Group of Coherent Lasers and Interferometry

Department of Coherence Optics

ISI ASCR Institute of Scientific Instruments AS CR, v. v. i.

THEMATIC RESEARCH FOCUS

Research area

– Optical frequency laser length standards
– Laser interferometers and refractive index of air measurement
– Absorption gas cells for laser spectroscopy
– Femtosecond laser based optical frequency synthesis
– Special optical sensing in industrial processes
– Laser induced fluorescence for body fluid level measurement and tissue necrosis detection
– Electronics for process control and measurement
– Design, fabrication and employment of Fibre Bragg Grating (FBG) elements for length measurement

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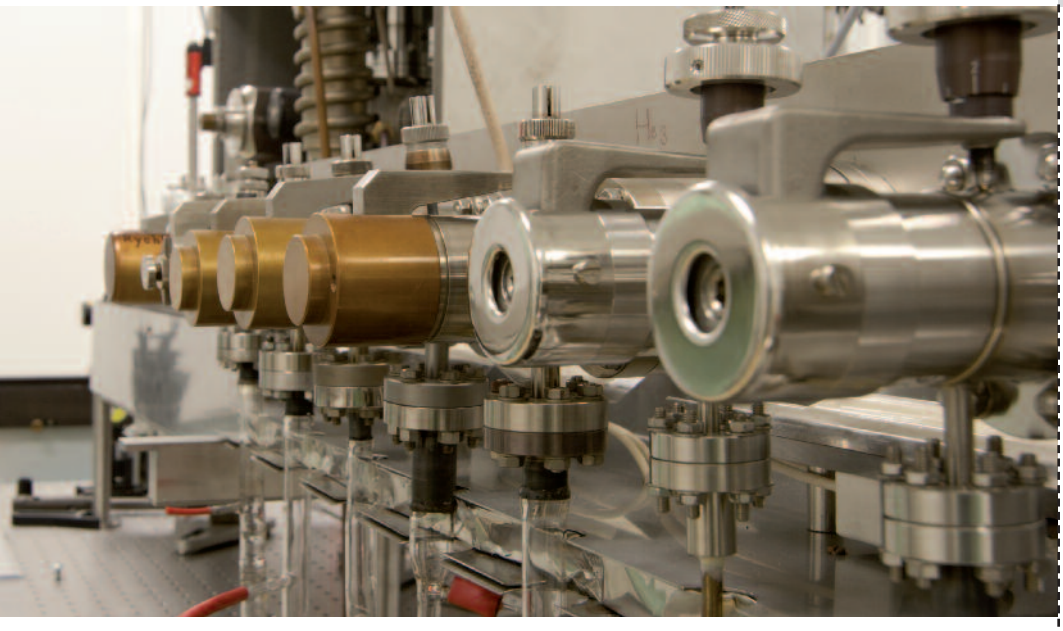


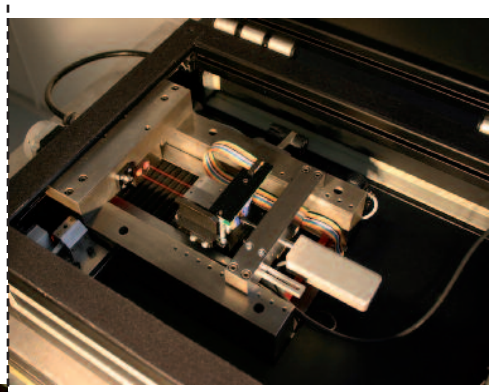
Vacuum system for filling of absorption cells with highly pure gases

Excellence

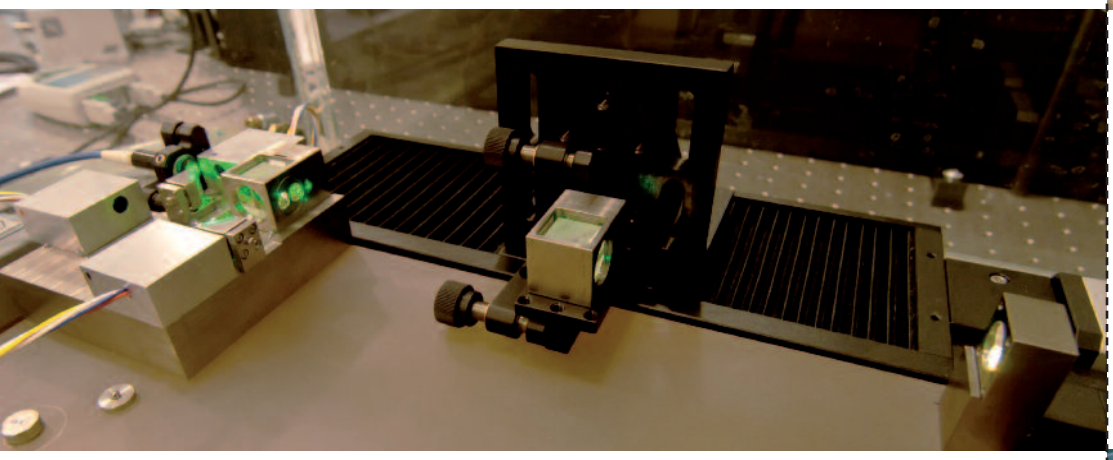
– Laser length measurement with sub-nanometer resolution for scale-linearity testing of length sensors
– Measurement of coefficient of thermal expansion of ultra-stable optical glass or ceramics (ULE, Zerodur)
– High purity absorption gas cell for frequency locking of laser wavelength with stability at the level of 10^{-14}
– Techniques for the measurement of refractive index of air with 10^{-8} accuracy
– Contactless laser interferometry for gauge block length calibration
– Real-time dissemination of process values via industrial networks (CANbus and Ethernet)

Mission

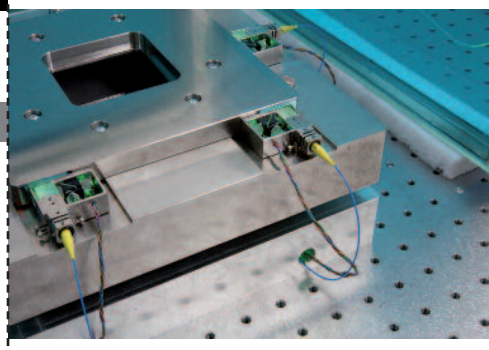
Our mission is to stay in the wider world top in the field of methodology of laser interferometers and optical sensing of lengths in vacuum and in the air. Our aim is the development of laser spectroscopy methods for gas concentration measurement, measurement of body fluid level and tissue quality, research of methods for long-distance measurement with the suppression of refractive index of air fluctuation, FBG gratings for mechanical stability testing of concrete blocks in nuclear power plants, design and control of X-Y positioning system with position sensing by laser interferometers.



Laser interferometer for length sensors calibration



Refractive index of air measurement with special configuration of laser interferometer



Example of the multiaxis interferometer for the 3D positioning of the sample for AFMmicroscopy

DEVELOPED TECHNOLOGIES

Content of research

- Optical frequency laser length standards
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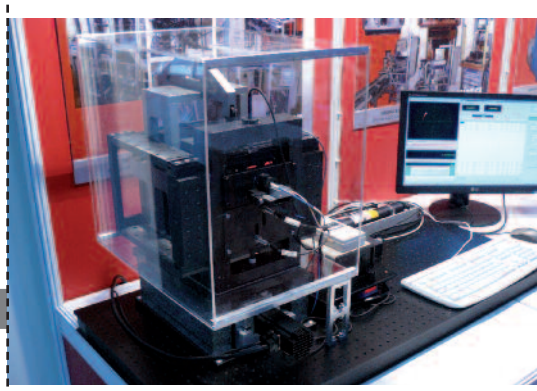
Main capabilities

- Technology of ultra-precise measurement of lengths with stable, tuneable and femtosecond lasers
- Methods of suppression of fluctuation of the refractive index of air for length measurement in the air
- Techniques for the stabilization of the angle of reflecting mirrors in laser interferometry
- Method for scale linearization of interference fringe for ultra-precise laser interferometry
- Techniques of locking tuneable lasers to optical frequency components of femtosecond laser spectrum
- Technology of high purity absorption gas cell production (also custom-made) and high purity gas production
- Methods for real-time dissemination of process values through network (CANbus and Ethernet)

Fields of research results application

– Optics
– Medical Technology
– Automotive industry
– Software
– Telecommunications



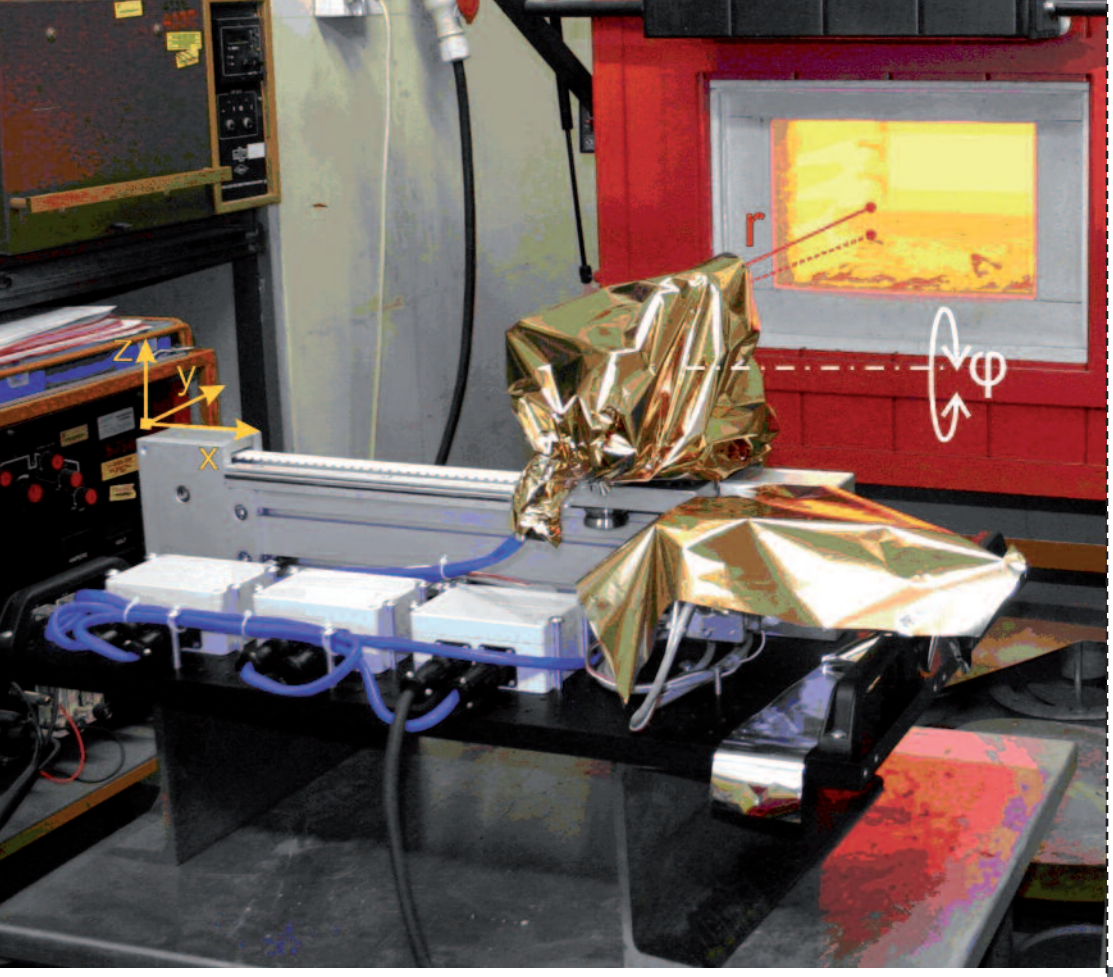
System for automated calibration of length sensors

KEY RESEARCH EQUIPMENT

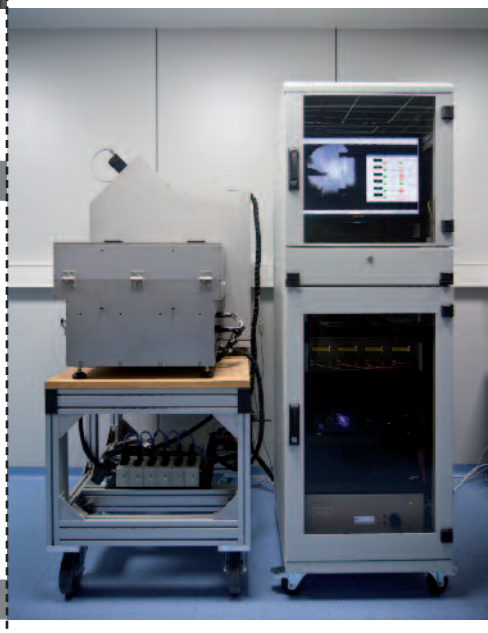
– Optical frequency synthesizers (optical "combs") based on femtosecond lasers
– Set of optical frequency standards working at 532 nm, 633 nm and 1550 nm wavelength
– Active H-maser – highly stable radiofrequency generator
– Laboratory instrumentation for methodology experiments with optics, vacuum technology and electronics

ACHIEVEMENTS

- **A method for non-linearity compensation of interference fringes in homodyne laser interferometer**
  – Číp, O.; Petrů, P.; *A scale-linearization method for precise laser interferometry.* Measurement Science & Technology, 11, (2000), p. 133–141
- **A method for the suppression of refractive index of air fluctuation in interferometric measurement of precise length**
  – Lazar, J.; Holá, M.; Číp, O.; Čížek, M.; Hrabina, J.; Buchta, Z.; *Displacement interferometry with stabilization of wavelength in air.* Optics Express, 20, (2012), p. 27830–27837
- **Tunable extended cavity laser (ECL) as an optical frequency standard**
  – Lazar, J.; Číp, O.; Jedlička, P.; *Tunable extended cavity laser (ECL) as an optical frequency standard working at 633 nm*. Applied Optics, 39, (2000), p. 3085–3088
- **A method for the measurement of coefficient of thermal expansion of stable materials (Zerodur, ULE)**
  – Číp, O.; Šmíd, R.; Čížek, M.; Lazar, J.; *Study of the thermal stability of Zerodur glass ceramics suitable for a scanning probe microscope*. Central European Journal of Physics, 10, (2012), p. 447–453
- **A novel method of contactless gauge block calibration by combination of coherent light and white light produced by mode-locked laser**
  – Buchta, Z.; Řeřucha, Š.; Mikel, B.; Čížek, M.; Lazar, J.; Číp, O.; *Novel Principle of Contactless Gauge Block Calibration.* Sensors, 12, (2012), 3350–3358
- **Gold medal of 54th International Engineering Fair in Brno (2012)** for Contactless laser interferometer system for gauge block calibration by combination of coherent light and white light produced by picosecond laser (in cooperation with an industrial partner – the Mesing company).
- **Werner von Siemens Excellence Award (2012)** for Novel method of contactless gauge block calibration by combination of coherent light and white light produced by mode-locked laser.
- **Prize at the 50th International Engineering Fair in Brno (2008)** Prize was awarded by the editors of the Technický týdeník and of the periodical Automatizace for development the Laser nano-comparator. The research group for the first time presented a unique method for the active stabilization of the laser beam position which improves the reproducibility of the calibration process at the nanometer level.
- In the past ten years, **three scientists from the group were awarded by the international community URSI**, **IMEKO** and **SPIE** for their work in the field of precise measurement of lengths and methods of laser optical frequency stabilization.



Laser tracking detection of shape deviations of objects with high surface temperature



Contactless calibration of gauge blocks

MAIN COLLABORATING PARTNERS

Collaboration with academic partners

Czech Metrology Institute (Brno, CZ)
Brno University of Technology (Brno, CZ)
Palacky University in Olomouc (Olomouc, CZ)
PTB Braunschweig (Braunschweig, D)
VSL Delft (Delft, NL)
CESNET (Prague, CZ)
BEV Vienna (Wien, AT)

Collaboration with companies

MESING (Brno, CZ)
Delong Instruments (Brno, CZ)
Meopta-Optika (Přerov, CZ)
PROFIcomms (Brno, CZ)
NETWORK GROUP (Brno, CZ)
ÚJV Řež (Prague, CZ)

EXPECTATIONS

Offers

Many quality basic research results in these fields:
– High-resolution laser interferometry for length measurement in vacuum and air
– Optical measurement of concentration of various gases
– Detection of stress and length changes by Fibre Bragg Grating technology
– Scientific instruments for real-time processing of signals in laser interferometers and length measurement

Requirements

Cooperation in joint projects where the partner solves technical and technological aspects of the research subject while our group focuses at the development of new methods or at the adaptation of state-of-the-art methods to solve the topic.