Group of Coherent Lasers and Interferometry

Department of Coherence Optics

ISI CAS Institute of Scientific Instruments The Czech Academy of Sciences

THEMATIC RESEARCH FOCUS

Research area

Fundamental optical metrology
- Optical ion clocks
- Femtosecond laser based optical frequency synthesis
- Standards of optical frequencies and distribution of highly stable optical frequencies
- High resolution interferometry and nanometrology

Industrial metrology and measuring methods
- Industrial interferometry
- Optical sensing and measuring techniques
- Fibre Bragg grating based fibre-optic sensors

Special instrumentation in optics and electronics

Excellence

- Quantum mechanics with trapped Calcium ions with the goal of development of optical laser oscillator
- Optical frequency synthesis with a technique of locking optical frequency to a mechanical standard
- Technology of time and frequency transfer through long haul optical networks
- Contactless gauge blocks calibration and diagnostics combining through novel interferometric technique
- High resolution interferometry for nanometrology
- Refractometry and interferometry with compensation for variations of the refractive index of air
- World leader in technology of high purity absorption cells for fundamental metrology
- Methods and techniques for industrial dimensional optical metrology
- Fibre strain and deformation sensing via a of FBG strain sensors
- Real-time dissemination of process values via industrial networks (CANbus and Ethernet)

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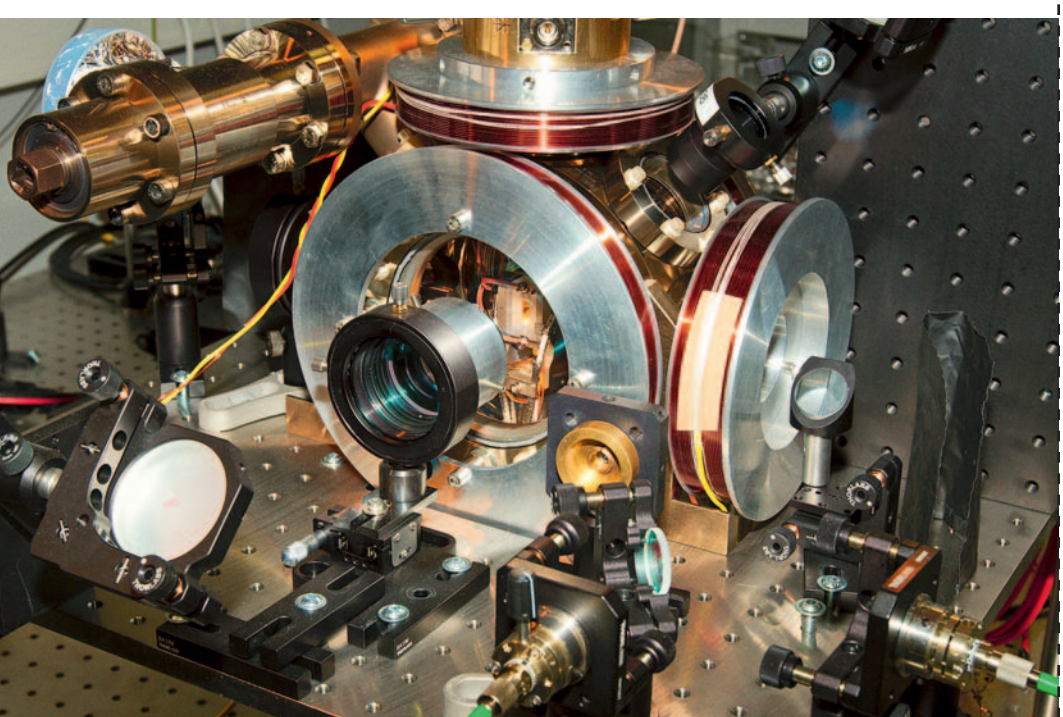


Experimental arrangement of the ion trap for Calcium ions oriented to development of ultrastable laser optical frequency standard

Mission

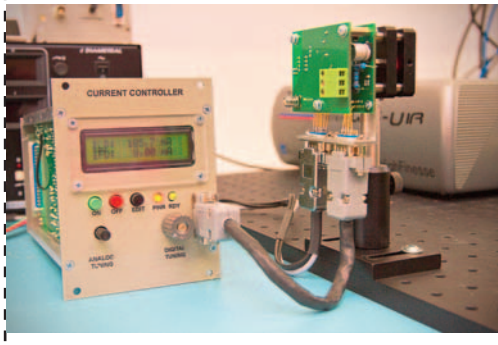
Our mission is research on the border between physics and technical sciences, which includes fundamental, targeted and applied research as well. Our research is methodologically oriented. The goal of most of our projects is an introduction of a novel method, technique or approach and its experimental verification. This includes design of often highly complex and sophisticated experimental assemblies. In optical metrology it often means pushing the limits of resolution and precision. Fundamental research in our case means predominantly research in fundamental metrology. Our involvement in applied research is motivated by the tradition of the institute, which has always tried to promote technology transfer and applications of its research in practice.

Operation of the Hydrogen maser – a radiofrequency reference

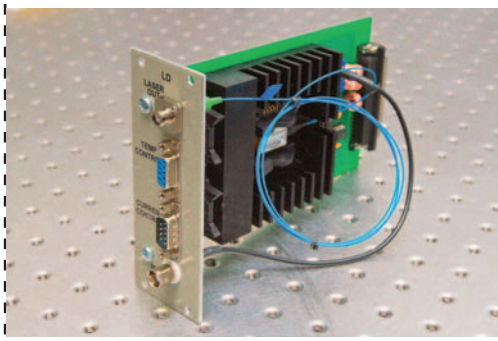
DEVELOPED TECHNOLOGIES

Content of research

- Stabilized lasers – standards of optical frequencies for fundamental and industrial metrology and interferometry
- Laser interferometric systems for coordinate measurement and various special applications
- References of optical frequencies – absorption cells for metrology and laser spectroscopy
- Technology and electronic control systems for femtosecond laser based optical frequency synthesis
- Special optical sensors for various applications
- Technology and electronic control of phase coherent optical frequency transfer via fiber links
- Laser induced fluorescence for body fluid level measurement and tissue necrosis detection
- Electronics and control electronics for experiments and special instrumentation
- Methodology and instrumentation for contactless gauge blocks calibration and diagnostics
- Design, fabrication and employment of Fibre Bragg Grating (FBG) elements for length measurement

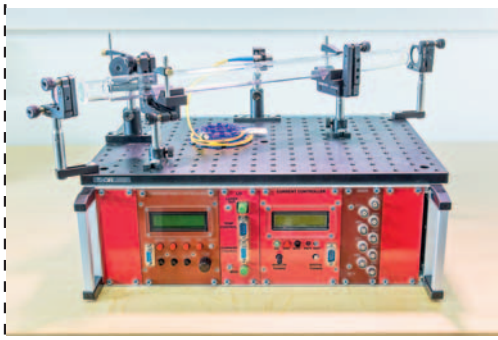


Controller and supporting circuitry for single-frequency laser diode operating in the visible spectral range



Highly coherent semiconductor laser for the telecommunication applications

Stabilized laser source designed as optical frequency reference in the near-infrared spectral range



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
- Interferometry using a novel digital derivative technique for detection of the interference signal
- 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 (CAN-bus and Ethernet)

Fields of research results application

- Optics
- Precision engineering
- Medical technology
- Automotive industry
- Software
- Telecommunications

KEY RESEARCH EQUIPMENT

List of devices

- Optical frequency synthesizers (optical "combs") based on femtosecond lasers (visible and IR)
- Set of optical frequency standards operating at 532 nm, 633 nm and 1550 nm wavelengths
- Active H-maser – highly stable radiofrequency time and frequency standard
- Laboratory instrumentation for experiments with optics, vacuum technology and electronics

ACHIEVEMENTS

A method for non-linearity compensation of interference fringes in homodyne laser interferometer

- O. Číp, F. Petrů: "*A scale-linearization method for precise laser interferometry*", MEASUREMENT SCIENCE & TECHNOLOGY **11**, 133-141, 2000

A method for the suppression of refractive index of air fluctuation in interferometric measurement of precise length

- J. Lazar, M. Holá, O. Číp, M. Čížek, J. Hrabina, Z. Buchta: "*Displacement interferometry with stabilization of wavelength in air*", OPTICS EXPRESS **20**, 27830–27837, 2012

Tunable extended cavity laser (ECL) as an optical frequency standard working at 633 nm

- J. Lazar, O. Číp, P. Jedlička: "*Tunable extended cavity laser (ECL) as an optical frequency standard working at 633 nm*", APPLIED OPTICS **39**, 3085-3088, 2000

A method for the measurement of coefficient of thermal expansion of stable materials (Zerodur, ULE)

- O. Číp, R. Šmíd, M. Čížek, J. Lazar: "*Study of the thermal stability of Zerodur glass ceramics suitable for a scanning probe microscope*", CENTRAL EUROPEAN JOURNAL OF PHYSICS, **10**, 447–453, 2012

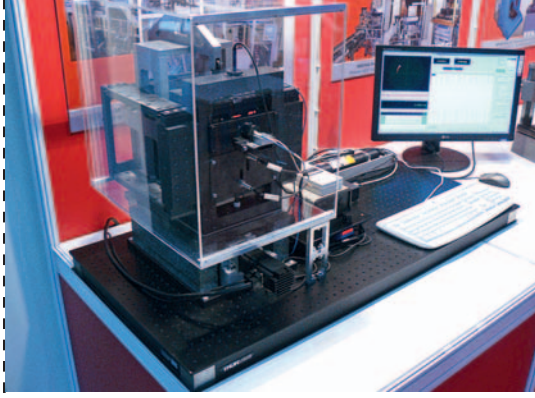
A novel method of contactless gauge block calibration by combination of coherent light and white light produced by mode-locked laser

- Z. Buchta, S. Řeřucha, B. Mikel, M. Čížek, J. Lazar, O. Číp: "*Novel Principle of Contactless Gauge Block Calibration*", SENSORS **12**, 3350-3358, 2012

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

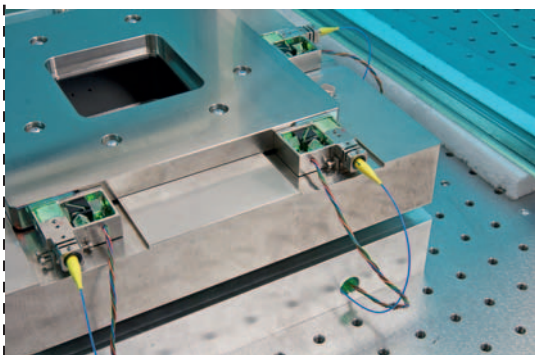
The editors of the Technický týdeník (Technical Weekly) along with the editors of the periodical Automatizace (Automatization) awarded their prize at the 50th International Engineering Fair in Brno (2008) to the joint team of researchers that developed the Laser nano-comparator. The research group for the first time presented a unique method for



Nanocomparator for interferometric calibration of displacement sensors for the automotive industry

Fibre-optic hub for distribution of precise optical frequencies

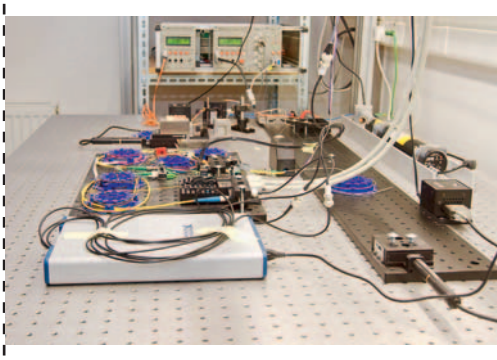
Positioning platform with six-axis interferometric measurement and motion control for nanometrolgy



Contactless laser interferometer system for gauge block calibration awarded Gold medal of 54th International Engineering Fair in Brno

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 (International Union of Radio Science), IMEKO (International Measurement Confederation) and SPIE (International Society for Optics and Photonics) for their work in the field of precise measurement of lengths and methods of laser optical frequency stabilization.**



Testbed for fiber-optic displacement sensors based on FBG technology and evaluation through spectrum analysis

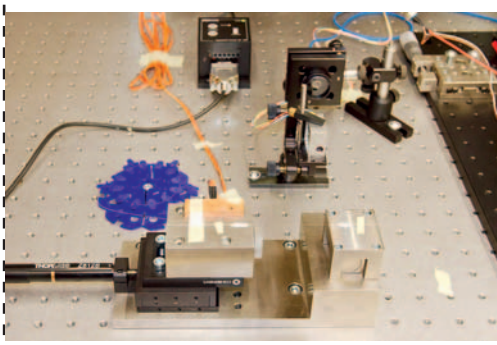
MAIN COLLABORATING PARTNERS

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)
- NPL (Teddington, UK)

Collaboration with companies

- MESING (Brno, CZ)
- TESCAN ORSAY HOLDING (Brno, CZ)
- Meopta-Optika (Přerov, CZ)
- PROFIcomms (Brno, CZ)
- NETWORK GROUP (Brno, CZ)
- ÚJV Řež (Prague, CZ)



Calibration setup for FBG sensors with laser interferometer as a reference

EXPECTATIONS

Offers

- A number of excellent fundamental 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 FBG grating technology
- Scientific instrumentation for real-time processing of signals in laser interferometers and length measurement

Requirements

Cooperation in joint collaborative projects where we are looking for a partner able to concentrate on technical and technological development following the research phase.