

# Fiber link

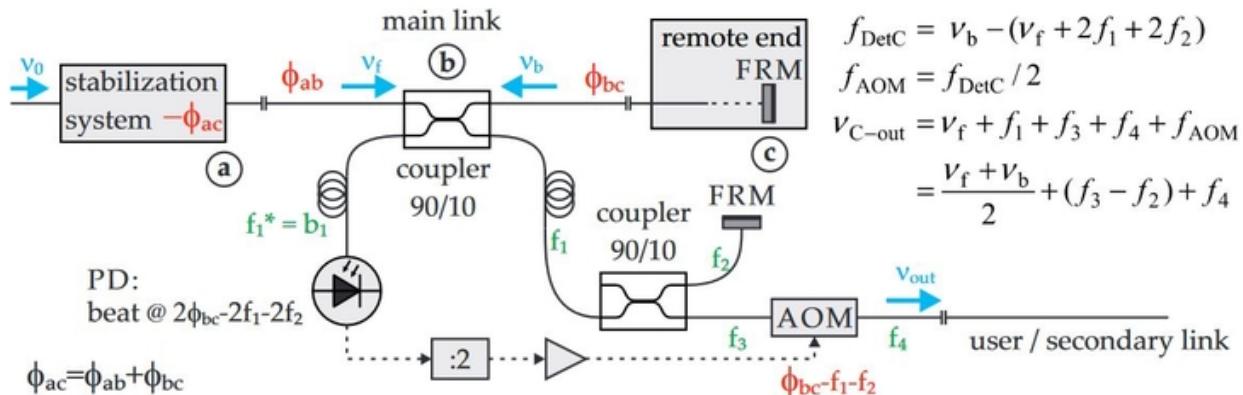
## Fiber stabilization

### Multipoint/Manypoint box (PTB)

Eavesdropping time and frequency: phase noise cancellation along a time-varying path, such as an optical fiber:

ol-39-9-2545.pdf

## Multipoint Frequency Dissemination



## Paper

- <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6702156>
- <https://www.osapublishing.org/ol/abstract.cfm?uri=ol-39-9-2545>

## Scheme

**Multiple Frequency Dissemination and Fiber Brillouin Amplification for the Optical Fiber Link PTB-Hannover**

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**Optical Fiber Link PTB-Hannover**

Main Goals:

- Transfer optical frequency ( $\sim 194$  THz) referenced to a primary clock [1]
- Transfer to several places in Hannover using a single link [2,3,5]
- Transfer instability below  $10^{-10}$  at 1 s of averaging time
- Transfer uncertainty below  $10^{-10}$
- Tests with transportable Sr optical clock [4] and new transportable cavity stabilized laser.

Fig. 1 Planned setup of the optical fiber link for frequency dissemination from PTB to Hannover.  
ACOM: Acousto-optical modulator, FRM: Faraday-Rotating Mirror, PD: Photo-Detector

**Multiple Frequency Dissemination**

Fig. 2 Setup Extraction Box [5]: Extraction of the forward propagating signal  $v_s$ , correction of link phase noise  $b_{\text{ph}}$  as well as noise terms  $b_s$ ,  $b_{\text{c}}$ , introduced by the extraction setup itself. ACOM: Acousto-optical modulator, FRM: Faraday-Rotating Mirror, PD: Photo-Detector

**Performance of Link and Extraction Box**

Fig. 3 Overlapped Allan Deviation ( $A_s$ , ADEV) [6], i.e. A counting with 1 s gates and applying the ADEV of the inloop, remote and extracted signal test setup: see inset, signal extraction at the "end" of the link

**Quadrupole Fiber Brillouin Amplifier**

Fig. 4 Simplified setup of a quadrupole fiber Brillouin amplifier, currently deployed on the PTB-Straßburg-Paris optical fiber link

**Fiber Brillouin Amplification**

Fig. 5 Fiber Brillouin amplification benefit from a combination of high gain and narrow bandwidth. The setup has been demonstrated both in the lab and in the field [7,8].

Fig. 6 View of the optical part and the complete fiber Brillouin amplifier

Fig. 7 Left: High gain, narrow bandwidth, offset-lock at 11 GHz required, right: Gain is polarization dependent, polarization stabilization required

**Conclusion**

- Successful implementation of fiber Brillouin amplifiers
- Successful extraction of a signal from a stabilized 144 km link
- Instability of  $4 \times 10^{-10}$  at 10000 s allows tests of transportable cavity stabilized lasers
- Instability and uncertainty  $< 5 \cdot 10^{-10}$  at 100000 s allows tests with the Sr optical lattice clock [4] (mb/s  $> 10^{-10}$  and uncertainty at low  $10^{-10}$  mb/s)

**References**

[1] G. Grosche, N. Henkel, S. Werner, R. Schäfer, D. Cichocki & R. Wessels, Metrologia, 47, p. 63-79, 2010  
[2] G. Grosche, D. Töns, R. Pohlitz et al., Optics Letters, 36, p. 2279-2281, 2011  
[3] P.A. Williams, M. C. Gazeau, J. L. Vallee, J. Opt. Soc. Am. B, 27, p. 1304-1307, 2010  
[4] Kuhl, A. & Kuster, A. Unpublished PTB Data, 2014

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## Next steps (06.10.2016)

- Comparison measurement with strontium/caesium
- Link to AEI (contact partner: Michael Tröbst?)
- Link HighTec, but how?

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