Characterization of dispersion in pumped erbium-doped fiber using Fourier transform spectroscopy

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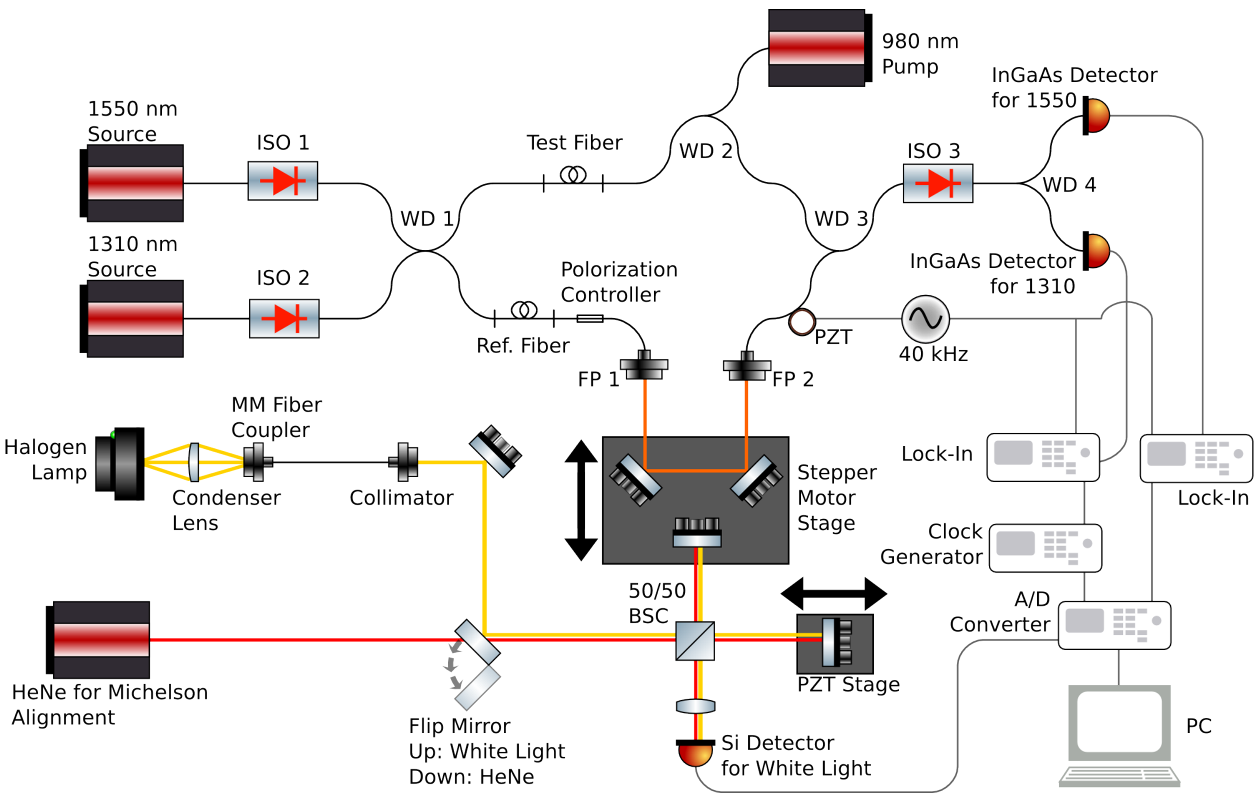

Figure 1: Experimental setup. ISO: in-fiber isolator at operational wavelength 1550nm. WD 1: dual-window 1310/1550 2x2 50/50 coupler. WD 2: 980/1550 WDM. WD 3: dual-window 1310/1550 1x2 50/50 coupler. WD 4: 1310/1550 WDM. FP 1, FP 2: Thorlabs PAF-X-11-C fiber port. PZT: Boston Piezo Optics Piezoceramic loop with 2π phase shift at 18.9V.

1 Experimental Setup

This is an attempt to recreate an experiment performed during the early 1990s, which was reported in two papers [1][2].

The apparatus consists of two interferometers: a fiber Mach-Zehnder interferometer made of SMF28 (except for the test fiber), and a white-light Michelson interferometer to provide a start trigger. The coherence length of the white-light source is between 1.5 and 2.0 microns (meaning the path length difference of the Michelson must be less than this). The PZT stage in the Michelson may be used to find the interference fringe from the white light. The flip mirror allows for alignment of the Michelson using the HeNe (alignment is much more difficult using the white light source). We collimated the white light by sending it through a pinhole, followed by an asphere achromat doublet condenser lens into a length of multimode fiber. The collimator is a standard telescopic beam expander with the distance between the lenses selected to achieve a collimated beam.

The path length of the fiber interferometer is changed by moving the stepper motor translation stage. The fiber ports couple the light from the interferometer out of the fiber, to a retroreflector made of two turning mirrors, and back into the fiber. Our procedure to collimate and align the fiber ports may be found in the HPPFL lab notebook. The instructions provided by Thorlabs are also helpful. The polarization controller is intended to prevent the two Mach-Zehnder arms from having orthogonal polarization states which would not interfere. The Zaber stepper motor stage is on loan from Walter Hurlbut. It is controlled by a LabView VI entitled "Expert - Enter a list of commands." This VI is located on a laptop we left on the table.

The dispersion characteristics of doped fiber change when the fiber is pumped. As such, 980nm pump light may be coupled into the test fiber using WD 2.

The 1550nm source is intended to be incoherent (i.e. broadband). It can either be a laser diode operating below threshold (as it is now), or an LED. The LED would be a significant coupling challenge, but it would likely provide a larger range of wavelengths. It is currently a laser diode. The 1310nm source is a coherent source from a laser diode.

2 Progress

We constructed both interferometers. The Michelson is finished and performing perfectly. The Mach-Zehnder interferometer is constructed, but not yet finished. 1550nm light can be detected at the detector, but we ran out of time before producing an interferogram using the 1550 light. The 1310 source is not currently working either.

3 Problems for the next group

The detection electronics need to be constructed. We left two lock-in amplifiers on the table, but they aren't hooked up. The clock generator needs to be constructed from scratch. Its input will be from the 1310 detector. The circuit needs to output a "yes" pulse for each zero crossing from the 1310 interference pattern, as well as its quadrature output. At each "yes" pulse, the clock generator will tell the computer to digitize a point from the 1550 detector. In this way, the 1550 interferogram will be created.

The 1310nm source needs to be implemented. We created a temperature controller using two copper plates and a thermistor, and we left the laser with its driver (Thorlabs LD3000) on the table, but the driver is not currently making the LD lase.

We have concerns about the wavelength dependance of the isolators and WD 2, specifically with regard to the 1310 source. The operational wavelengths of WD 2 are 980 and 1550. We don't know how 1310 will behave. The WDM should be tested with 1310nm light to see if it will continue through that arm. If not, another solution must be devised to inject pump light into the test fiber. Similarly, the isolators may not work as well for the 1310nm light. We think an easy solution to this problem will be to purchase isolators with a 1310nm operational wavelength and fusion splice them in series with ISO 2 and ISO 3.

Finally, a LabView VI to read information from the A/D converter and produce an interferogram must be written. It may be useful to implement the Zaber VI functionality into this VI so that the stepper motor may be controlled by the same VI that collects data.

4 Contact

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References

[1] Robert K. Hickernell, Kazumasa Takada, Makoto Yamada, Makoto Shimizu, and Masaharu Horiguchi, *Pump-induced dispersion of erbium-doped fiber measured by Fourier-transform spectroscopy*, (Optics Letters Vol. 18, No.1, 1993).

[2] Kazumasa Takada, Masaru Kobayashi, and Juichi Noda, *Fiber optic Fourier transform spectrometer with a coherent interferogram averaging scheme*, (Applied Optics, Vol. 29, No. 34, 1990).