## Engineering Facts

The 4-meter* (158-inch) telescope weighs 375 tons, 250 of which are in moving parts. The moving portion of the telescope is supported on a .005-inch film of oil by 8 bearings and is so precisely balanced that it can be moved by a one-half horsepower motor. The telescope is mounted on a concrete pier, 92 feet in height and 37 feet in diameter. The pier is structurally isolated from the rest of the building so that when the wind shakes the building the telescope remains undisturbed. The main observing area is maintained at a temperature equal to that of the nighttime air. This ensures that no turbulent air disturbances will be created when the dome is opened and the telescope is to be used.

The dome weighs 500 tons, rotates on 32 sets of wheels around its 105-foot diameter, and is designed to withstand gale force winds up to 120 mph. In addition to the telescope and its operating facilities, the building houses a mirror aluminizing chamber, photographic darkrooms, mechanical and electrical shops, offices, a kitchen and a dormitory.

The heart of the telescope is its fused quartz primary mirror, 4 meters in diameter—or just over 13 feet. It is 61 cm. (2 feet) thick and weighs 13.6 metric tons (15 tons). Its surface was ground and polished at the KPNO optical shop in Tucson, in a painstaking process that took three years. Its reflective coating—a uniform layer of aluminum 1/1000 the thickness of a human hair—is replaced approximately every two years. The secondary mirror, which is on the "flip side" of the prime-focus cage, is 1.3 meters (52 inches) in diameter.

The telescope is operated from the console room. A computer controls the telescope's pointing and tracking, dome position, and most of the functions of the auxiliary equipment.

The telescope and building cost approximately $10 million and have been in operation since March 1973. The project was funded by the National Science Foundation.

*Only the dimensions of the telescope's mirrors are given in metric units.

**Kitt Peak**
**National Observatory**
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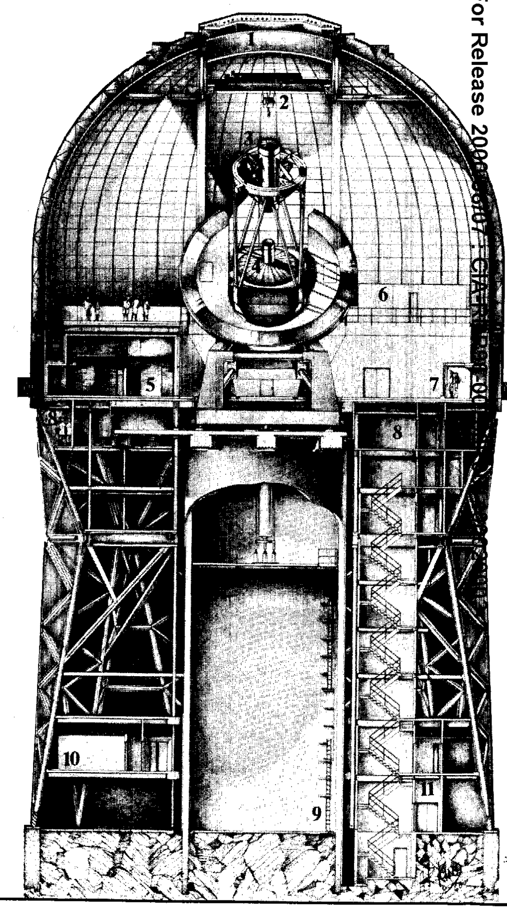
# The Mayall 4-Meter Telescope

## Kitt Peak National Observatory

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## Astronomical Research

Astronomers from throughout the United States and the world come to Kitt Peak to use the Mayall 4-meter (158-inch) telescope. The telescope, named after Nicholas U. Mayall, Observatory Director from 1960 to 1971, is funded solely for astronomical research. Visiting astronomers from other institutions use over 60 percent of the research time, and scientific staff members at KPNO are scheduled for somewhat less than 40 percent of the nights. Some of the visiting observers are graduate students working on doctoral dissertations.

To obtain telescope time, an astronomer submits a detailed scientific proposal to KPNO at least 6 months in advance. Competition for observing time is very keen and the telescope is scheduled for astronomical research every night of the year except Christmas. It is also used frequently for daytime observations at infrared wavelengths. As a result of this constant scientific use, time to look through the telescope cannot be extended to the general public.

The 4-meter telescope is reserved for observations at extremely low light levels. Some of the objects observed, such as quasars and galaxy clusters, appear faint simply because they are so very distant. Other objects are relatively nearby but intrinsically faint, such as the wisps of material in the remains of exploded stars.

Projects scheduled on the 4-meter telescope cover a wide variety of astronomical subjects. Recent observations have included:

- a search for planetary companions to stars other than the sun
- studies of stars in the process of condensing out of gaseous clouds
- searches for black holes
- infrared observations of the nucleus of the Milky Way Galaxy
- measurement of the internal motions and masses of galaxies
- determination of the expansion rate and age of the universe

The continuing use of the Mayall telescope makes significant contributions to U.S. and international astronomy.

*Horsehead Nebula* in Orion, NGC 2024. KPNO 4-meter photograph.

## How the Telescope Works

The Mayall telescope moves on two sets of main support bearings: the "horseshoe" bearing for right ascension (corresponding to longitude in the sky) and a perpendicular set of bearings for declination (corresponding to latitude in the sky). The right ascension bearings are mounted parallel to the Earth's axis of rotation and the telescope can track an object westward across the sky by moving on these bearings at the rate necessary to compensate for the Earth's rotation. As the telescope moves, the dome of the building also rotates so that the telescope has a clear view of the sky through the opened slit. All of these motions are controlled automatically by a computer.

While using the telescope, the astronomer can choose one of three focus positions:

*Prime focus* (f/2.8), inside the large black cylinder near the top of the telescope. This focus is formed by only one mirror, the main 4-meter mirror. To use this focus, the astronomer actually rides inside the cylindrical cage. Prime focus is used mainly for direct photography, sometimes with electronic detectors instead of photographic plates.

*Ritchey-Chrétien focus* (f/8), just beneath the main 4-meter (158-inch) mirror. This focus is formed by two mirrors: the 4-meter primary and the 1.3 meter (52 inches) secondary. The secondary mirror is located in the same black cylinder that holds the prime-focus camera. To change from one focus to the other, the telescope operator simply flips the mounting ring that holds the central cylinder—an operation that takes only about 15 minutes. One of several instruments can be used at this focus: a spectrograph (which separates starlight into its component colors), a photometer (which measures light intensities), or a camera for direct photography.

*Coudé focus* (f/160), in a stationary observing room adjacent to the telescope's base. This focus is formed by the primary mirror plus four smaller mirrors that direct the light beam to the observing station. Since the coudé focus is in a fixed position, large and heavy instruments can be used.

The Mayall 4-meter telescope control room

### Key to front cover illustration

(Fold front cover back for easy reference.)

1. Building is 56.7 meters (186 feet) or approximately 18 stories high
2. Dome cranes—50-ton and 5-ton capacity
3. Prime focus cage
4. Ritchey-Chrétien focus
5. Coudé focus laboratory
6. Telescope control room
7. Visitors' gallery
8. Visitors' scenic walkway—26.8 meters (88 feet) above ground
9. Telescope pier
10. Second floor—dormitory
11. Ground floor—visitors' entrance at 2082 meters (6830 feet) above sea level