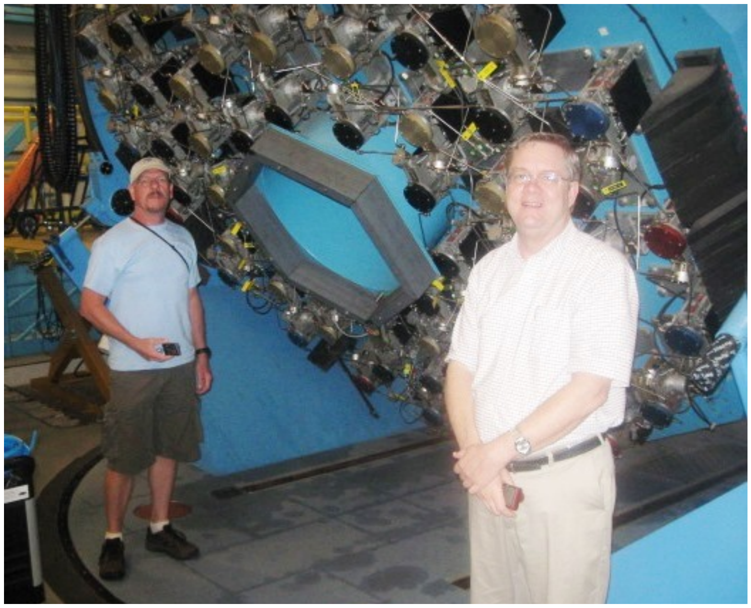

Figure 14. Tom and Kent at the WIYN telescope.

After our engineering checkout, Dave Summers kindly gave us a tour of the 3.5-m WIYN telescope. Tom and Kent stand by the back of the WIYN's primary mirror (Figure 14) which has many active supports controlled by an algorithm. The active supports can also be manually fine-tuned by the telescope operator.

Figure 15. Russ at the 4-meter telescope.

Dave also showed us around the 4-meter telescope. Russ poses in front of the large RA disc (Figure 15). The optical tube assembly (OTA) was tipped over for maintenance, although the Cassegrain cage is visible on the left.

Acknowledgments

We thank NOAO instrument scientists Richard Joyce and Di Harmer for their assistance in the design of the speckle camera/2.1-m telescope interface, David Mills for providing a telescope parameter extraction program, and Bellina Cancio for her help with quarters and other logistical matters. We also thank Vera Wallen for reviewing this manuscript. The Andor Luca-S EMCCD camera was funded through an American Astronomical Society Small Research Grant, while Andor made the camera available at a reduced price. We are grateful to both organizations. Moonlite Telescope Accessories modified their motorized focuser to accommodate the inward facing negative lens.