1st Workshop
Metrology for Long Distance Surveying

Spectroscopic inline thermometry

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Spectroscopic inline thermometry?
Background

Refractive index of air must be known accurately in optical length measurements, as the length scale is derived from the speed of light:

- Parameters of air → Edlén and Ciddor formulae. To reach $10^{-7}$:
  - 0.1 °C in air temperature
  - 5 % in relative humidity at high air temperatures (near 35 °C)
  - 0.4 hPa in air pressure

- Temperature can be deduced from absorbance using spectroscopy according to

\[
\sigma = S(T)f(v, v_0, T, p)
\]

\[
I = I_0 e^{-\sigma_{NL}}
\]

\[
S(T) = S(T_0) \frac{Q(T_0)}{Q(T)} e^{-\frac{hcE_r}{k} \left( \frac{1}{T} - \frac{1}{T_0} \right)} \times \left( \frac{1 - e^{-hc_1/T}}{1 - e^{-hc_1/kT_0}} \right)
\]
Temperature measurement in long distance interferometry

1. Using a Pt-100 sensor
Temperature measurement in long distance interferometry

1. Using a Pt-100 sensor
2. Using an ensemble of Pt-100 sensors
Temperature measurement in long distance interferometry

1. Using a Pt-100 sensor
2. Using an ensemble of Pt-100 sensors
3. Using laser spectroscopic thermometry
Spectroscopic thermometry in practice

- Compensating a real interferometer (HP 5518) in a real environment (MIKES 30 m rail)

- MIKES spectroscopic thermometer vs. 10 equidistant Pt-100 sensors

- Induce local and temporal temperature variations
Spectroscopic thermometry in practice

![Graph showing temperature changes over time with heater position changes and spectroscopic temperature averages marked.]

- **Spectroscopic temperature**
- **Pt-100 average**
- **Heater position changed**

Temperature [°C] vs. Time [hours]
Spectroscopic thermometry in practice

Compensation with:
- Pt-100 ensemble average
- Spectroscopic sensor

Relative interferometer displacement vs. Time [hours]
Spectroscopic thermometry in practice

- It works, but it comes with a price...
From laboratory to outdoor environment

- Simplified (optical part) and robust set-up for outdoor environment using large diameter optics
What next?

• Parts for the new set-up have been designed and machined

• Assembly and preliminary tests in late 2014 and early 2015

• MIKES and FGI will validate the optical thermometer at the Nummela baseline (864 m) in summer 2014