



Instrument: Title

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Report for the MOSFIRE project:
Flat Fielding Lamps – version 0.2

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Observers acquire imaging and spectroscopic flat fields using the dome after the telescope is moved to an elevation of 45 degrees and the dome is rotated such that the shutter and telescope azimuth differ by ± 90 degrees. On both Keck I and II, there are two sets of lamps used to illuminate the dome, which are referred to as the “imaging” and “spectroscopic” flat fielding lamps. Observers toggle the lamps on using a dome lamp control GUI, which allows OAs to leave the summit as scheduled in the morning while observers continue acquiring calibration data. The flat-fielding lamps on Keck I were installed “in-a-pinch” by a former instrument technician, and the Keck I flat fielding lamp design was copied for Keck II.

Both the imaging and spectroscopic lamps are APO-15000 Eclipse Portable Overhead Projectors manufactured by Apollo and are missing their folding flats usually used to redirect the projected image onto a vertical screen. The projectors are baffled to direct the light toward the dome where the telescope is currently pointed. The baffling material used with the Keck II lamps may be aluminum with a flat black finish, but at least one lamp on Keck I is baffled using aluminum foil.

There is one type of light bulb used with all the Keck I overhead projectors for flat fielding. The overhead projectors used for imaging have a neutral density filter in the light path to reduce the brightness. The manufacturer and spectral response of the neutral density filter is unknown. The bulb type used on Keck I is an ENX 360W 82V bulb operating at an approximate color temperature of 3,300 K and with an output 2,700 lumens. On Keck II, flat lamp bulbs are of type EBY and are comparable to those on Keck I. The predicted spectral response of the ENX bulb is plotted in Figure 1.

The spectroscopic lamps do not work for all instrument spectroscopic configurations. Online documentation for the Keck instruments recommend not using spectroscopic flat-fielding lamps in some circumstances because the lamps do not provide enough flux at the blue end of the spectrum or because the lamps are not bright enough to permit flat-fielding in any reasonable amount of time. The flat fielding lamps are quite anemic at wavelength shorter than 400 nm (see Figure 1), thus for LRIS, flat fielding currently cannot be done for 400 and 1200 line grism spectroscopy in the deep ultra-violet.



KECK INSTRUMENT TECHNICAL NOTE

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On both Keck I and II the lamps are mounted on opposing sides of the primary mirror at the largest diameter of the primary mirror (Figure 2). Both lamps illuminate the dome through the secondary mirror support structure. The portion of the dome illuminated is a region on the dome that is very rough, somewhat silver in color, but free of major structures, such as ladders, the shutter, and the crane. Instrument technicians report that the illumination is brighter on one side of the telescope than the other, suggesting that the lamp power is not identical in all lamps or that the lamp optical path passes unique components in the secondary support structure.

There was a plan to upgrade the lamps that was not completed. The upgrade goals were to more evenly illuminate the dome, increase the brightness to permit shorter calibration exposure times, and make K1 and K2 lamps the same for easier maintenance. This plan was never completed.

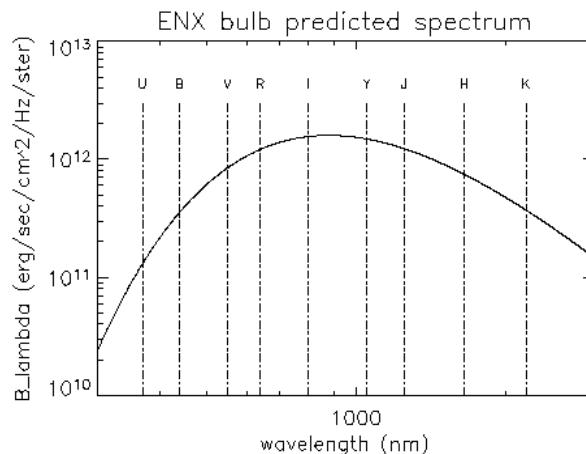


Figure 1: Predicted ENX bulb spectrum from assuming that the ENX bulb on Keck I behaves like a black body (solid line) with a temperature of 3,300 K. The central wavelengths of common optical and near infrared filters are plotted for reference (dashed lines).

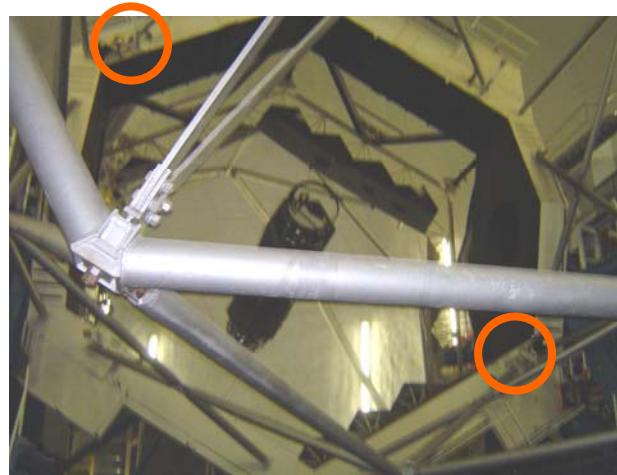
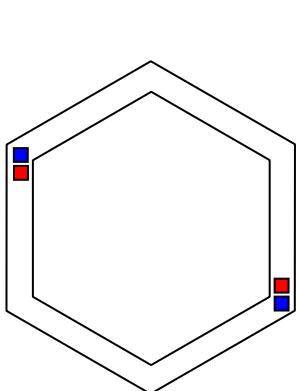


Figure 2: Cartoon showing the location of the flat fielding lamps as seen by the secondary (left). The blue and red boxes represent the locations imaging and spectral flat fielding lamps, respectively. At right is a photo of the Keck I primary with the flat fielding lamps circled in red.

The reflectance and transmittance of four components of the overhead projector were measured at the University of Hawaii Hilo with assistance from Sun Park and Lisa Canale (UH Hilo). UH Hilo has a portable spectrometer capable of measuring the light from 350 to 2400 nm. Typically, the reference spectrum used in the field with this spectrometer is a small three inch diameter disk that reflects Sun light. Sun light could not be used as a reference spectrum during these tests as it was overcast and raining.

The reference spectrum we used was the light from overhead projector's bulb. Below is a raw spectrum of the projector bulb. The bulb raw spectrum provides a crude sense of how the instrument responds. The predicted black body spectrum from the bulb is presented in Figure 1.

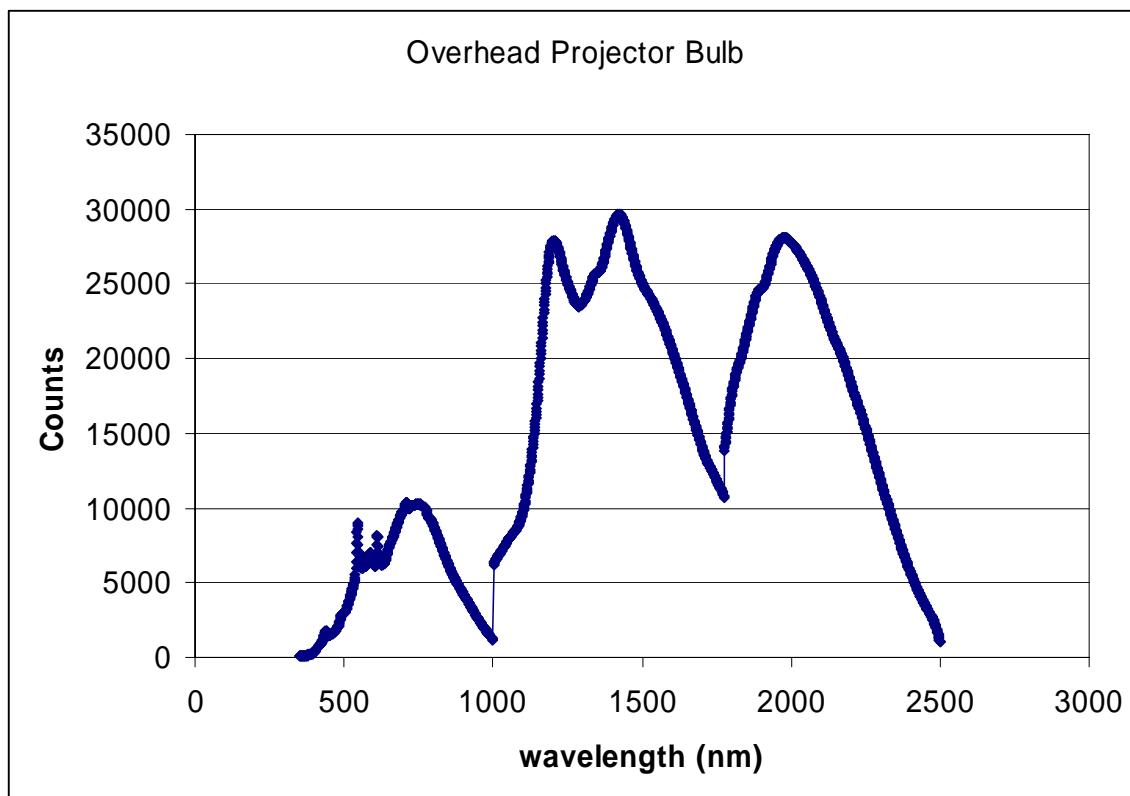


Figure 3: Raw spectrum of the bulb from an overhead projector similar to the overhead projectors used for calibration purposes on K1 and K2. The spectrum was measured using a portable spectrometer. Discontinuities are due to the three different wavelength regimes which the spectrometer scans.

The transmittance, relative to the projector bulb, of three overhead optical components was measured. Two of the components have power: Fresnel lens and Objective Lens. Because of the power on these two lenses, the measured transmittance was well above 100% for these two optical components. The measured transmittance also varied with the location of a hand-held light sensor used with the portable spectrometer. Thus, in order to compare the transmittance of all three optics, the measured transmittance was normalized by the maximum transmittance over the wavelength range of 350-2400 nm in the graph below. Also, we measured the reflectance of a paint sample from the dome. The experimental setup was crude and could be better designed for future tests.

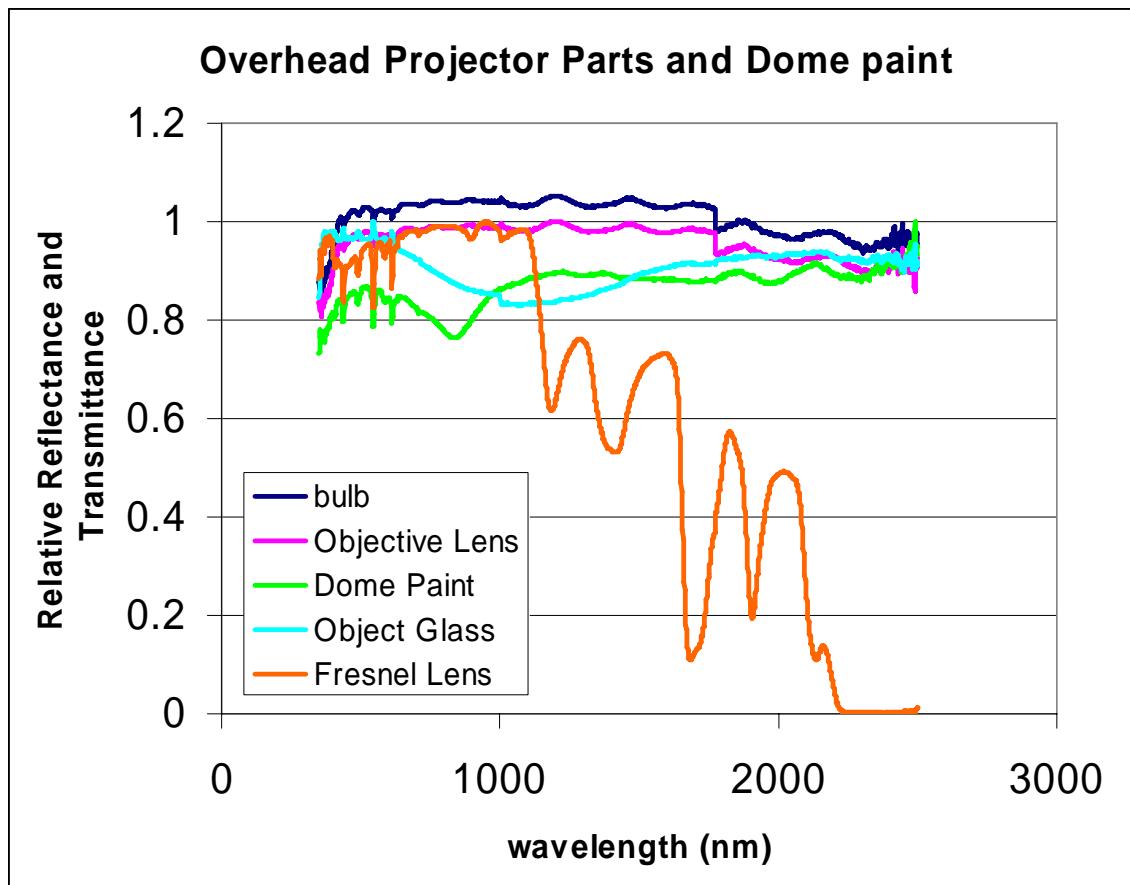


Figure 3: Relative transmittance of three optical components of an overhead projector. The navy blue line is a quotient of two separate projector bulb raw spectra (reference spectrum). The green line is a reflectance spectrum of the dome paint.

Figure 3 shows that light with wavelengths greater than one micron is attenuated by the Fresnel lens. Other optical components, including the dome paint, do not attenuate near-infrared light any more than optical light. The quotient of two raw spectra of the light from the bulb should have a value of 1 across the entire spectral region. The variations in the bulb are due to sensor positioning.