Automated Testing of Optical Fibers

Adventurous internship at Fibertech Optica

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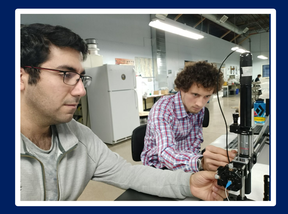


Introduction

The high throughput, stability, and reliability of optical fibers has made them an excellent industry standard for use in astronomical applications where high signal-to-noise data is needed. Despite their robustness, fibers are not without fault. Stresses within the fiber combined with polishing errors on the fiber face, result in a decline in data quality. Focal ratio degradation (FRD) is a common adverse effect where the input f-ratio is degraded to a faster f-#, translating to a loss of signal, diminished spatial resolution, and increased complications in the calibrations. By minimizing FRD, one may maximize the efficiency of a fiber. Measurement of the FRD is a non-trivial endeavor, however, as repeatable image processing techniques are required, and the lack of standardization within the industry is prohibitive when comparing measurements. Here we explore two testing methods to determining the FRD: the “ring test” and the full aperture/stability test.

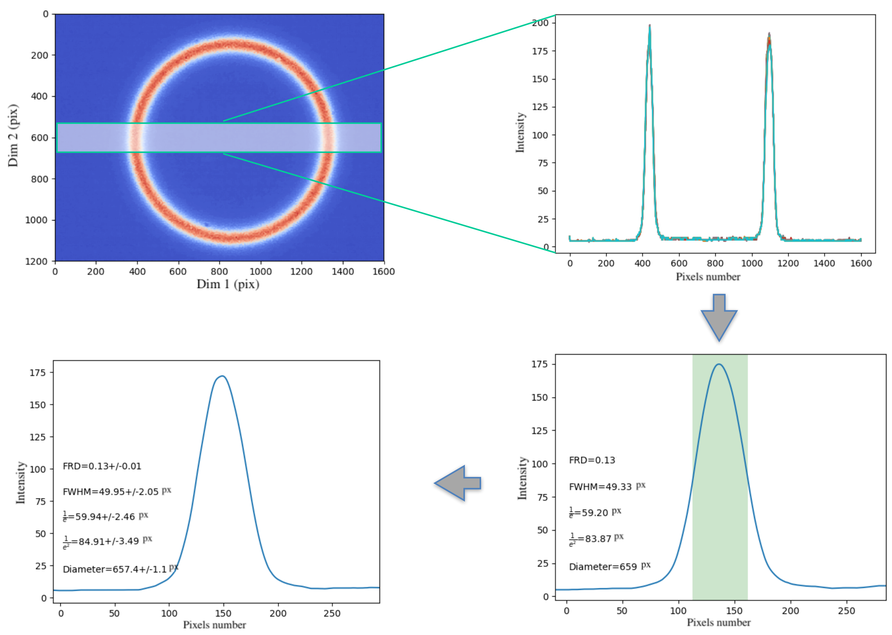
FiberTech Optica (FTO)

We have interned at FTO, an Ontario based fiber design and manufacturing company specializing in custom fiber assemblies for use in industrial and research applications. FTO was intimately involved in the production of the GRACES fiber which is one of the lowest loss fibers used in astronomy today. They are a critical member in the development of new Canadian based fiber-fed instruments.

Objectives

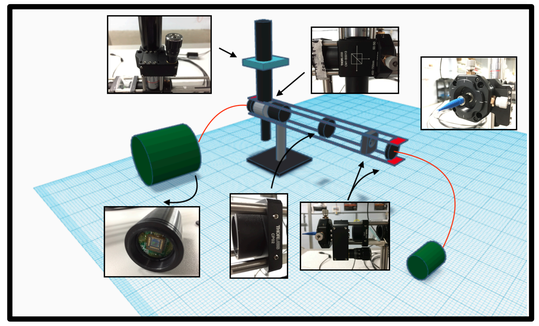
- Understand the fiber testing methods being performed at FTO
- Recreate and expand upon the FTO techniques here at UVic
- Develop image processing software to automate the data analysis
- Develop hardware to automate the fiber testing process

Image Processing and Automation of the Data



Full Beam/Stability Test

A direct measure of FRD which measures the spatial distribution of the output beam energy and compares it to the energy of the input beam



Advantages

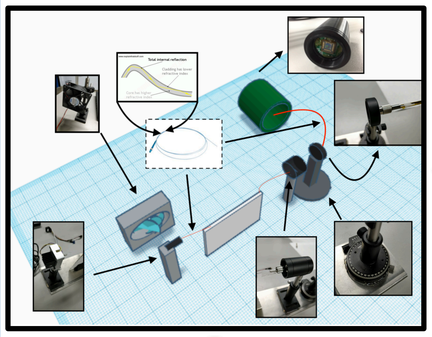
- Direct measure of FRD, capable of reaching the fundamental limit
  - Important for high precision radial-velocity measurements
- Measures transmission as well as FRD
- Set up is physically representative of typical fiber-based instruments

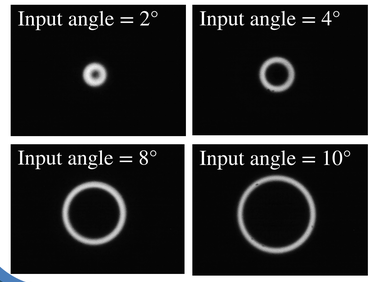
Disadvantages

- More complex set up than ring test
- Need for hardware control systems
- Need for high precision/low noise imaging processing

Ring Test

An indirect measure of FRD which varies the beam injection angle and measures the resulting change in the far field fiber intensity pattern





Advantages

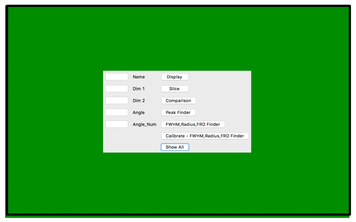
- Quick to set up
- Qualitative; less need for high degree of image processing
- Capable of reaching 5% measurement error (good enough for most applications)

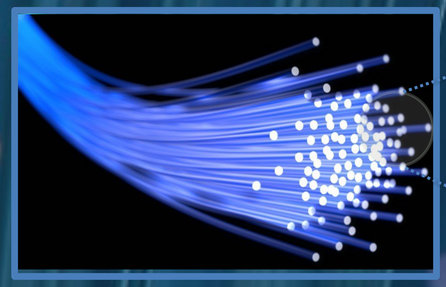
Disadvantages

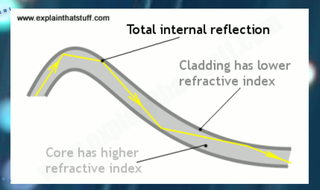
- Less representative of the true fiber performance
- Difficult to calibrate to an absolute FRD
- Results can be overly optimistic

The FRD of a fiber can be calculated by measuring the diameter and width of the ring produced in the output image.

Graphical User Interface for the Ring Test







Conclusions

During our nine days at FTO we studied and practiced FTO's current fiber testing methods. We have developed a rudimentary software package capable of robust and repeatable measurements the FRD of various fibers. Our preliminary results from a simple ring test set up are consistent with previous FRD tests performed by FTO and improve on their existing methods by providing homogeneity in the analysis method and simple comparative statistics.

Future Directions

Currently, we are working on recreating the FTO set up in our lab here at University of Victoria. We seek to expand upon the hardware and software elements of FTO's existing operation by creating a stand-alone software package, which can be utilized by FTO to accelerate their in-house testing methods, in addition to creating a mechanical system which can automatically test multi-fiber arrays (up to 5000 fibers) with varying fiber geometry. We aim for sensitivity down to 5% FRD and 1% precision between repeated measurements. Ultimately these tools will be utilized in the fiber testing stage of development for future large, multi-object spectroscopic surveys.