Chapter 3

Optical Fibre

Since the use of optical fibres in astronomy was first proposed by Angel et al. (1977), it has become obvious that the ability (or lack of it!) of a fibre to preserve the angular distribution of a beam (usually referred to as Focal Ratio Degradation or FRD) is of as much, if not more importance than the spectral transmission characteristics of the fibre. If relatively short fibre lengths are used light loss is dominated by the FRD. In this Chapter the characteristics of step index, multi-mode, high OH fused silica core fibres will be discussed. As in most astronomical applications [Powel, 1983], this type of fibre was chosen for use in this project.

3.1 Fibre Type

There are a large number of fibre types available. Apart from a variety of fibre sizes, there are 3 refractive index profiles and a number of materials used to make optical fibres. Our choice of fibre type, however, was significantly simplified by the fact that the majority of fibres manufactured are designed for IR communications use and perform poorly in the visible region.

Step-index silica core fibres have a broad spectral transmission range (Nelson 1988). The introduction of controlled quantities of OH radicals into the silica can be used to optimise the UV / visible transmission of the fibres. These “high OH" fibres, such as the FH series fibres from Polymicro Technologies, are by far the most commonly used type for visible wavelength spectroscopy.

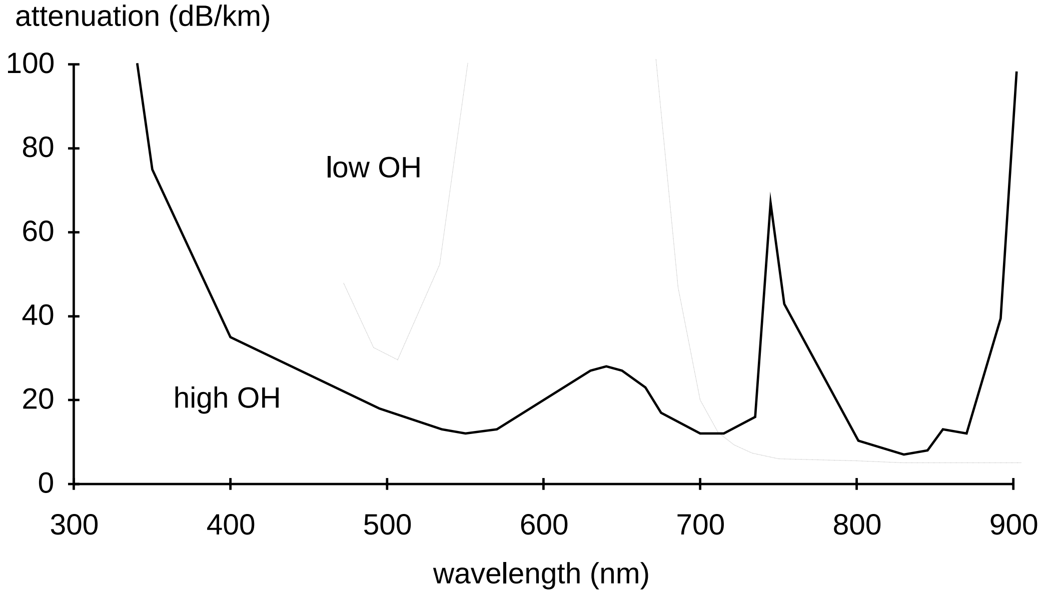

Figure 3.1: Visible transmission for Polymicro high OH (FH series) and low OH (FL series) optical fibres.

3.2 Spectral Response

The spectral response of a fibre is generally specified by the manufacturer in terms of attenuation per kilometre. This data usually doesn't include losses due to coupling at the fibre ends or FRD. Figure 3.1 shows the spectral attenuation for silica fibres from Polymicro Technologies. The effect of adding OH radicals to the core material can be clearly seen.

For our 4 metre length of FH series fibre the transmission data is shown more conveniently in terms of relative transmission in Figure 3.2.

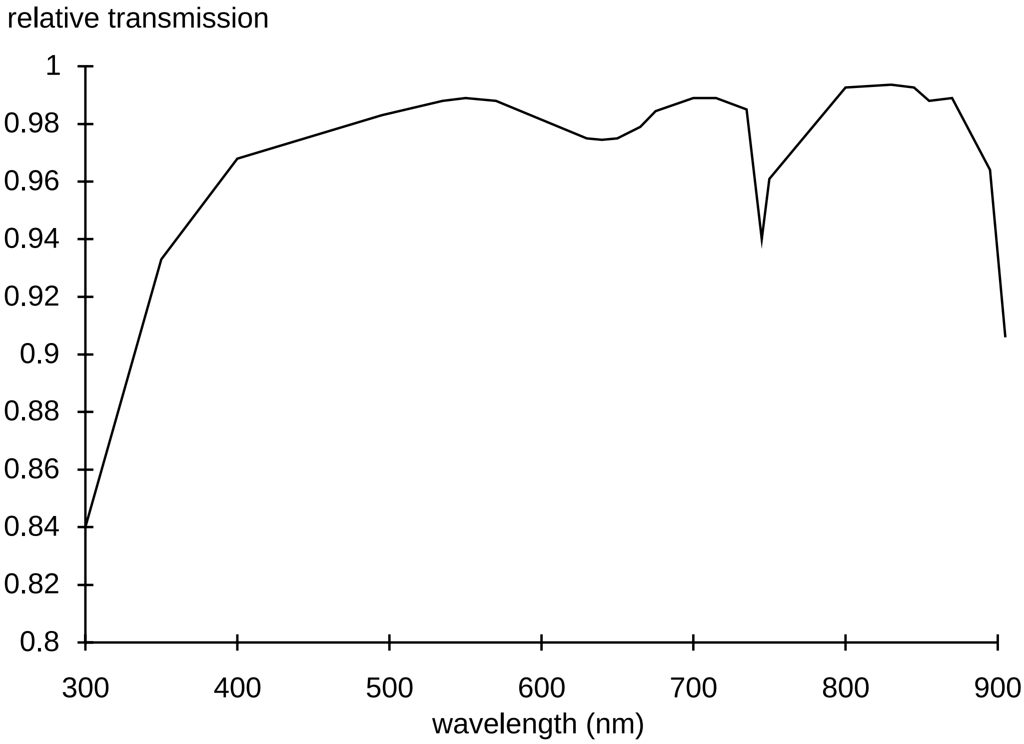

Figure 3.2: Relative transmission for a 4 metre length of Polymicro FH series fibre.

3.3 Focal Ratio Degradation

FRD is thought to be largely due to stresses on the fibre and irregularities at the core-cladding interface called “microbends" [Lund and Enard, 1983]. Although the results of Powel [1983] indicate that FRD losses are relatively independent of fibre length and diameter ($> 200\mu$m cores measured), more recent measurements by Ramsey [1988] have shown that FRD losses in smaller 100μm core fibres are significantly worse than in fibres with larger core diameters. The use of soft silicon buffer material can result in a notable improvement in performance at the expense of reduced protection for the fibre.

Keeping in mind the effects of fibre length on FRD measured by Powell, an estimate of the FRD properties of our 4m length of FHS100/140/500 fibre was obtained by extrapolating the data obtained by Ramsey for similar FH series fibres.

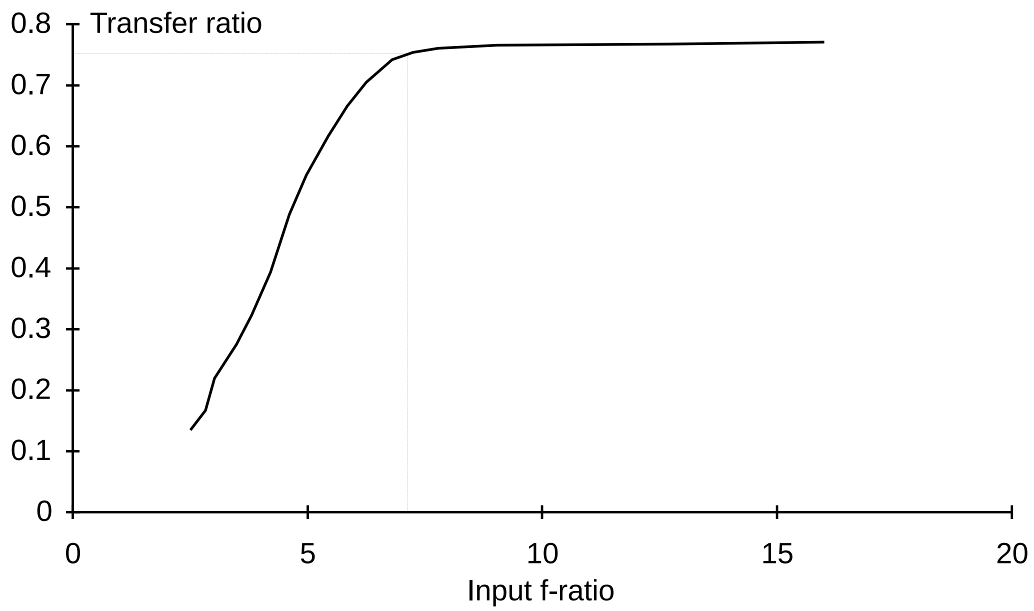

Figure 3.3: Absolute transfer ratio for a Polymicro FHS 100 / 140 / 500 fibre into a focal ratio of 6.3 at 600nm wavelength.

The results shown in Figure 3.3 illustrate clearly the rapid reduction of light through-put that occurs as the input focal ratio becomes less (faster) than that at the fibre output. Our use of a f-6.3 collimator lens means that telescope focal ratios of 7 (approx) or greater must be used if excessive light loss in the fibre link is to be avoided. Actual losses, however, may be somewhat greater as the light output from the collimator slightly overfills the grating when used at focal ratios faster than f-8.