Workshop on
Laser Sources for LIDAR Applications

Weßling (Germany), 25-26 November 2014

Location: Deutsches Zentrum für Luft- und Raumfahrt (DLR) Oberpfaffenhofen, Institut für Physik der Atmosphäre, Münchner Straße 20, 82234 Weßling, Germany

Book of Abstracts

Organized by the BRITESPACE consortium:

The FP7-Space Project *BRITESPACE* is pleased to welcome you to the international Workshop on "Laser Sources for LIDAR Applications", devoted to promote the contact between developers and manufacturers of laser sources with developers and users of LIDAR systems.

The aim is to promote the interaction between communities of laser manufacturers and LIDAR system developers and users in both research and industry environments. In particular, this workshop will focus on the needs of appropriate laser sources and configurations required by specific LIDAR applications and on the performances of state-of-the-art LIDAR transmitters.

Scope

- Pulsed and CW laser sources: Solid State lasers, Fiber lasers, Semiconductor lasers, any other type of laser and configuration (Master Oscillator Power Amplifiers, Optical Parametric Oscillator...).
- Types of LIDAR systems: Coherent/incoherent backscatter lidar, High Spectral Resolution Lidar (HSRL), Differential-Absorption Lidar (DIAL), Integrated-Path Differential-Absorption (IPDA) Lidar.
- LIDAR applications: distance/motion measurements, 3D imaging, bathymetry, measurements of aerosol-, cloud-, wind- and humidity profiles, atmospheric turbulence, climate related trace gases (CO_2, CH_4), canopy height and surface reflectance.

Technical Committee

Ignacio Esquivias, Universidad Politécnica de Madrid, Spain.
Michel Krakowski, III-V Lab, France.
Martin Traub, Fraunhofer-Institut für Lasertechnik, Germany.
Juan Barbero, Alter Technology Group, Spain.
John G. Rarity, University of Bristol, United Kingdom.
Gerhard Ehret, Deutsches Zentrum für Luft- und Raumfahrt, Germany.

Organizing Committee

Mathieu Quatrevalet, Deutsches Zentrum für Luft- und Raumfahrt, Germany.
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Information: www.britespace.eu/workshop

Contents

Pratical Information

Welcome to the Institute of Atmospheric Physics at DLR's Oberpfaffenhofen premises in Weßling. We wish you a nice stay and a fruitful Workshop.

Local public transportation

Suburban trains (S-Bahn) of the **S8 line** run every 20 minutes in both directions between **Steinebach** (where the ***Florianshof* guesthouse** is located), **Weßling** (where the ***Seehof* hotel** is located) and **Neugilching**.

Located halfway between Weßling and Neugilching, DLR is within walkable distance of both (20 to 30 minutes). Bus lines **947**, **952** and **955** may also be used. From Wessling station, the direction is **"Gilching-Argelsried"**. From Neugilching station, the directions are **"Weßling"** (947), **"Inning, Marktplatz"** (952) or **"Starnberg Nord"** (955).

Workshop Dinner

The Workshop Dinner will take place at the ***Klostergasthof*** next to the **Andechs Monastery** by the Ammer lake, on **November 25th** starting at **19:30**.

A **charter bus** to and from Andechs will leave DLR's premises at **19:00** and serve the ***Seehof* hotel in Weßling** and the ***Florianshof* guesthouse in Auing** on its way.

Wifi Internet Access during the workshop

A public wireless internet access is available to all guests within the building of the Institute of Atmospheric Physics, under the name ***DLR-SfR Gastzugang***. The password will be displayed in the conference room.

Workshop Program

Tuesday, November 25th

Time	Duration	Topic
09:00	10 min	Welcome to DLR (Prof. Markus Rapp, Director of DLR Institute of Atmospheric Physics)
09:10	10 min	Welcome to the Workshop (Ignacio Esquivias, UPM)
09:20	**90 min**	**Session 1: (Chairman: Ignacio Esquivias, UPM)**
	30 min	*High power fiber lasers for Doppler wind lidars: requirements and experimental performances* (Jean Pierre Cariou, LEOSPHERE)
	30 min	*Diode based coherent LIDARs for wind sensing* (Christian Pedersen, DTU Fotonik)
	30 min	*Potential of compact light sources based on hybrid integration of tailored diode lasers and electronics for LIDAR applications* (Bernd Sumpf, FBH)
10:50	**30 min**	***Coffee break***
11:20	**80 min**	**Session 2: (Chairman: Michel Krakowski, III-V Lab)**
	30 min	*BRITESPACE: High Brightness Semiconductor Laser Sources for Space Applications in Earth Observation* (Ignacio Esquivias, UPM)
	30 min	*High power pulsed fiber laser for spaceborne DIAL lidar and system modelling* (Claudine Besson, ONERA)
	20 min	*Frequency Reference Stabilized Laser System for CO2 Monitoring* (Renaud Matthey, Université de Neuchâtel)
12:40	**80 min**	***Lunch break and photo session***
14:00	**100 min**	**Session 3: (Chairman: Martin Traub, Fraunhofer ILT)**
	30 min	*Optical parametric devices for airborne and spaceborne lidar applications* (Andreas Fix, DLR)
	20 min	*Robust design and assembly technology of a 1645 nm OPO for French-German satellite mission MERLIN* (Florian Elsen, Fraunhofer ILT)
	30 min	*Range-resolved atmospheric CO2 measurement using coherent DIAL at 2 µm* (Fabien Gibert, LMD-IPSL)
	20 min	*Lidar activity at ENEA Frascati* (Luca Fiorani, ENEA)
15:40	**30 min**	***Coffee break***
16:10	**70 min**	**Session 4: (Chairman: John Rarity, University of Bristol)**
	30 min	*High Peak Power Solid State Laser Sources for LIDAR Applications* (Hans-Dieter Hoffmann, Fraunhofer ILT)
	20 min	*Single-Frequency Pulsed Solid-State Lasers for Lidar Applications* (Christoph Bollig, Abacus Laser)
	20 min	*Photonic devices and components for airbone and spaceborne lidar systems/Case study: Development of an innovative DPSS laser system (ESA QOMA project)* (George Avdikos, Raymetrics)
17:20		***First day ends***
19:00		***Coach departure to restaurant for Workshop Dinner***

Wednesday, November 26th		
Time	**Duration**	**Topic**
09:30	**70 min**	**Session 5: (Chairman: Juan Barbero, ATN)**
	30 min	*BELA Laser - qualifying a reliable laser source for planetary missions* (Reinald Kallenbach, MPI / Kai Weidlich, Zeiss Cassidian Optronics)
	20 min	*Laser ranging interferometer for future gravity missions – GRACE–FO and beyond* (Kolja Nicklaus, SpaceTech Gmbh)
	20 min	*Laser power requirements for space-borne remote sensing of CO2* (Xiao Ai, University of Bristol)
10:40	**30 min**	***Coffee break***
11:10	**60 min**	**Session 6: (Chairman: Gerhard Ehret, DLR)**
	30 min	*Laser source specification for applications in ground airborne and space LIDARs* (Pierre Flamant, LMD-IPLS)
	30 min	*Direct detection UV LIDARs for avionics* (Nikolaus Schmitt, Airbus Innovation Works)
12:10	15 min	Concluding remarks (Ignacio Esquivias, UPM)
12:25	**95 min**	***Lunch break***
14:00	**60 min**	***Tour of DLR's research aircraft at the Flight Experiments Facility***
15:00	***Workshop ends***	

Session 1

Talk 1.1

High power fiber lasers for Doppler wind lidars: requirements and experimental performances.

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Fiber lasers, first developed for telecoms, are now becoming new effective sources for coherent lidars, thanks to their spatial and spectral qualities. Allowing operation in continuous, modulated and pulsed mode, their increasing power at eye-safe wavelengths is well suited to long range coherent lidars.

For ten years, Leosphere has been developing and manufacturing Doppler wind lidars for applications in meteorology, wind energy, airport safety and air quality. Based on fiber laser architectures and pulsed operation, these lidars require dedicated fiber amplifiers to ensure simultaneously range, velocity resolution and time resolution.

Requested laser qualities are here discussed concerning wavelength, power, pulse duration and frequency, beam shape and spectral width, and are compared to existing fiber amplifier technology.

Experimental results are presented and compared to simulation models, highlighting the high performances of this disruptive technology.

Talk 1.2

Diode based coherent LIDARs for wind sensing

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One of the main considerations in the development of the wind industry is metrology issues. Essentially, more cost efficient and accurate wind velocity and turbulence mapping systems are highly desired for uptimisation of the wind turbine. Traditional cup and sonic anemometers require either meteorological masts or installation in the wake of the rotor blades obstructing the measurement quality. For this particular task the laser remote sensing (lidar) technology offers an attractive alternative. However traditional lidars are not well-suitable due to production cost. Exchanging costly fibre laser assemblies with diode laser technology offers a solution to this lidar challenge.

Talk 1.3

Potential of compact light sources based on hybrid integration of tailored diode lasers and electronics for LIDAR applications

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Diode lasers have a great potential for the generation of short optical pulses in the nanosecond and picosecond ranges by means of gain-switching, Q-switching or mode-locking. Such short pulses are required, for example, for LIDAR applications to detect aerosols or molecules (DIAL), for fluorescence spectroscopy as well as for applications in medicine, measuring technology, and data communication. The applications as seed lasers in master oscillator power amplifier systems are well established.

In this talk different concepts and methods for the generation of short optical pulses using GaAs-based semiconductor lasers and laser systems will be presented. After a short description of the multi-section distributed feedback (DFB), distributed Bragg reflector (DBR), and tapered lasers as well as amplifiers, experiments will be presented using gain-switched, Q-switched and mode-locked lasers in the range between 940 nm and 1080 nm.

For many applications nearly diffraction-limited and spectrally-stabilized emission is needed. Diffraction limited emission is achieved by a ridge waveguide (RW) with several microns width, so that only the fundamental lateral mode should lase. Spectral stabilization is realized with a Bragg grating integrated into the semiconductor chip, resulting in DFB- or DBR-lasers. In pulsed mode, peak powers in the Watt-range for 4 ns long pulses were obtained using gain-switching. 65 ps were reached applying Q-switching.

Even higher peak powers of several tens of Watts can be achieved by an amplification of the pulses with semiconductor optical amplifiers, which can be either monolithically or hybrid integrated with the master oscillators. Here compact modules with a small footprint of only 4 x 5 cm^2 integrating the active optical elements, the micro-optical beam-shaping elements and also the high-frequency electronics will be presented. Amplified output powers up to several 10 W will be reported.

The multi-section optical amplifiers can also be used for a control of the repetition rate, either as pulse picker to select individual pulses or as optical gate to generate an optical pulse out of a cw master oscillator with excellent spectral properties as needed for example for the measurement of aerosol or molecular gases in the atmosphere using Micro-DIAL. Besides peak powers in the range of several 10 W a spectral line width smaller than the width of absorption lines under study are necessary. For water vapour at atmospheric pressure this width should be smaller than 10 pm at 975 nm. Using a DFB-RW laser operated in continuous wave as master oscillator and a multi-section tapered amplifier, optical pulses having a length of 15 ns at a repetition rate of 25 kHz with peak powers up to 16 W limited by the available driven electronics were obtained. The emission width of the MOPA system is smaller than 10 pm with a SMSR of 40 dB and therefore suitable for the detection of e.g. H_2O.

Session 2

Talk 2.1

BRITESPACE: High brightness semiconductor laser sources for space applications in Earth observation

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The availability of suitable laser sources is one of the main challenges in future space missions for accurate measurement of atmospheric CO_2. In the framework of European Project BRITESPACE, we propose an all-semiconductor laser source for an Integrated Path Differential Absorption (IPDA) lidar system for column-averaged measurements of atmospheric CO_2 in future satellite missions. Standard IPDA systems use high peak power optical pulses at two sounding frequencies to calculate the column averaged gas concentration. Semiconductor lasers are superior to other types of lasers in terms of reliability, compactness and efficiency, but they cannot provide the high peak power required by the application. In consequence, the complete system architecture has to be adapted to the particular emission properties of these devices. The proposed transmitter design is based on two InGaAsP/InP monolithic Master Oscillator Power Amplifiers (MOPAs), providing the ON and OFF wavelengths close to the selected absorption line around 1.57 µm. Each MOPA consists of a frequency stabilized Distributed Feedback (DFB) master oscillator, a modulator section, and a tapered amplifier. Initial experimental results on the fabricated MOPAs indicate that the use of a bended structure to avoid undesired feedback provides good spectral properties together with high output power and good beam quality. The modulator section is required by the Random Modulated Continuous Wave (RM-CW) approach that has been selected as the best adapted to semiconductor laser. Initial results show a good quasi-static extinction ratio when internally modulating the laser. The laser module includes the beam forming optics and the thermoelectric coolers. The DFB emission is tuned and stabilized by an offset locking technique referenced to a CO_2 gas cell. A state-of-the-art InGaAs negative feedback avalanche diodes (NFAD) is proposed for single photon counting of the received signal, in order to improve the Signal to Noise Ratio. Experimental results on the MOPA and laser module characteristics will be presented.

Talk 2.2

High power pulsed fiber laser for spaceborne DIAL lidar and system modelling

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Talk 2.3

Frequency Reference Stabilized Laser System for CO_2 Monitoring

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A compact frequency-stabilized laser system is being developed to serve as absolute frequency reference for CO_2 monitoring lidar instrumentation. Rubidium atoms were preferred to CO_2 molecules, as they demonstrate strong and narrow sub-Doppler transition lines achievable with low laser power and a couple of centimeters long optical pathlength. By applying light modulation and frequency conversion techniques, the high frequency stability obtained from rubidium at 780 nm is transferred to the 1.55-μm and 1572-nm CO_2 regions. Frequency stability better than 2 kHz has been reached on time scales between 20 minutes and 2 days. The laser system will be described together with ongoing activities.

Session 3

Talk 3.1

Optical parametric devices for airborne and spaceborne lidar applications

Andreas Fix, Martin Wirth, and Gerhard Ehret

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In recent years several airborne differential absorption lidar (DIAL) systems for the detection of atmospheric trace gases have been developed at DLR [1]. As their transmitters, various optical parametric oscillators (OPOs) and amplifiers (OPAs) have been deployed generating wavelengths from the ultraviolet to the mid-infrared range. Next to advantageous spectral properties, their high electrical-to-optical efficiency, ruggedness, and small volume are prerequisite for their successful deployment. In general, the fundamental or harmonics of Q-switched, diode-pumped Nd:YAG lasers serve as the pump. Past and current developments include OPO/OPA based lidar systems to measure ozone (O_3), water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), and mesospheric sodium (Na).

Ozone DIAL requires wavelengths in the range around 300 nm which is efficiently generated by sum frequency mixing of OPO radiation with the harmonics of the pump. For water vapour measurements the required wavelengths (~935 nm) can be directly generated by means of a 532-nm pumped OPO. However, the spectral requirements are stringent since the spectral width need to be close to the Fourier limit and the spectral purity is required to be high (>99.9%). This is achieved by applying the technique of injection seeding. While a spaceborne lidar mission to measure water vapour is put on hold, the German and French space agencies selected MERLIN as a satellite mission to measure atmospheric columns of methane being the second most important anthropogenic greenhouse gas after carbon dioxide. MERLIN whose launch is envisaged in 2019 will carry a near IR (1.6 µm) injection-seeded OPO.

To support the MERLIN and future greenhouse gas lidar missions, a demonstration system is being built at DLR that will be capable of simultaneously measuring both, CH_4 and CO_2 from an airborne platform. Considerable experience is drawn from a recent development of a helicopter-borne lidar system to detect leaks in natural gas transmission pipelines.

[1] A. Fix, “Tunable Light Sources for Lidar Applications” in: U. Schumann (ed.), Atmospheric Physics, Research Topics in Aerospace, Springer-Verlag Berlin Heidelberg 2012. ISBN: 978-3-642-30182-7 (Print) 978-3-642-30183-4 (Online) DOI: 10.1007/978-3-642-30183-4.

Talk 3.2

Robust design and assembly technology of a 1645 nm OPO for French-German satellite mission MERLIN

Florian Elsen, Heinrich Faidel, Matthias Heinzig, Marie J. Livrozet, Jens Löhring, Ansgar Meissner, Matthias Winzen, Jochen Wüppen, Bernd Jungbluth, Hans-Dieter Hoffmann

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We present a robust design and the assembly technology of a pulsed 1645 nm OPO for a spaceborne laser transmitter in an Integrated Path Differential Absorption Lidar (IPDA) system. The investigation is part of the French-German satellite mission MERLIN (Methane Remote Sensing Lidar Mission).

By means of numerical simulations we studied the performance and alignment tolerances of the OPO and investigated means to optimize the optical design in terms of higher efficiency and lower fluence on the optical components. In recent experiments the OPO obtained 12.5 mJ pulse energy at 1645 nm from 32.0 mJ of the pump at 1064 nm, corresponding to a conversion efficiency of 39%. We proved the feasibility of the OPO for spaceborne methane LIDAR-measurements and identified the requirements on the thermomechanical stability of the optical elements.

The usability of soldered optomechanical mounts, which have been developed by the ILT, was tested by assembling two OPO modules. These modules exhibit similar output characteristics and were successfully thermomechanically tested in a climate chamber. We studied the laser induced damage thresholds of the optical components in an automated LIDT setup which is suitable for ISO 11254-2 compliant LIDT-measurements at the pump wavelength of 1064 nm. These LIDT-values were verified by LIDT-testing during OPO operation.

Talk 3.3

Range-resolved atmospheric CO_2 measurement using coherent DIAL at 2 µm

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High space and time resolution measurements of carbon dioxide mixing ratio and radial wind speed in the atmosphere are addressed by a 2-µm high power coherent differential absorption lidar (CDIAL). The CDIAL system relies on an innovative high power two wavelengths single-mode pulsed Ho:YLF laser which delivers 12 mJ-energy 40-ns-duration pulses at a 2 kHz repetition frequency. The lidar uses an all-fibre-coupled Tm pump laser, sequential seeding module, coherent receiver and frequency reference system locked to the R30 CO_2 absorption line centre at 2050.967 nm, which all enable compactness and easy deployment for field experiment. Daytime and nighttime 20-hour measurements of the system are presented. The lidar reveals CO_2 mixing ratio variations in the atmospheric surface layer with 10min time and 100m space resolutions and 1% statistical uncertainty over 1km. The simultaneous radial wind speed measurements enable to understand CO_2 gradient anomalies as a result of non-perfect

mixing of surface anthropogenic emissions. Preliminary advected CO_2 anthropogenic fluxes are estimated. Potential applications are discussed in details.

Talk 3.4

Lidar activity at ENEA Frascati

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Earth, water, air and fire: According to the ancient Greek philosopher Empedocles they are the elements of all matter. Indeed the three main spheres of our natural environment are mainly made of earth (lithosphere), water (hydrosphere) and air (atmosphere). This presentation ideally complete the Empedocles' set of elements by reporting on recent applications to earth, water and air of such a modern fire constituted by the laser source. In particular, we will focus on the lidar activity carried out at the Diagnostics and Metrology Laboratory of ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development). The following systems are operational or under development at present:

- Differential absorption lidars for the remote sensing of volcanic plumes (EU FP7 projects BRIDGE and CO2VOLC, Italian project VulcaMed)
- Atmospheric lidar for the remote detection of explosive precursors (EU FP7 project BONAS)
- Raman lidar for the remote detection of explosives (NATO project RADEX)
- LIBS (laser induced breakdown spectroscopy), LIF, Raman lidar for the remote detection of explosives (EU FP7 project EDEN)
- Lidar fluorosensors for the remote detection of dissolved/particulate matter in natural waters (Italian projects RIMA, RitMare, ROME)
- Subsea 3D laser scanner (Italian project It@cha)
- RGB imaging topological radar (service to cultural heritage Italian and Vatican authorities)
- LIF lidar (service to cultural heritage European authorities)

The above systems will be presented, emphasizing available (at present) and desirable (in the future) characteristics of their laser sources.

Session 4

Talk 4.1

High peak power solid state laser sources for LIDAR applications

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Talk 4.2

Single-Frequency Pulsed Solid-State Lasers for Lidar Applications

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Pulsed Single-frequency operation, i.e. operation on a single longitudinal mode, is of importance for many lidar applications. The presentation will give an introduction into strategies to achieve single-frequency pulsed operation and their implementation. Different pulsed single-frequency lasers in the eye-safe wavelength region with pulse energy ranging from 15 µJ to 330 mJ will be presented. These are useful for example for coherent Doppler lidar.

Talk 4.3

Photonic devices and components for airborne and spaceborne lidar systems/Case study: Development of an innovative DPSS laser system (ESA QOMA project)

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Session 5

Talk 5.1

BELA Laser - qualifying a reliable laser source for planetary missions

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The space-qualified design of a miniaturized laser for the BepiColombo laser altimeter (BELA) will be presented. BELA will become the first laser altimeter on a planetary mission of ESA and will form an integral part of a larger geodesy and geophysics package on board the Mercury Planetary Orbiter (MPO) of the BepiColombo mission.

The laser facilitates pulsed operation at 10 Hz repetition rate and at 1064 nm wavelength. The laser design consists of a pair of diode-laser pumped, actively q-switched Nd:YAG rod oscillators encapsulated into dry synthetic air. The system delivers at least 300 million laser pulses with 50 mJ energy and 5 ns duration. It will be launched in 2016 and, after a six-years cruise, will start recording topographic data from orbital altitudes between 400 km and 1500 km above Mercury's surface.

Critical qualification issues of the BELA Laser comprise reliable operation of laser diodes, accurate transmitter-to-receiver alignment, stable pulse energy and stable beam divergence over 300 million laser pulses.

Talk 5.2

Laser ranging interferometer for future gravity missions – GRACE FO and beyond

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GRACE (launched 2002) and GOCE (launched 2009) are two very successful missions to measure earth's gravity field, both leading to a large number of publications. For future gravity missions, like GRACE FO and the potential Next Generation Gravity Mission (NGGM), a satellite-to-satellite tracking (SST) scheme, similar to GRACE is in development. Instead of the Ka-Band link used on GRACE, a laser link will be used to enable much lower measurement noise in the range of some nm/sqrt(Hz) in the measurement band from 0.1 mHz to 0.1 Hz. To achieve this accuracy highly stable laser sources, optical systems and spacecraft environments are required. In this talk the current development status of the laser ranging interferometer on GRACE-FO as well as the work on a high stability laser source for NGGM and the influence of the spacecraft environment on the ranging performance will be presented.

Talk 5.3

Laser power requirements for space-borne remote sensing of CO2

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The ability to accurately observe the Earth's carbon cycles from space gives scientists an important tool to analyze climate change. Current space-borne Integrated-Path Differential Absorption (IPDA) lidar concepts have the potential to meet this need. They are mainly based on the pulsed time-of-flight principle, in which two high energy pulses of different wavelengths interrogate the atmosphere for its transmission properties and are backscattered by the ground. We have previously proposed the Pseudo-Random Single Photon Counting (PESPC) IPDA lidar for this application. In this work we report through simulation the CO_2 detection precision under the influence of various geophysical parameters, atmospheric pressure (altitude), as well as absorption cross-section of the CO_2 at different wavelengths. It has been shown that the 1.5ppm threshold retrieval precision is attainable with 2W average power.

Session 6

Talk 6.1

Laser source specification for applications in ground airborne and space LIDARs

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Talk 6.2

Direct detection UV LIDARs for avionics

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Airborne LIDARs as part of commercial airplane avionics can provide essential in-flight information like air data (density/temperature/pressure/humidity/speed), which are currently measured by traditional sensors using a redundant number of such sensors on each aircraft, but with potentially common failure modes. Optical measurement would provide an independent physical measurement approach with non-communal failure modes to the traditional sensors.

Apart from air data, LIDAR can provide information on hazardous situation (like volcanic ash concentration, ice or icing conditions) in the proximity of an air plane and even remotely at a distance ahead (forward looking). With the help of such forward looking LIDAR measurement, closely connected to the flight control, even an automated active counteraction to air flow disturbances can be envisaged (e.g. in clear air turbulences, shear wind, wake vortex situations).

LIDAR thus can enable and support increased situation awareness, increased safety and reliability, reduced pilot work load by improved auto-piloting functionalities, reduced load on the structure and optimized operational efficiency.

While some of the physical parameters mentioned above might be measureable using coherent LIDAR, a larger number of parameters or phenomena, especially but not only at higher altitudes and larger distances, require UV LIDARs. Main reason is the much higher (Rayleigh or Raman) backscatter of objects like molecules being much smaller in size than the laser wavelength used. On the other side, molecular measurements do not allow coherent detection because of the high Doppler shift of the molecular backscatter at reasonable temperatures, leading to highly broadened frequency spectrum of the backscatter (typ. GHz range). Nevertheless, the lower sensitivity of direct detection is more than outweighed by the higher backscatter.

Examples of UV LIDARs for multiple air data measurement and forward-looking applications for commercial aircraft will be given, based on experimental results of systems developed and tested in feasibility lab and flight tests, and consequences for the laser sources pointed out.

Taking into account the constraints for LIDAR on board commercial aircraft as part of the aircraft avionics, it turns out that a multifunctional LIDAR will be required to measure a number of parameters with the same LIDAR system, thus splitting cost, size and weight of the LIDAR to this number of functionalities.

List of participants

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