New Robotic 32-Inch Relay Telescope

Mario E. Motta
19 Skipper Way, Gloucester, MA 01930

Presented at a memorial symposium in honor of Dr. Janet A. Mattei, Brandeis University, Waltham, MA, October 29, 2004; received January 18, 2005; accepted January 19, 2005

In order to greatly increase my observing time and to shorten the time to observe transient phenomena such as gamma-ray bursters, I have undertaken to develop a new observatory with a state-of-the-art robotic telescope as physically part of my home. Up to this point, travel to my dark-sky observatory in New Hampshire required about a 90-minute drive. With a recent move to Gloucester, Massachusetts, and a reasonably dark-sky site, I have built a new 20-foot dome as an integral part of my new home, blessed with an excellent horizon and dark sky.

To take advantage of this new site, I have, with the assistance of Scott Milligan and others in the Amateur Telescope Makers of Boston, designed a new telescope—a "Relay Telescope." In this design there are a number of significant advantages over a conventional Newtonian, Cassegrain telescope, or even a Dall-Kirkham telescope. The main advantage is that all of the optical elements are spherical surfaces; there are no aspherics to grind and polish, allowing for highly accurate and smooth surfaces. The optical design involves a 32-inch primary mirror, a 7.8-inch Mangin secondary mirror, and four 3.8-inch corrector lenses (see Figure 1).

The primary (Figure 2), which was cast by Wangness Optics in Tucson, is 32 inches in diameter, and tapers from a central thickness of 4.5 inches to 1.5 inches at the periphery. It has a ribbed back to allow rigidity, but allows fairly rapid temperature equilibration. This will be ground to a f/3 spherical surface. The Mangin-type mirror intercepts the cone of rays converging from the primary in

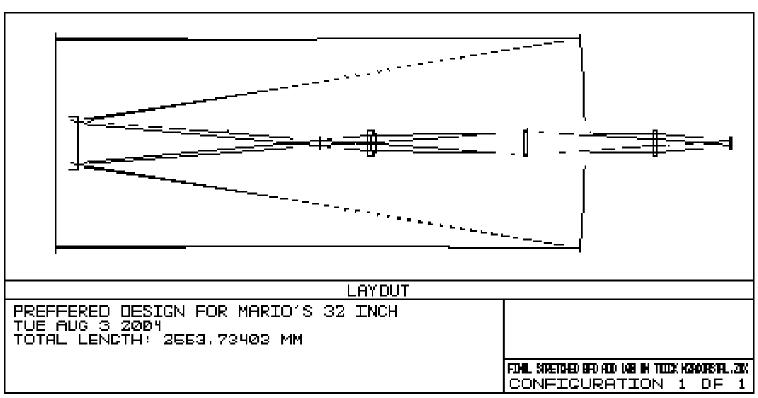

Figure 1. Optical design of the 32-inch telescope.

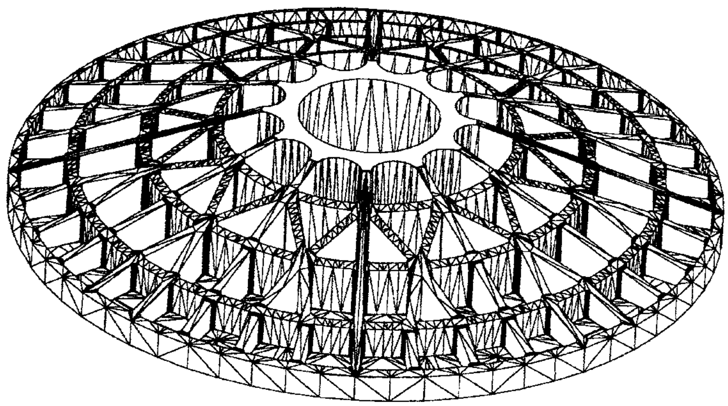

Figure 2. Design of the 32-inch primary mirror.

front of the primary focus. The plano side of the Mangin is reflective coated, and must be figured to a high degree of regularity ($\lambda/20$). The double-pass through the spherical front surface will remove the spherical aberration of the primary mirror. The converging beam then comes to a focus back down the central axis, allowing for a natural field stop for much greater contrast enhancement than conventional telescopes. This converged beam is now passed through an all-spherical doublet, then two separate spherical lenses. These lenses both collimate the beam for refocusing back behind the primary, and also remove the color aberrations from the system. The final focus is passed through a central 5-inch perforation in the primary mirror, and comes to a focus 11 inches behind the primary.

Donald Dilworth pioneered this type of telescope with his award winning 16-inch design 20 years ago at Stellafane. Scott Milligan has made notable improvements to the design to improve the chromatic correction to cover a wider spectral band, and extend the region of sharp imagery to improve off-axis performance. The design would not be feasible without the availability of fully coated optics not readily available until recently. These non-reflective coatings allow for minimum light loss through the various optical lenses employed in the design. The design would also suffer from the rather strict optical collimation requirements, including very tight tolerances for the separation of the primary and the secondary Mangin mirror. In fact the tolerances are such that temperature expansion of metal struts in the mechanical structure of the telescope would exceed the allowable separation and degrade the image considerably. Thus all of the longitudinal supports of the telescope tube will be made of carbon fiber tubing to prevent such expansion and contraction problems yet maintain the stiffness needed to keep the optics highly collimated.

The telescope will be housed in a 20-foot diameter dome that I have constructed as an integral part of my new home in Gloucester, Massachusetts (Figure 3). I am fortunate that my wife, Joyce Motta, had found a plot of land on a ridge overlooking

Ipswich Bay to our North, and a large salt water marsh to our south, allowing for very good seeing conditions and reasonably dark skies. To take full advantage of the location, the foundation of the home also has a 22-foot tall, 2 by 6 foot pier that rises through the south side of the home, up through the garage, through a second floor sun room, and then to the observatory proper. To prevent any heat currents, there is a fully ventilated 5-foot high crawl space below the observatory floor, which is well insulated from the house proper but allows any heat to be ventilated out, similar in concept to the WIYN telescope at Kitt Peak National Observatory. This pier is independent of the home itself, resting on its own foundation below ground level to prevent any floor vibrations from affecting the telescope in any way.

The dome is constructed from structural fiberglass and motorized, with a six-foot wide slit. The mount is being constructed on my lathe and milling machine as a double arm fork on a large disk equatorial mount. This mount will track and slew under computer control. The entire complex is currently conceived to be fully robotic, with the telescope and dome able to be controlled either from the warmed control room that is adjacent, or from anywhere in the house. It will eventually be Internet-controllable as well.

By having the telescope fully robotic, and always in a “ready” state, I hope to have my response time to transient events, such as gamma-ray bursts, to be the time it takes to open the dome and cool the CCD (minutes), and thus make more valuable contributions to the AAVSO.

Figure 3. Dome housing the 32-inch telescope observatory.