Large Binocular Telescope

By John M Hill

The Large Binocular Telescope (LBT) is an optical-infrared telescope which uses two 8.4-meter primary mirrors mounted side-by-side on the same mount to produce a collecting area equivalent to an 11.8-meter circular aperture. The two Gregorian telescope sides point at the same object, or groups of objects close together (1 arcmin) on the sky. A unique feature of LBT is that the light from the two primary mirrors can be combined in the center of the telescope to produce phased-array imaging of an extended field (up to 1 arcmin diameter).

These optically phased images provide the diffraction-limited image sharpness of a 22.65-meter telescope. Active and adaptive optics augment the telescope performance from visible to mid-infrared wavelengths. The main wavefront correctors are the two F/15 Gregorian adaptive secondary mirrors. Deployable swing arms allow changing the optical configuration of the telescope during the night to use different instruments. Partner astronomers using the LBT telescope observe objects ranging from asteroids in the outer parts of our solar system; to planets and dust disks around nearby stars; to stars in nearby galaxies; to galaxies and quasars at the limits of the observable universe. The telescope and its enclosure are located on Mt. Graham in southeastern Arizona at an elevation of 3192 meters.

The Large Binocular Telescope has followed in the spirit and tradition of Galileo Galilei in several ways. We have developed and are continuously developing new technology to expand the capabilities of our astronomical observations and thus to provide a wider perspective on our universe. In particular, the development of the borosilicate honeycomb primary mirrors is one of the key technologies that make this telescope possible. The fast focal ratio (F/1.142) of the paraboloidal primary mirrors allows the telescope to have a compact mechanical structure. The telescope mechanical structure for LBT is unique in the sense that it has very little resemblance to the conventional telescope ``tube'' which dates back to the time of Galileo as a way to support telescope optics. In another sense, this mechanical structure represents common practice in 21st century large telescopes because it is a structure which has been extensively optimized by Finite Element Analysis to maximize the stiffness-to-weight performance. The particular geometry of the elevation-over-azimuth mount chosen for LBT was optimized to provide a direct load path down from the primary mirror cells, to the azimuth frame, to the telescope pier. This allowed the LBT to obtain quite high values for the lowest eigenfrequencies (near 8 Hz) while maintaining conventional steel construction and reasonable cost. The moving mass of this ``lightweight'' telescope structure is about 700 metric tons. The telescope moves on precision oil bearings which float the telescope on a 60-micron thick layer of oil to maintain high stiffness and low friction. This telescope is also the first of a generation of telescopes to have adaptive secondaries designed in from the beginning. The adaptive secondaries have been developed by groups of astronomers and engineers in Tucson, Arizona and Firenze, Italy. The pyramid wavefront sensor used in the adaptive optics system was also developed by groups in Firenze and Padova. From the beginning, the telescope design was an iterative process between the desired astronomical observations (the astronomers), and the available or achievable technological solutions (the engineers).

European Industrial Engineering (EIE) was involved with the design and construction of the Large Binocular Telescope from 1993 to 2003. Many cattle were killed by the telescope project in this period as design meetings always included a visit to Alla Vecchia Bettola in Firenze or Lil' Abner's Steakhouse in Tucson. EIE played a key role in telescope structural optimization by Finite Element Analysis. They carried out the detailed telescope design, and made the final telescope drawings including significant aspects of telescope system engineering. EIE was exceptionally skilled at merging standard industry fabrication practices with the special technical needs of astronomers. They played a key role in writing the telescope construction specifications, and were heavily involved in telescope contruction monitoring including shipping. The LBT telescope structure was fabricated by industry from a set of drawings with mechanical specifications, while responsibility for the astronomical performance requirements remained with the design team. Also involved with EIE during the telescope and enclosure design and construction were ADS International (Lecco), M3 Engineering (Tucson) and the LBT Project Offices in Arcetri and Tucson. The LBT telescope structure was fabricated and pre-assembled in Milan, then disassembled and shipped to Arizona in 2002.

The international partners in the Large Binocular Telescope Corporation include Arizona (25\%), Germany (25\%), Italy (25\%), Ohio State (12.5\%) and Research Corporation (12.5\%). The Arizona portion of the project includes astronomers from the University of Arizona, Arizona State University and Northern Arizona University. The German portion is represented by the LBT Beteiligungsgesellschaft which is composed of Max-Planck-Institut f\"{u}r Astronomie in Heidelberg, Zentrum f\"{u}r Astronomie der Universit\"{a}t Heidelberg, Max-Planck-Institut f\"{u}r Radioastronomie in Bonn, Max-Planck-Institut f\"{u}r Extraterrestrische Physik in Munich and Liebniz Institut f\"{u}r Astrophysik Potsdam. National participation in Italy is organized by the Istituto Nazionale di Astrofisica (INAF).

Partners at individual institutions include the Ohio State University in Columbus, Research Corporation in Tucson, the University of Notre Dame, the University of Minnesota and the University of Virginia