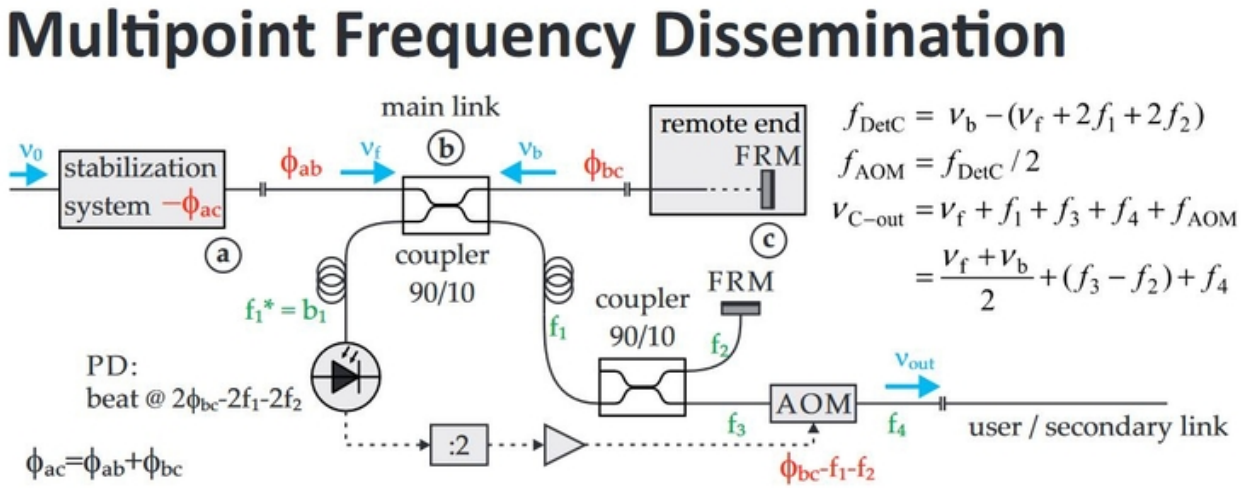
Fiber link

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

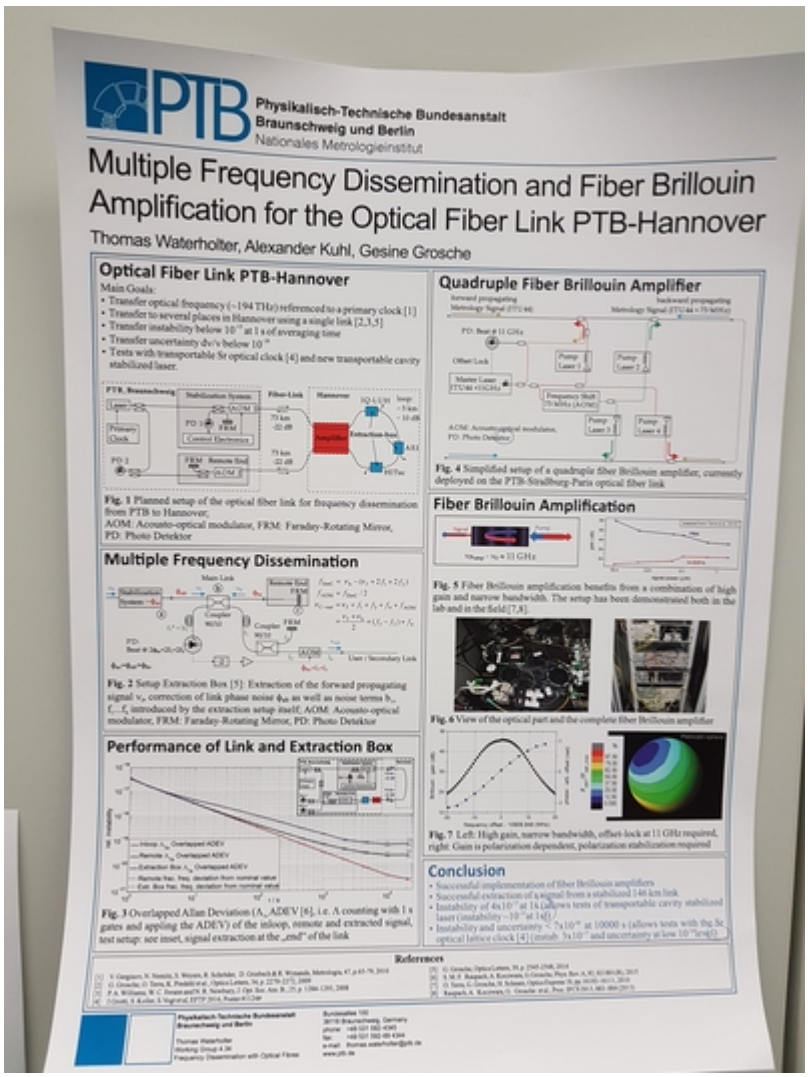


* Nach Möglichkeit sollten die Strecken f2 = f3 + f4 gleich lang sein, damit die Strecke f3 + f4 stabilisiert ist!

Paper

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

Scheme



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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 (~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^{-15} at 1 s of averaging time
- Transfer uncertainty dv/v below 10^{-20}
- 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;
AOM: Acousto-optical modulator, FRM: Faraday-Rotating Mirror,
PD: Photo Detektor

Multiple Frequency Dissemination

Fig. 2 Setup Extraction Box [5]: Extraction of the forward propagating signal ν_0, correction of link phase noise ϕ_{ab} as well as noise terms b_{-1}, f_{-1}, f_0 introduced by the extraction setup itself; AOM: Acousto-optical modulator, FRM: Faraday-Rotating Mirror, PD: Photo Detektor

Performance of Link and Extraction Box

Fig. 3 Overlapped Allan Deviation (A_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

Quadruple Fiber Brillouin Amplifier

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

Fiber Brillouin Amplification

Fig. 5 Fiber Brillouin amplification benefits 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 146 km link
- Instability of 4×10^{-17} at 1 s (allows tests of transportable cavity stabilized laser (instability ~10^{-16} at 1 s)[4])
- Instability and uncertainty < 7×10^{-20} at 10000 s (allows tests with the Sr optical lattice clock [4] (instab. 3×10^{-16} and uncertainty at low 10^{-18}[9]))

References

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Working Group 4.34
Frequency Dissemination with Optical Fibres