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Fibre Optic Light Guide for the Telescope: Some Experiments

Andrianto Handojo and Noor Fachrizal

Optics Laboratory, Department of Engineering Physics, Bandung Institute of Technology, Bandung 40132, Indonesia

Abstract. Optical fibres are used to convey light from star images to the entrance slit of a spectrograph. Using an arrangement, the position of the fibre ends are monitored. The spectral transmission factor of the system and modification in the beam divergence have been measured.

1. Introduction

In connecting an analyzing instrument to a telescope, difficulties may arise due to the limited space around the telescope image plane. To solve the problem, optical fibres can be used to convey light from the image to the instrument, placed separately from the telescope. Additional advantages can be obtained (Heacox 1980), such as the simultaneous analysis of several galaxies (Hill et al. 1980).

This paper reports some experiments in developing such a system for the GOTO 45 cm telescope at the Bosscha Observatory, where five optical fibre strands are used to transfer light from five star images to a spectrograph. The study mainly concerns the following aspects:

1. An arrangement to monitor the location of the fiber input ends with respect to the star images.

2. The spectral transmission factor of the optical fibers and of the complete setup.

3. Modification in the divergence of the transmitted light.

2. The Arrangement

An adaptor is employed in the telescope. It has an input plate, where the fastened fibre ends can be aligned to coincide with particular star images. To monitor the locations of the fibres and the star images, the adaptor is constructed as in Fig. 1. The input plate, IP, is located at the telescope image plane. The incident light is partly directed by the beam splitter, BS, to the mirror, M, where it is reflected to the observer's eye. In this reflected light, the eye sees the star images. On the other hand the input plate is dimly illuminated by the lamp L

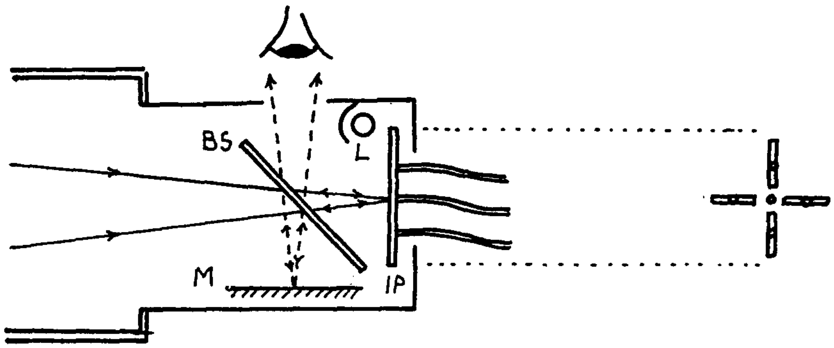

Figure 1. Schematic diagram of the adaptor. BS: beam splitter, M: mirror, IP: input plate with fibre ends, L: small lamp

(which is switched off during operation of the spectrograph) so that the eye can observe the location of the fibre ends via BS.

One fibre end is fixed at the center of the plate IP. The other four are held in four slots forming a cross; each fibre end can be shifted along the respective slot. The input plate is further rotatable. At the output side, the fibres are aligned in line to fill the entrance slit of the spectrograph.

Table 1. Spectral Transmission Factor

	Wavelength (nm)				
	436.3	478.5	515.9	581.2	645.7
Fibre	.66	.77	.84	.88	.89
Beam splitter	.63	.65	.69	.71	.72
Overall	.41	.50	.58	.63	.64

3. Spectral Transmission

To measure the spectral transmission factor of the beam splitter and the optical fibres, a tungsten-halogen light source was used, equipped with a condenser lens to produce a beam with the same convergence (4.8°) as the imaging light incident on the telescope focal plane. Five interference filters were used to select the wavelength, while photodiode and photographic film, analyzed by a microdensitometer, were alternately employed as the light detector. The measurement results (Fachrizal 1994) are presented in Table 1.

Apart from the beam splitter which is a 70/30 device, some attenuation has resulted from the optical fibre. This is due to the use of low-cost, easy-to-handle plastic fibre. For higher accuracy, light from a reference source is guided to the entrance slit by two additional fibres.

4. Beam Divergence

The preservation of beam divergence or focal ratio is an important matter in spectroscopy (Angel et al. 1977). We measured this property by sending a convergent beam from the halogen source to the input surface of the fibre. The beam focal ratio was varied by shifting the condenser lens axially. We let the output beam from the fibre fall on a screen and measured its diameter. The resulting divergence is shown in Table 2.

Table 2. Change in Beam Divergence

Input		Output	
f-ratio	divergence °	f-ratio	divergence °
15.2	3.8	5.8	9.9
12	4.8	5.5	10.4
10	5.7	5.0	11.4

The focal ratio degradation is rather severe, comparable to some other measurements (Barden et al. 1981). The origin presumably lies in the surface quality of the plastic core.

5. Conclusion

In this experimental system, the fibre positioning is monitored visually. Some spectral attenuation and beam divergence degradation have resulted from the plastic fibres. Further improvement might be achieved using silica fibres.

References

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Discussion

Hewett: Do you hope to develop from your experiments to produce a working fibre system for one of the Bosscha telescopes?

Handojo: At the moment the work is still in the experimental stage. The intention is to improve and to develop the fibre system for the GOTO 45 cm telescope and eventually for the Bosscha Schmidt telescope.