



University  
of Victoria

Graduate Studies

Notice of the Final Oral Examination  
for the Degree of Master of Applied Science

of

**JOOYOUNG LEE**

BSc (Dongguk University, 2015)

**“Development of An Automated System for the Measurement of Focal  
Ratio Degradation of High Numerical Aperture Fibres”**

Department of Mechanical Engineering

Friday, July 26, 2019

10:00 A.M.

Clearihue Building

Room B017

Supervisory Committee:

Dr. Colin Bradley, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)

Dr. Martin Byung-Guk Jun, Department of Mechanical Engineering, UVic (Co-Supervisor)

External Examiner:

Dr. Ulrike Stege, Department of Computer Science, UVic

Chair of Oral Examination:

Dr. Dante Canil, School of Earth and Ocean Sciences, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

## **Abstract**

The thesis presents the development and testing of an automated fibre optic test system for the measurement of focal ratio degradation (FRD) in high numerical aperture fibres. In particular, the fibres under examination are being proposed for use in the Maunakea Spectroscopic Explorer (MSE), a new telescope currently being designed for wide-field surveys of the night sky. A critical subsystem of the MSE is the Fiber Transmission System (FiTS) that connects the focal plane to the telescope's spectrographs. In preparation for MSE-FiTS, a method of characterizing the focal ratio degradation (FRD), between the input and output of every fibre, of candidate multi-mode fibres is highly important. The ultimate goal is the testing of all 4,332 fibres after assembly and prior to installation on MSE. An optical bench has been constructed to test the performance of an automated characterization system; a variation on the collimated beam test. Herein we present the underlying analysis FRD measurement method, the optical design of the test bench, the motion control system and the software for measuring FRD, and controlling the automated test system. The open-source automation software is also introduced; the Big FiTS Fibre Wrapper (Big FFW). The results of tests performed using the Big FFW on samples of candidate fibres are presented and compared with the results in the literature using manual methods. The results suggest that the candidate MSE fibre meets the science requirement of less than 5% focal ratio degradation for an  $f/2$  input beam measured at the fibre output. There is less than 1% disagreement between the automated measurement method and manual methods reported in the literature. The fully automated system can measure the FRD of up to 10 fibres in a typical MSE fibre bundle configuration.