The UPC Scanning Raman Lidar: An engineering overview

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ABSTRACT

The enhanced capabilities of lidars as active remote sensing instruments (as compared to passive remote sensing systems and active sensing with microwave radars) relies on the very good spatial resolutions (on the order of a few meters) and optical wavelengths often comparable to the size of the target aerosols, so that the backscattered return radiation coveys prime information about the intervening atmosphere.

Considering their target applications, elastic lidars (i.e., backscatter lidars, for which there is no wavelength shift in the return radiation) provide approximate range-resolved intensity profiles of aerosol and cloud cross sections along the exploration beam path. Although, one elastic channel enables qualitative and, quite often, semiquantitative inversion of meteorological (e.g. aerosol boundary layer studies) and pollution information of interest (usually in the form of backscatter intensity maps), the error bars obtained are large, and cooperative instrumentation is necessary to help to reduce them. An innovative approach to overcome the lack of quantitative information in the optical parameters – namely, extinction and backscatter- and hence to derive independent aerosol extinction and backscatter profiles over local scales is to combine at least one elastic (no wavelength shifted) with one inelastic (Q-branch Raman wavelength shifted) receiving channel into the lidar instrument. Thus, because of the inherent calibration that represents the Raman return from major atmospheric species of known proportion such as N_2, combined elastic/Raman lidars enable to retrieve quantitative range-resolved extinction and backscatter profiles of the low troposphere as well as temperature and relative humidity profiles. On a different category, Doppler systems have usually been devoted to wind measurements but not long ago, the combination of scanning elastic lidars and appropriate spatial correlation techniques have also proven fruitful to remote wind sensing with acceptable accuracies. Moreover, lidars are quite often too big and difficult to transport (if not ground based stations) so that any scanning and/or portability feature is of great advantage.

As a result of the above mentioned features, this work focuses on the technology, architecture and control integration of optical, electronic and mechanical subsystems composing a new Nd:YAG portable 3-D-scanning Raman lidar. The system simultaneously operates at 532-nm and 1064-nm emission/reception elastic wavelengths plus at the 607.4-nm N_2-Raman-shifted reception wavelength. In addition, the system is able to perform interspersed low-range (typ. 200 m - 4 km) and far-range exploration (typ. 3 km – 50 km) at the two elastic wavelengths by using a single 20-cm aperture telescope and specific design of the electronics of the receiving channels. By using a user-friendly LabView™ interface, distributed CPU control and digital control over the optoelectronic reception channels involved, user-configurable scanning tools and open-capabilities can be built and customised.

As far as we know, these contributions are new to the state-of-the art of the community of optical and electronic lidar system designers, particularly, in terms of the measurement of the four-dimensional space-time distribution of the atmospheric optical parameters, namely, extinction and backscatter.

Keywords: lidar, backscatter, Raman, remote sensing, scanning, system architecture, distributed control.

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