Optical parametric devices for airborne and spaceborne lidar applications

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Abstract: In recent years, optical parametric oscillators and amplifiers have advanced to a stage of maturity making them particularly suitable for use in airborne and even spaceborne lidar applications. Their large tunability opens up unprecedented capabilities to measure atmospheric species such as water vapour, ozone, carbon dioxide or methane.

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 nonlinear optical 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 prerequisites 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 lidar systems to measure ozone, water vapour, carbon dioxide and methane.

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 micro 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 the 2016 timeframe will carry a near IR (1.6 µm) injection-seeded OPO. In the meanwhile, a demonstration system is being built that will be capable of measuring both, methane and carbon dioxide 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.

Reference

[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.