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Precision Metrology with a Femtosecond Laser

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Faculty Mentor

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Project Summary

UAH has recently received a collection of optical fibers via corporate donation. It consists of about 20 spools of fibers of various types and lengths. It is currently being maintained and managed by Dr. Lingze Duan of the Physics Department, with the purpose of serving the need of the entire campus.

Since these fibers are used, their actual lengths are generally different from their labeled lengths. This is very inconvenient for future users because typically one would like to have a piece of fiber with a specific length. Therefore, it is necessary to find out the actual lengths of these fibers through measurement.

The objective of this RCEU proposal is to recruit an undergraduate summer student to set up a fiber-optic metrology system and determine the lengths of these fibers.

Specifically, the student will be asked to develop a *multi-frequency amplitude-modulated laser radar* that is capable of measuring a wide range of distances from a few hundred meters to tens of kilometers. The novelty here is that the amplitude modulation is not generated by a modulator but is instead derived from a femtosecond laser. Fig. 1 illustrates the principle of the proposed technique. A low-power femto-second fiber laser is used as the light source and it generates a train of ultrafast optical pulses. The measurement system is essentially an opto-electronic interferometer. The optical pulse train from the laser is split into two fiber arms. One of them is the fiber with unknown length and the other has a known length (the two arms do not necessarily have the same length). At the end of each arm, a fast photodetector converts the periodic pulse train into a set of microwave frequencies at the integer multiples of the pulse repetition rate (~90 MHz). One of these frequencies is isolated in both arms and treated as the AM signal. Then the two AM signals are mixed to reveal their phase

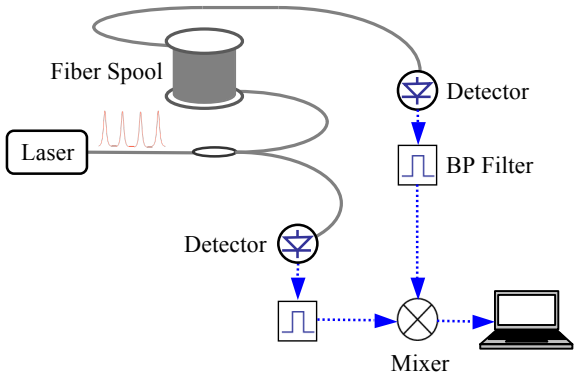

Fig. 1: The principle of the proposed fiber-length measurement technique.

differences, which is directly related the length mismatch between the two arms. This process can be repeated for other AM frequencies. This would help resolve the ambiguity problem in long-distance measurement.

Through the project, the student will gain hands-on experience in fiber optics, RF electronics and ultrafast optics. He/she will get the opportunity to operate a state-of-the-art femtosecond laser and learn advanced measurement and data analysis skills. In turn, his/her work will facilitate future use of these fibers.

Student Duties

The student will be responsible for setting up the experimental system shown in Fig. 1 and using it to measure the lengths of the donated fibers.

He will learn how to find references needed for solving immediate problems, how to carry out a big project systematically, and how to present a finished product. All these knowledge and experience are beyond, but closely related to, his optical engineering / physics curriculum.

Faculty Supervision and Mentoring

The prospective RCEU student will receive close mentoring from Dr. Lingze Duan during the project. The student will be encouraged to report to Dr. Duan every other day and seek his advice whenever a problem is encountered. Graduate student Lin Yang will also be available daily in the lab. The performance of the student will be evaluated based on his working progress as well as the quality of the work.

Student Qualifications

The student should have basic knowledge of optics by the time the project starts and must have finished OPT 341 (Geometrical Optics) and 342 (Physical Optics) with grades of at least B. A good working ethic and a high motivation toward research are also expected from the qualified candidate.