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A Study of the Radiance of the Fibers on the WIYN Hydra Multiple Object Spectrograph & DensePak Array

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INTRODUCTION

Fiber optics have been used in astronomical applications since the 1980's, and has allowed a slew of new instruments to be developed. One of the main uses for fiber optics in astronomy is for multi-object spectrographs. An important and potentially critical measurement for any fiber optic device is the radiance of the light exiting the fiber. Since the new generation 10m telescopes almost all have some form of fiber-optic instrumentation, it is desirable to understand and characterize the radiance from fibers in a typical fiber-optic spectrograph.

We present the results of fiber radiance measurement for the MOS/Hydra and DensePak instruments on the WIYN 3.5m telescope located on Kitt Peak, Arizona. With the current Bench Spectrograph using an f/6.7 collimator, we conclude that only 50-70% of the light exiting the fiber foot assembly is collected by the spectrograph. Fiber-to-fiber variations are large, but on average the radiance pattern for the blue MOS/Hydra fibers results in the highest efficiency as about 65% of the light is within an f/6.7 beam. About 55% of the light exiting the red fibers falls within this beam. DensePak fibers generally put about 60% of the light within an f/6.7 beam. The current filter-holder assembly for each of the three fiber cables does not vignette light within the f/6.7 limit. Significant improvement to the overall throughput for WIYN spectroscopy may be achieved with a faster collimator coupled to a field lens placed in front of the fiber ends.

SETUP

To do this experiment the Bench Spectrograph was configured to allow direct imaging of the radiance pattern of the fibers. The setup consisted of mounting a fiber cable foot on a movable stage and placing the ends of the fibers 4 inches from the T2KC CCD. The fiber-CCD distance was set taking into account the quartz window of the CCD dewar. This distance was chosen so that light emergent from a fiber within an f/2 beam would be incident on the 2048x2048 CCD (24 micron pixels). The results reported below assume that all of the light transmitted by the fibers is emergent at f/2 or slower. The WIYN telescope has a f/6.3 focal ratio, and for point sources the fiber light output should have exactly this f-ratio. Any deviation from this gives an idea of the imperfections in the fiber optic. We also are interesting in examining the amount of vignetting caused by the filter-holder assembly that is at the toe of the fiber foot.

A 2.004 inch spacer was created at the NOAO shops to allow an exact distance between the foot and the CCD camera to be known. The distance from the fiber output to the end of the foot is known to be 1.418'', and the distance from the front of the dewer to the CCD camera chip is known to have an optical thickness of 0.578". This gives a total distance from output of fibers to screen (the CCD) of 1.418" + 2.004" + 0.578" = 4.00". Knowing this distance and that the pixels on the CCD have a size of 24 microns, we are able to characterize the radiance pattern as a function of the f/ratio.