Dispersion Compensation in Mode-locked Thulium/Holmium Doped Fiber Laser

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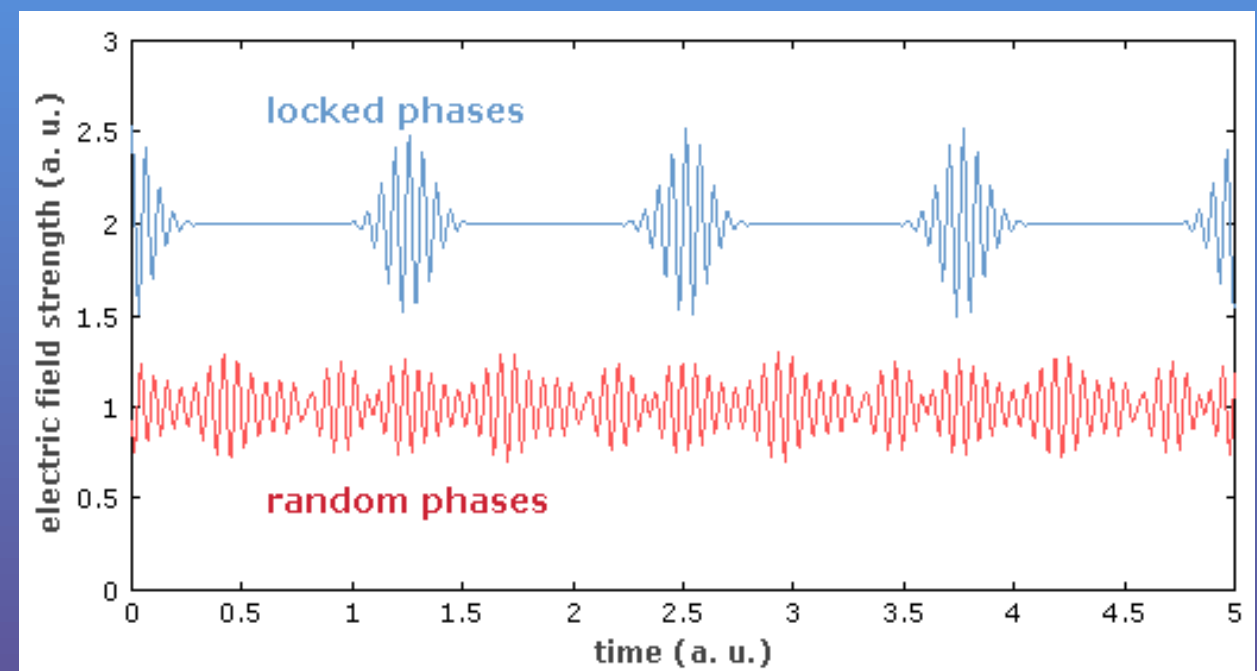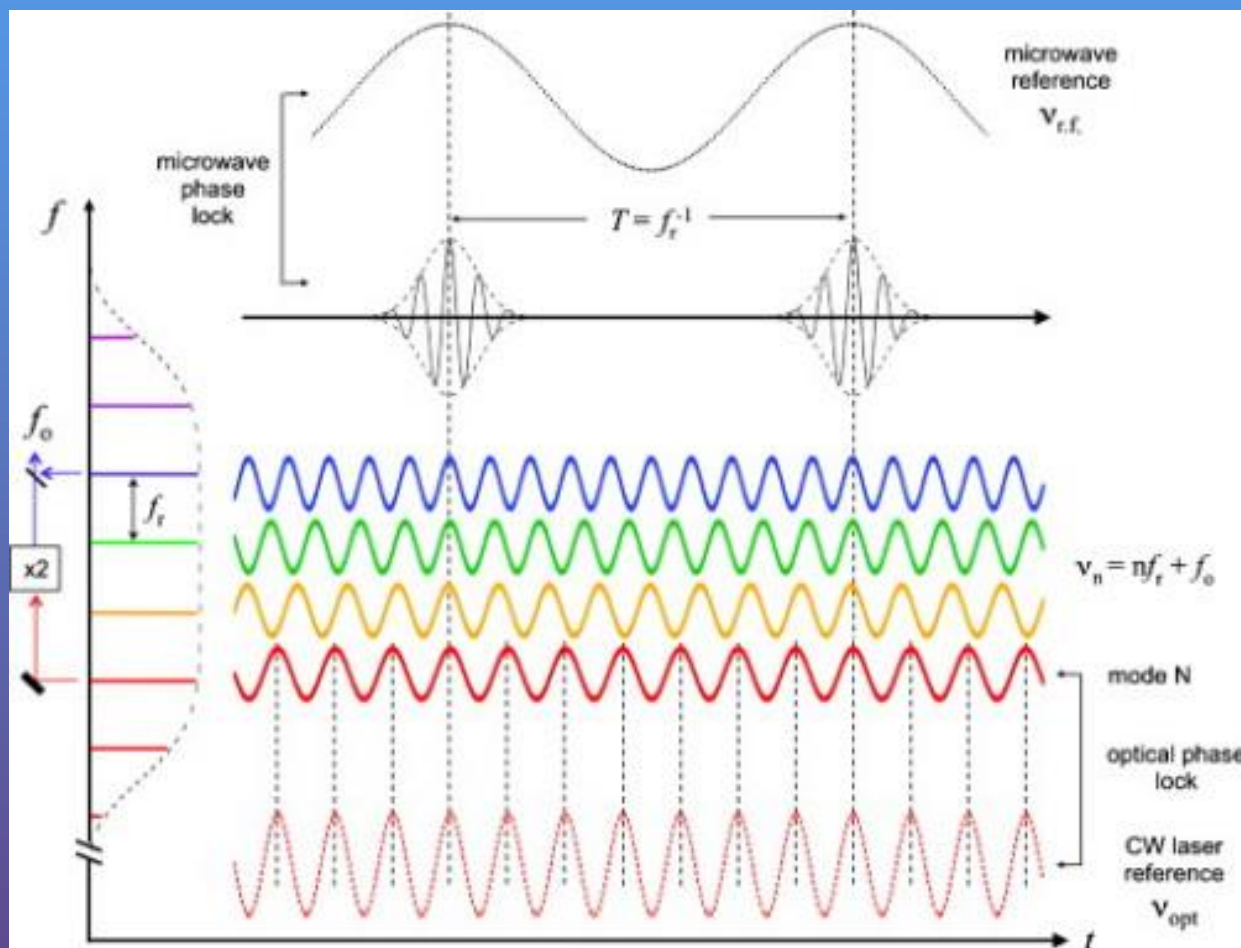
Mid-infrared Ultra-short Pulse Lasers

…can measure ultra-short timescales!
- Chemical reactions
- Biological processes
- etc.
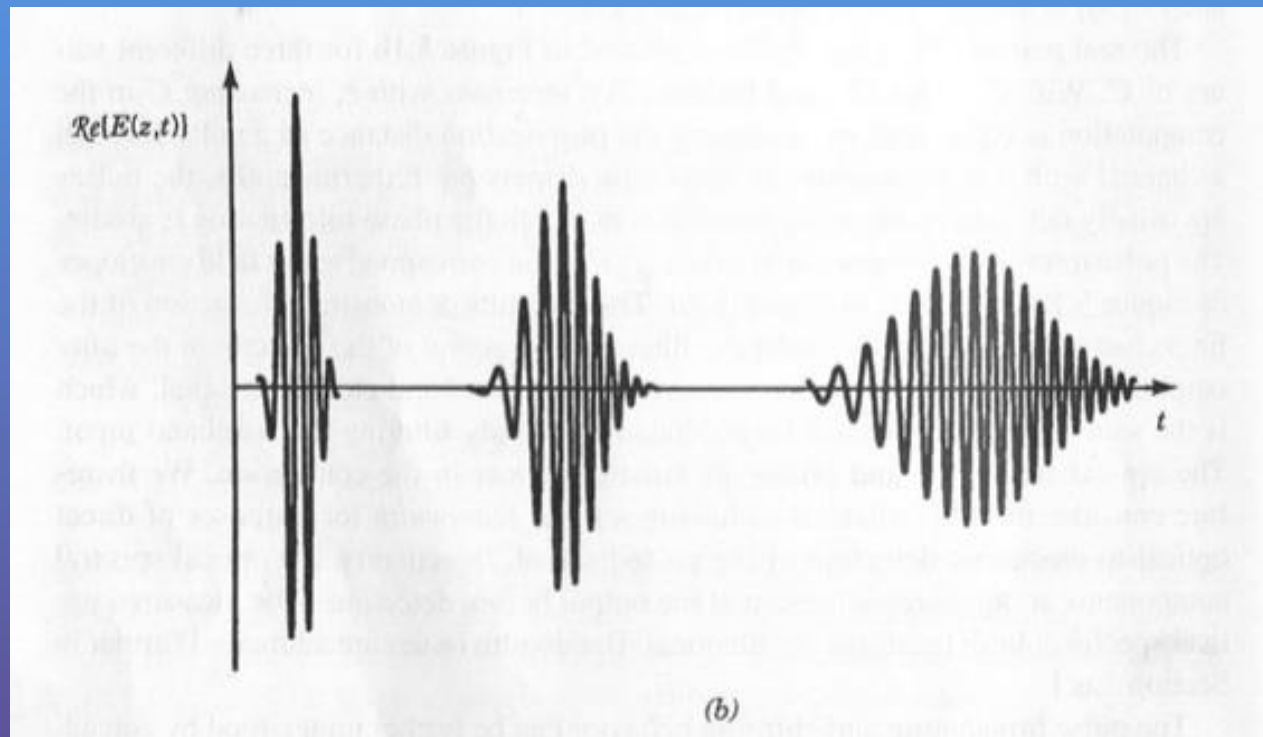

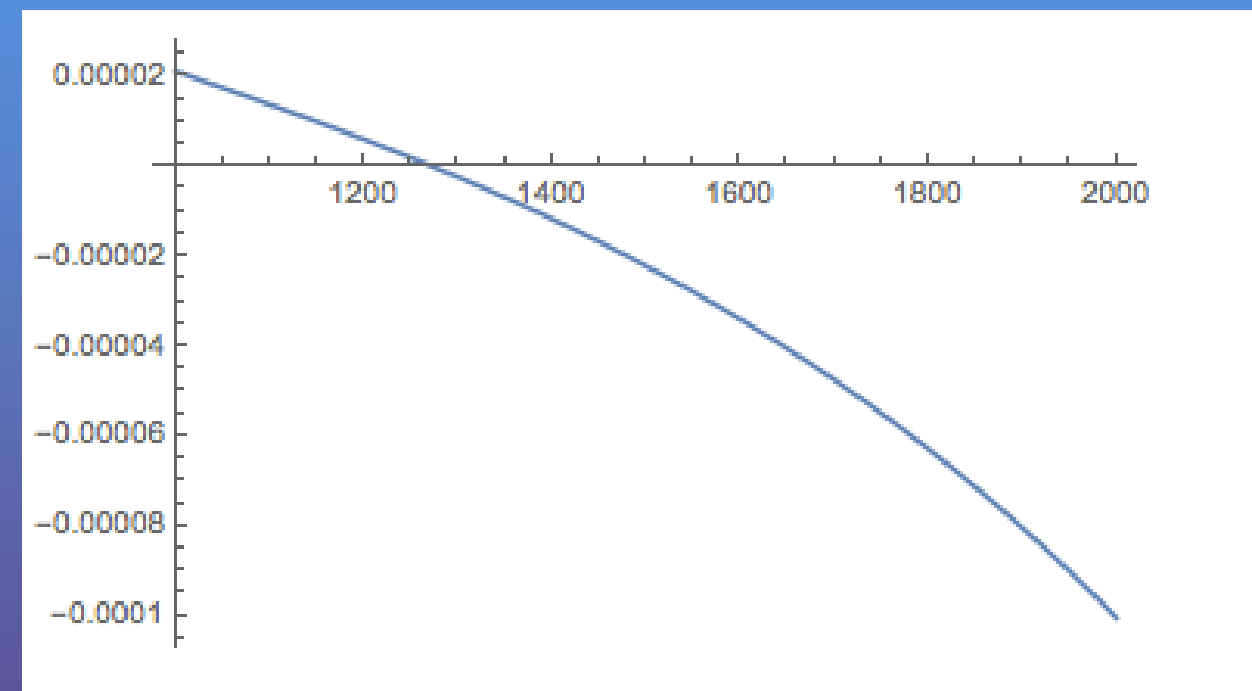…can measure absorption over a wide wavelength range!

Mode-locking

Group Velocity and Third-order Dispersion

$\beta2$ - Group velocity dispersion parameter
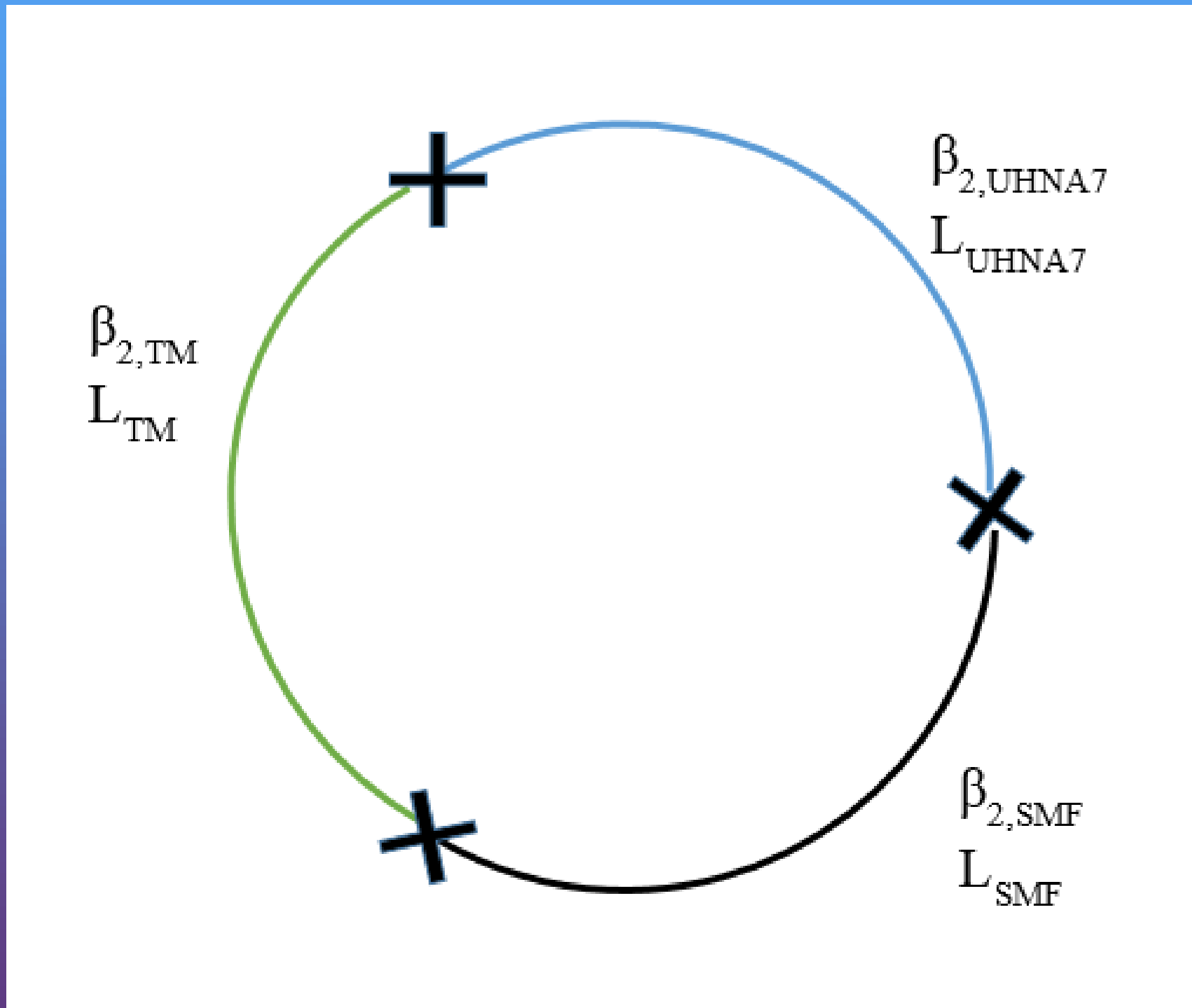- Related to 2nd derivative of Sellmeier equation

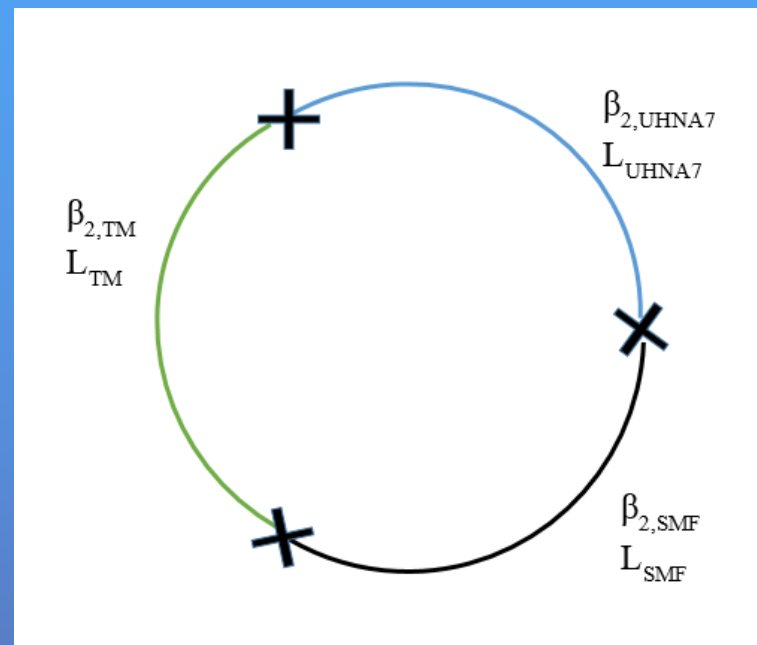Buck, John. *Fundamentals of Optical Fibers,* ch. 5. 1995.

$\beta3$ - Third-order dispersion parameter
- Derivative of $\beta2$ with respect to frequency
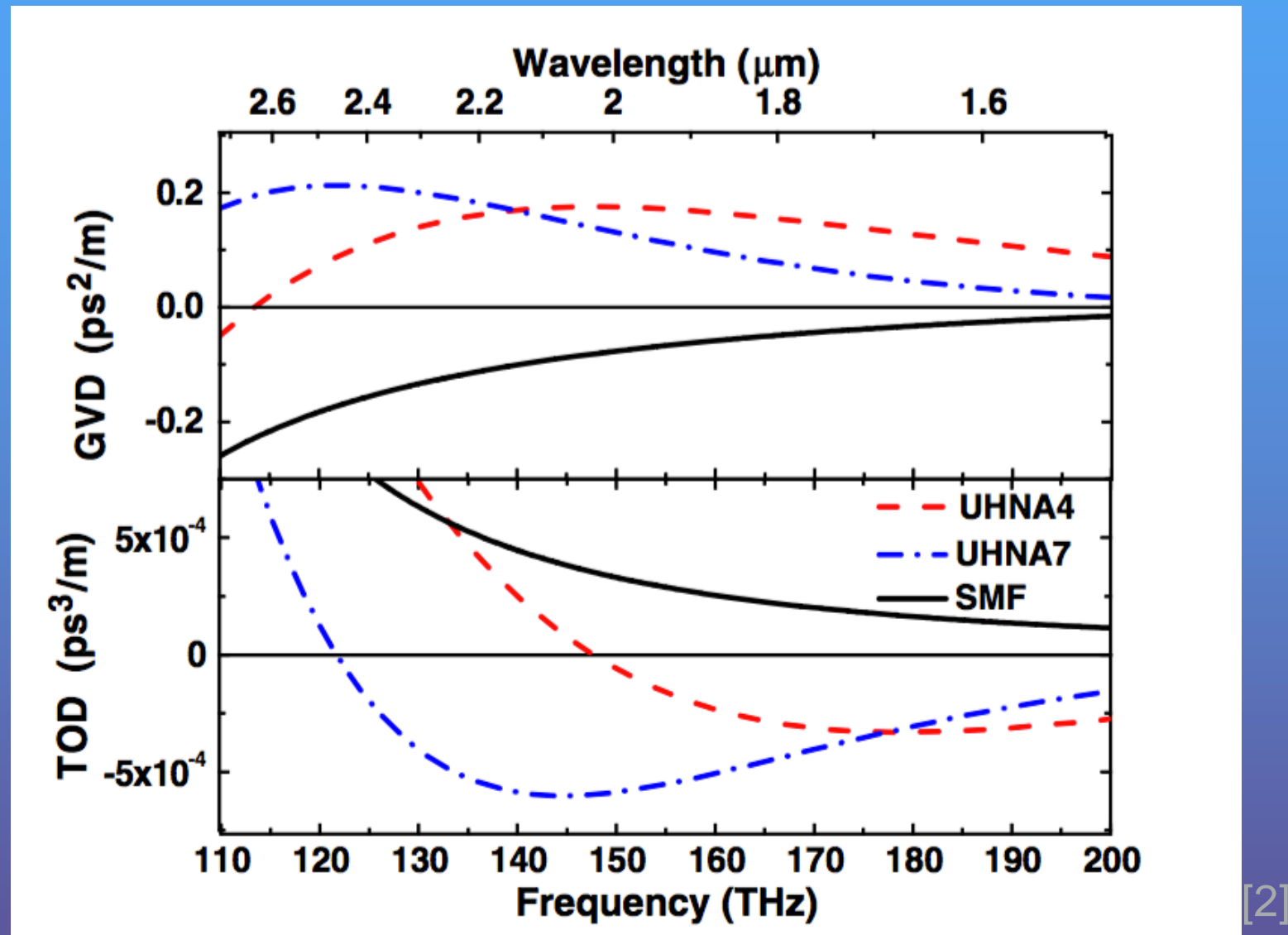
Dispersion Management

(Dispersion Management, cont.)

Net Cavity GVD (with no compensation fiber)

$$\beta_{2,TM} L_{TM} + \beta_{2,SMF} L_{SMF} = \left(0.01\ \text{ps}^2/\text{m}\right)\left(1.24\ \text{m}\right) + \left(-0.085\ \text{ps}^2/\text{m}\right)\left(4.46\ \text{m}\right) = -0.366\ \text{ps}^2$$

Net Cavity TOD (with compensation fiber)

$$\beta_{3,TM} L_{TM} + \beta_{3,SMF} L_{SMF} + \beta_{3,UHNA7} L_{UHNA7} = 0$$
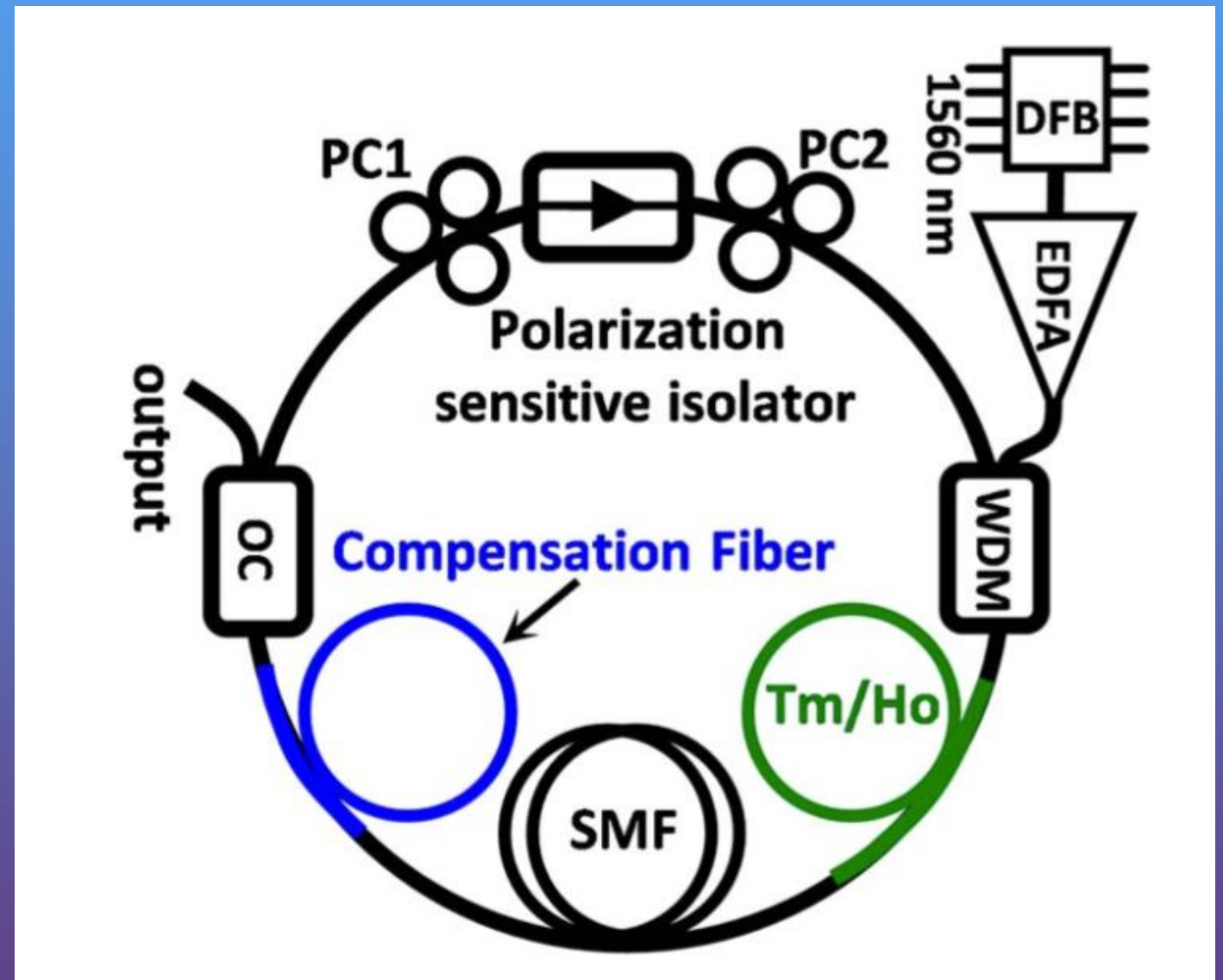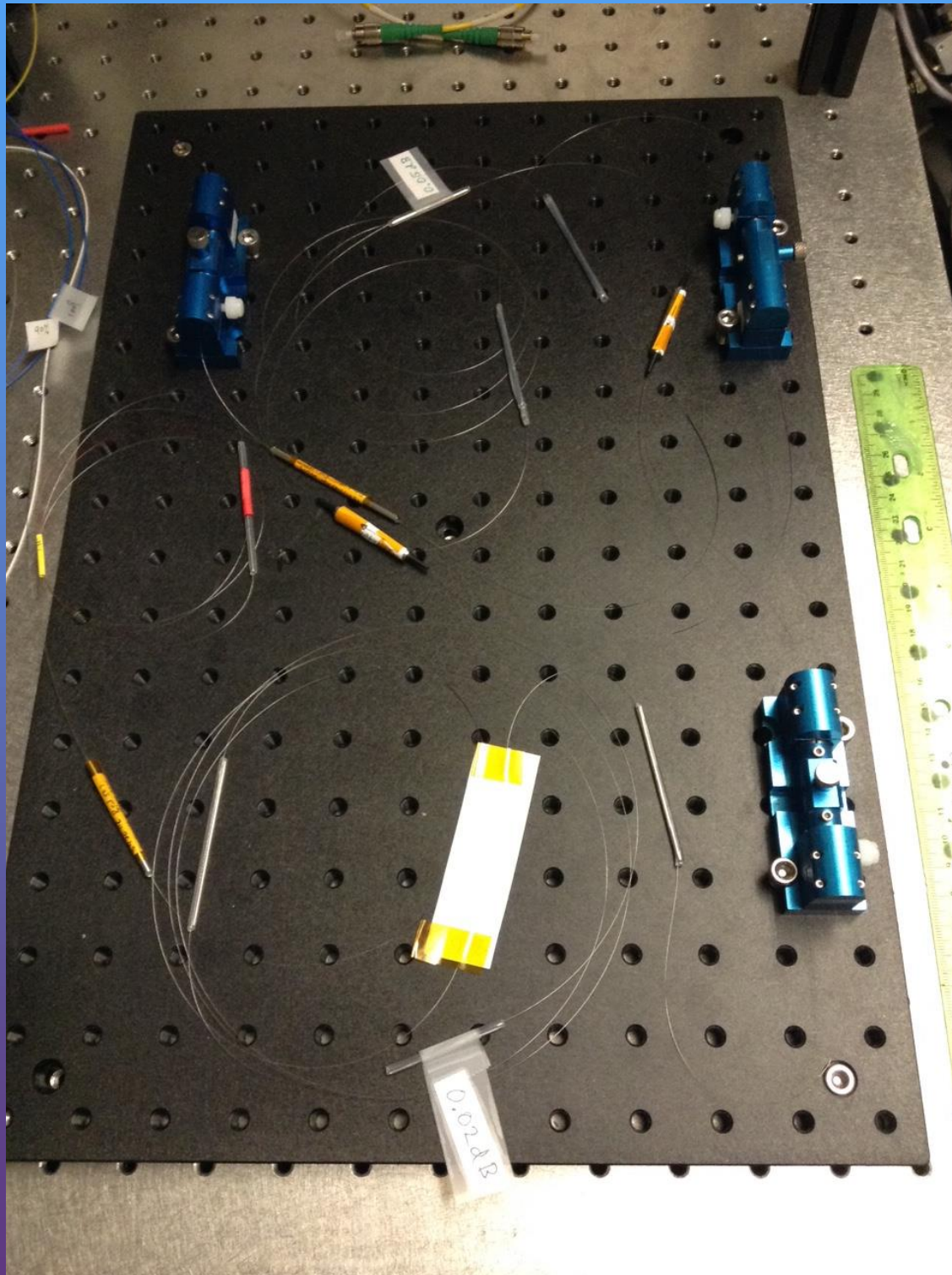
Ultra-high Numerical Aperture Fiber

Required UHNA-7 Length

$$L_{UHNA7} = \frac{NCD - \beta_{2,TM} L_{TM} - \beta_{2,SMF} L_{SMF}}{\beta_{2,UHNA7}}$$

Laser Setup

[1]

Spectrum: No UHNA-7

Spectrum 1 for Tm/Ho laser (1983nm)

Spectrum 2 for Tm/Ho laser (2028.5nm)
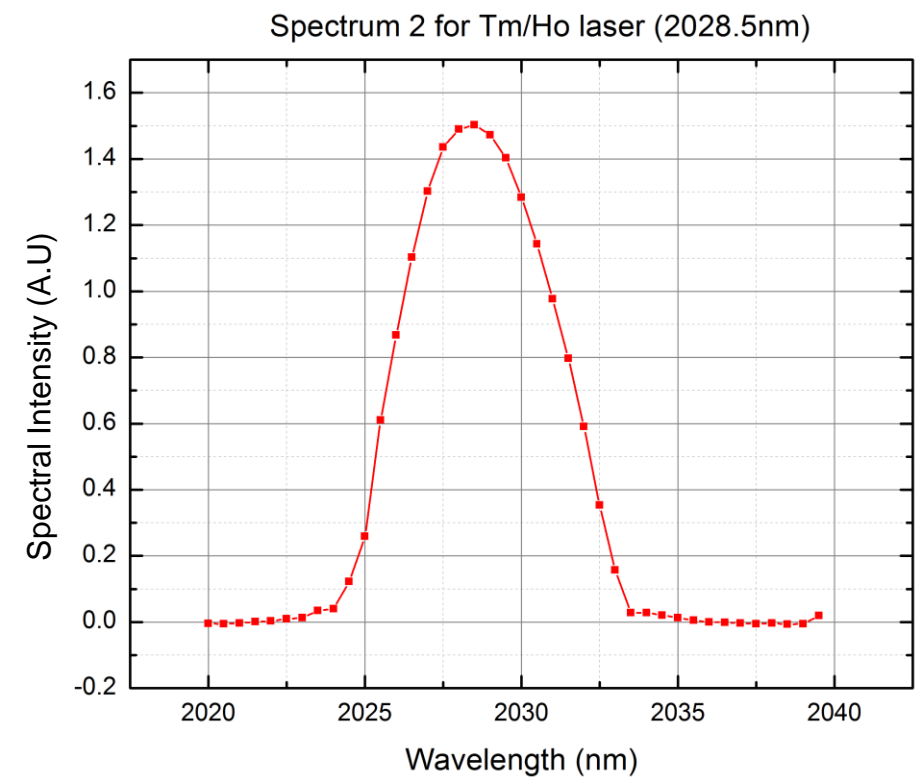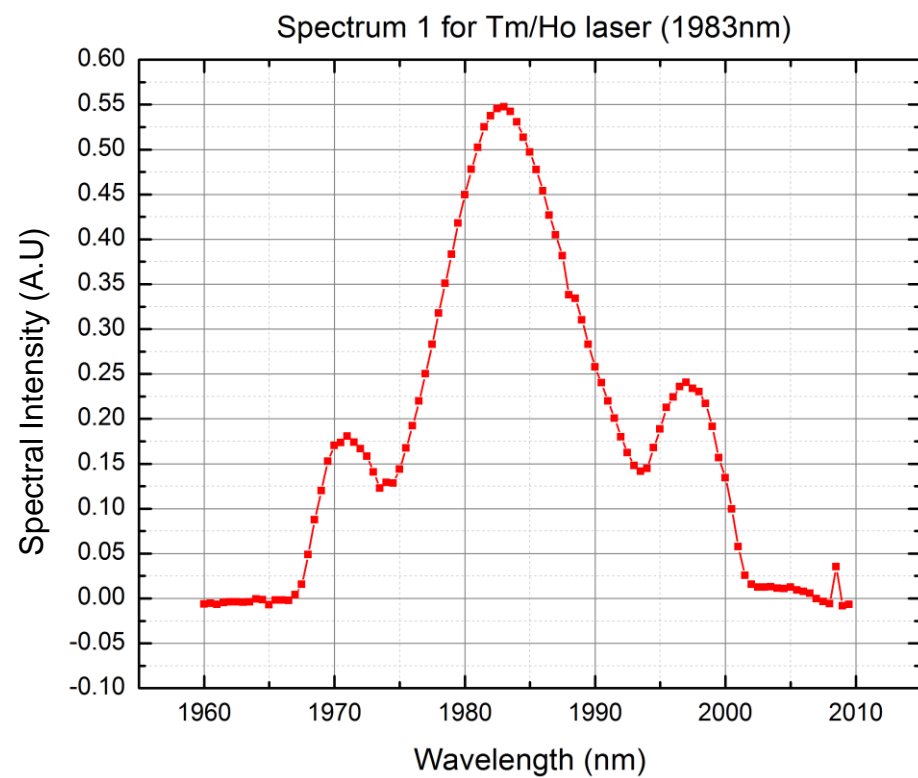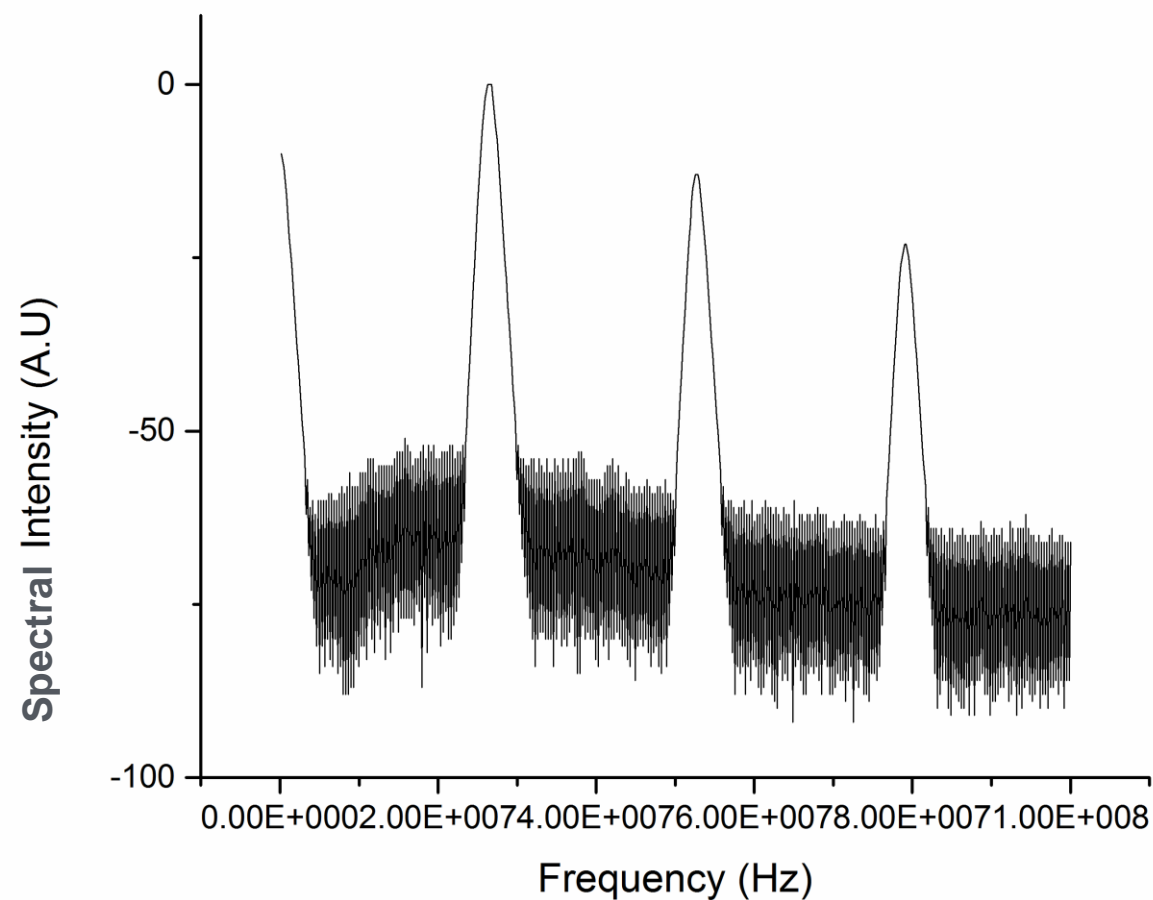
Spectrum: with UHNA-7

Length of Tm/Ho fiber: 1.24m
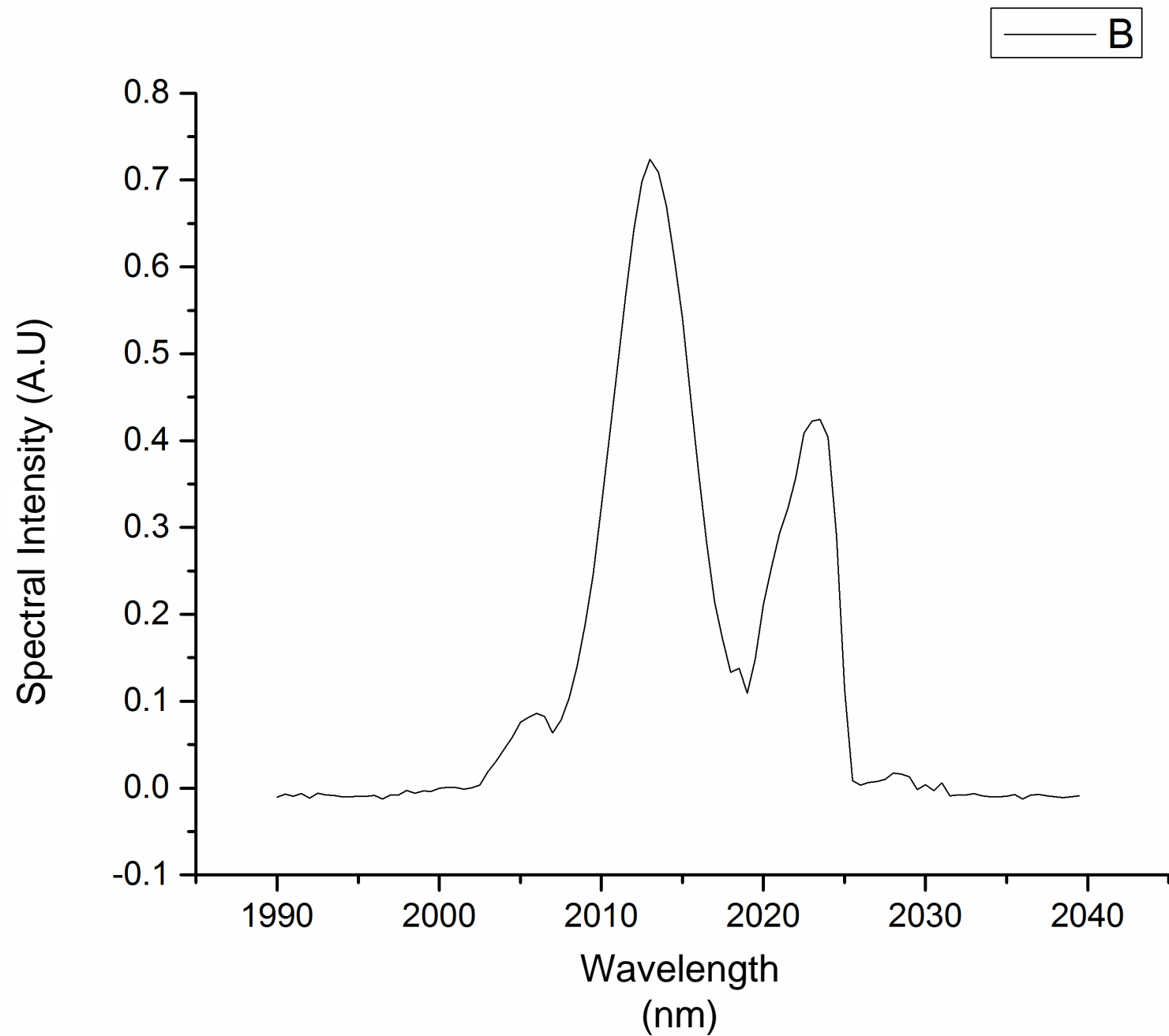Length of UHNA-7: 2.889m
Length of SMF: 3.628m
TOTAL cavity length:
L=7.757m

Total cavity length from
repetition rate:

$$\nu = \frac{c}{n} = \frac{L}{T}$$

L=7.85m

Single Peak

What's Next?

- Temporal pulse measurements
- Cut back UHNA-7 and see how the pulse changes

Acknowledgements

References

[1] R. Kadel and B. R. Washburn, "All-fiber passively mode-locked thulium/holmium laser with two center wavelengths," *Applied Optics,* vol. 51, no. 27, pp. 6465-6470, Sept. 2012.

[2] R. Kadel and B. R. Washburn, "Stretched-pulse and solitonic operation of an all-fiber thulium/holmium-doped fiber laser," *Applied Optics,* vol. 51, no. 4, pp. 746-750, Feb. 2015.