

Characterization of the BME fiber cable

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1 Fiber cable description

The fiber-optics cable that linked the Bench-Mounted Echelle (BME) to the 1.5-m telescope focus has been dismantled by O. Saá and studied in La Serena. In fact, there are two cables – one with fully finished terminations and one with bare polished fibers in ferrules at the slit end. Only the first cable is studied here. We presume that the second cable is a test or spare and is similar to the first one.

The cable contains 3 multi-mode “wet” fibers from Polymicro with core diameters of 200, 100, and 100 micron (hereafter fibers #1, #2, and #3). The entrance part is a cylinder of 0.5” diameter with fiber ends in equi-lateral triangle configuration of ~ 1.2 mm side. The polished steel surface is damaged by few scratches. The slit end is a cylinder of 0.25” diameter with a polished central chord where the 2 fiber ends are located in a linear configuration at a distance of ~ 0.5 mm from each other. The cable is enclosed in a PVC sleeve of 8 mm outer diameter. The cable length of 14.4 ± 0.2 m was measured.

The cable was originally used in BME for transmitting stellar light without any transformations from the focus of the 1.5-m telescope, at $F/7.5$ divergence. The exit beam fed the $F/6$ collimator. We propose to use the same (or similar) cable for transmitting the beam transformed to $F/5$. This study is done to evaluate the light loss and focal ratio degradation (FRD) in this cable.

2 Scheme of the measurements

The measurement setup was realized on the optical table (Fig. 1). The collimated beam is obtained from a combination of a single-mode fiber and a 20-cm lens. Originally, the fiber was fed by a He-Ne

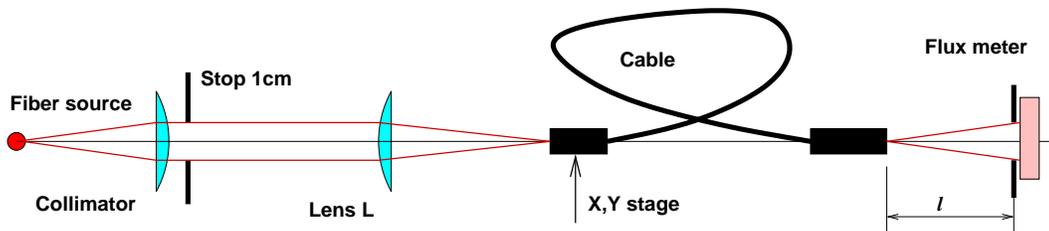


Figure 1: Scheme of the fiber transmission measurement (not to scale).

laser, but we found that the flux was unstable. A laser diode incorporated in the FC connector was used instead, giving higher and stable flux with ~ 650 nm wavelength. The collimated beam has 1 cm diameter defined by a round stop.

The beam was focused on the slit end of the cable by a 25-cm achromatic lens L . Two lenses with focal length of 100 mm and 50 mm were used to test the transmission at $F/10$ and $F/5$ focal ratio, respectively. The cable was mounted on a X, Y -translation stage with micrometers permitting to center the image and to scan it across the fiber end. The axis of the cable was made perpendicular to the input beam by observing the beam reflected from the polished steel surface and propagating back to the collimator. This beam re-entered the collimator stop with lateral shifts < 1 mm. To focus the beam on the fiber, we installed temporarily a beam-splitter cube in front of the lens L and observed the reflected beam on a paper screen. When the spot falls at the fiber border, the reflected beam is equivalent to the knife-edge test and permits good focusing.

The light emerging from the other end of the cable was observed on a screen or intercepted by a round aperture of the flux-meter (model 815 from Newport Research). The diameter of this aperture is 11.2 mm. Behind the aperture, there is a milk glass and a detector. The distance between the detector and the fiber end was set to 50 mm or 100 mm, leading to the output F -ratios of $F/4.5$ and $F/8.9$, respectively. The output beam filled the entire detector surface. The intensity of the input beam was measured by placing the same detector in the collimated beam in front of the lens, again illuminating the full surface. We found that if only a central part of the detector is illuminated, the signal increases by 5–10%, presumably because of non-uniform sensitivity across the 11-mm aperture of the detector. In both detector positions, the background was measured (by obscuring the laser beam) and subtracted from the flux-meter readings.

3 Results

3.1 Fiber transmission

Each transmission measurement was repeated at least 5 times by alternating the detector position before and after the cable. The rms scatter of the measurements was typically less than 1%. Average transmission values are listed in Table 1.

Table 1: Transmission measurements

Fiber	Input $F\#$	Output $F\#$	Transmission
Fiber #2	$F/10$	$\sim F/3$	0.77 ± 0.02
Fiber #2	$F/5$	$F/4.5$	0.78 ± 0.01
Fiber #3	$F/5$	$F/4.5$	0.80 ± 0.01
Fiber #1	$F/10$	$F/8.9$	0.62 ± 0.01
Fiber #2	$F/10$	$F/8.9$	0.45 ± 0.01

Out attempts to measure the total flux emerging from the fiber lead to the transmission of 0.95–1.0. The over-estimated transmission is a result of detector non-uniformity mentioned above (most light falls near the detector center). We believe that the transmission measurements in Table 1 are accurate because the detector illumination before and after the cable was equalized.

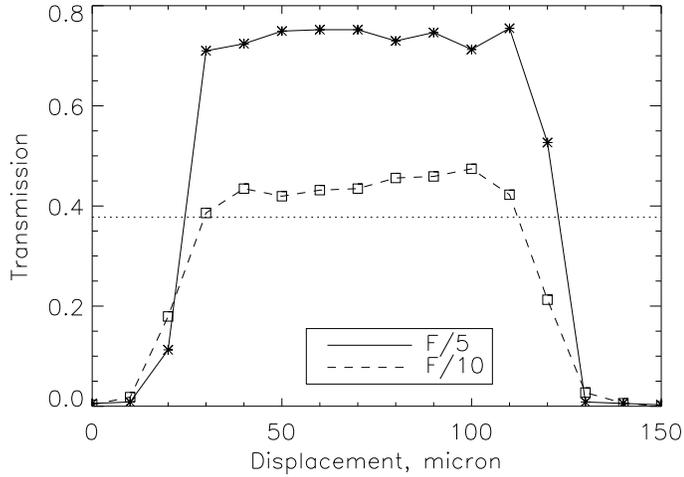


Figure 2: Scans across fiber # 2..

The size of the output light cone (which has a well-defined border) was measured on the paper screen to estimate the output F -ratio. The illumination at $F/10$ leads to the $F/7.8$ output beam. For the $F/5$ input beam, the output divergence is $F/4.5$.

3.2 Scans

Figure 2 shows the transmission profiles of the fiber #2 for $F/5$ and $F/10$ beams. These scans were taken primarily to check that the focusing was good and that the source was well centered on the input end during transmission measurements. The absolute transmission values may be not as accurate as in Table 1, but nevertheless are quite similar.