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The Multiple Telescope Telescope, an Inexpensive Fiber Fed Spectroscopic Facility

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Abstract. A unique telescope dedicated to spectroscopy is discussed. This instrument, the Multiple Telescope Telescope, uses many novel approaches to achieve high quality, medium to high resolution spectroscopy at low cost.

The Georgia State University Multiple Telescope Telescope (MTT) is located at Hard Labor Creek Observatory (80 km east of Atlanta, GA), and is a spectroscopic facility designed to gather medium to high resolution spectra of stellar objects, with high efficiency and accuracy, at a fraction of the cost of a traditional instrument. The MTT was originally designed in 1989 as an inexpensive alternative approach to building a telescope for spectroscopic studies (Bagnuolo *et al.*1990; Barry 1995).

The initial motivation for the MTT was to construct an instrument that could support stellar spectroscopic studies, particularly of massive interacting binary systems. This instrument would allow dedicated monitoring of objects without the need to apply for telescope time at other facilities, and allow for studies of interesting but ephemeral objects such as novae and supernovae. The determination to do spectroscopy alone helped to motivate the current design using lightweight structures, fiber optics and a segmented primary mirror. The main reason to use a segmented mirror system is to avoid building a telescope that is structurally monstrous; a solid mirror weighs much more than a segmented mirror of the same size and therefore requires substantially greater structural strength, larger mechanical systems, larger structures to house the telescope and more infrastructure for system construction. A segmented mirror system requires substantially smaller structures for support, leading to a smaller telescope structure and a resultant decrease in costs that can be applied elsewhere.

As can be seen in Figure 1, the MTT primary consists of nine separate mirrors instead of the classical telescope paradigm of a single large mirror. Each mirror injects light into a fiber optic assembly mounted at prime focus on the upper telescope structure. The MTT is not alone in using separate mirrors for its light gathering surface, but it is unique in that each mirror is treated as a separate aperture, gathering an independent spectrum that is then combined

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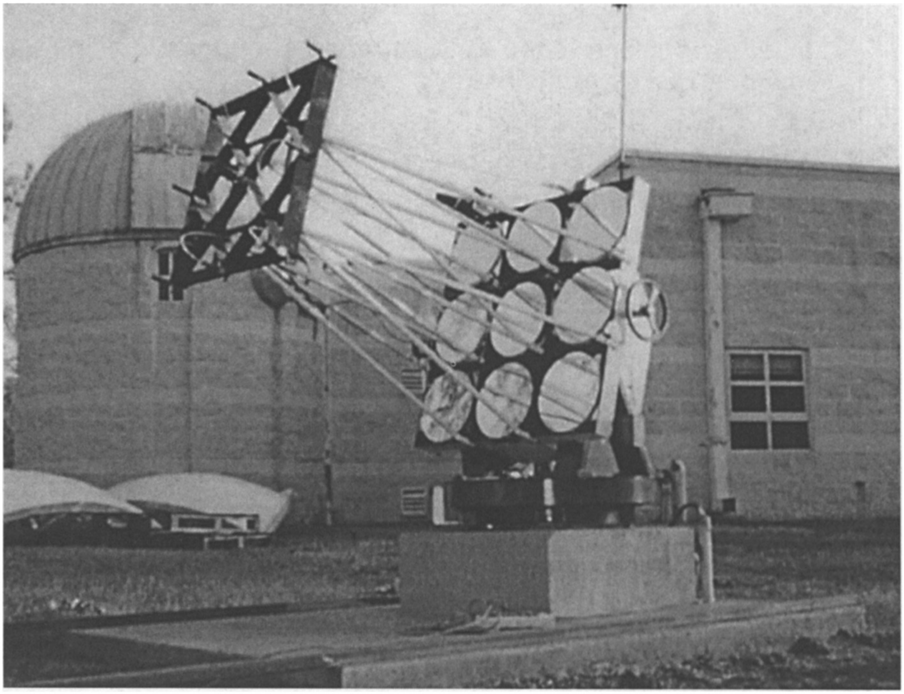

Figure 1. A photograph of the Multiple Telescope Telescope illustrating the important design elements. Note the multiple mirror configuration and the fiber bundles mounted opposite each mirror on the structure at prime focus.

in post-processing with the spectra from the other apertures to create the final spectrum. Therefore, each coupled mirror/fiber pair acts as a separate telescope system, from which the "Multiple Telescope" moniker is derived. Each of the nine mirrors (33.3 cm diameter, f/4.5 parabolic) is controlled by three stepper motors, which allow kinematic motions in tip, tilt and focus through a computer interface, and automated software allows for mirror alignment during observations.

The Newtonian-Ebert Spectrograph was constructed along with the MTT, and designed to function at a variety of resolutions, concentrating in the medium resolution regime (i.e. $R = \lambda/\delta\lambda = 10,000\text{–}30,000$). The basic design is the Fastie-Ebert (Fastie 1952), which shares the camera and collimator mirror, a design that is not explored in modern astronomical instrumentation. There are many advantages in this system (simpler alignment, fewer optics), which are further explored elsewhere (Barry 1995; Bagnuolo, Riddle, & Barry 2001).

The entire MTT telescope system, including the spectrograph, enclosure, optics, computers, and everything else, cost about $100K (with the spectrograph CCD accounting for 40% of this cost); a comparable 1 m class, single mirror telescope would cost five to ten times as much today. Two other groups

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have constructed telescopes based on the MTT design: the NDAMTT in Japan (Kambe 1999) and the SUMMIT in Australia (Moore 2001). The MTT has participated in numerous scientific projects (Riddle 2000), and has evolved from an experimental project into a robust scientific instrument.

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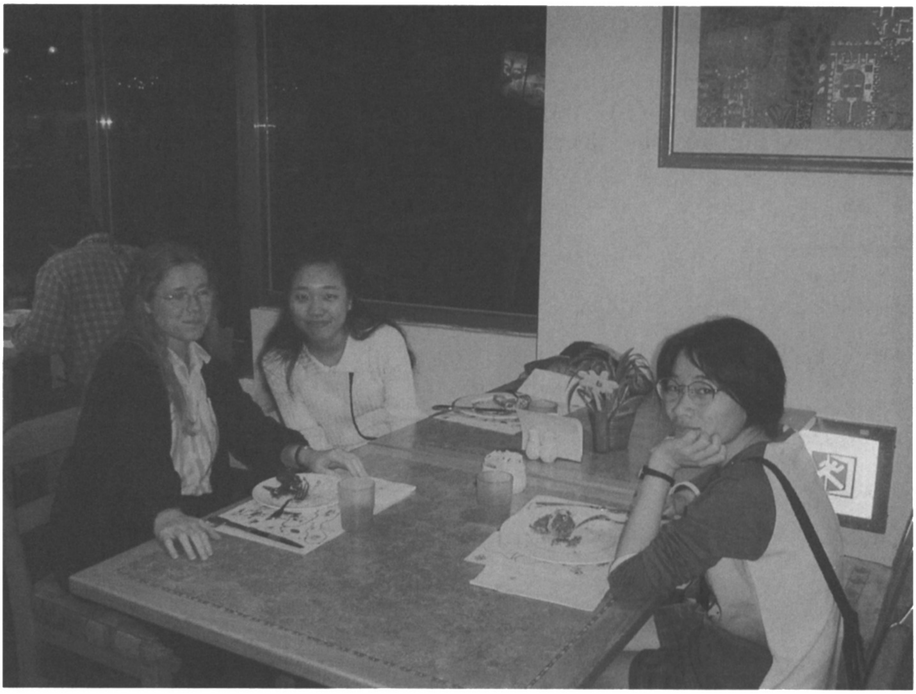

There were quiet moments (top from left: Lemme, M. Y. Chou, and Y. S. Li) and wild ones (bottom from left: T. L. Lee and Z. Y. Lin).

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