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3β+3α+2δ, water vapor, and fluorescence high-performance Raman lidar for an enhanced observation of atmospheric aerosols and clouds

S. Fernández-Carvelo[1,2*], J.A. Bravo-Aranda[1,2], J.L. Guerrero-Rascado[1,2], M.J. Granados-Muñoz[1,2], F. Navas-Guzmán[1,2], D. Pérez-Ramírez[1,2] and L. Alados-Arboledas[1,2]

[1] *Andalusian Institute for Earth System Research (IISTA), University of Granada, Granada, 18006, Spain*
[2] *Department of Applied Physics, University of Granada, Granada, 18071, Spain*

***Corresponding author e-mail**: solfcarvelo@ugr.es

The 3β+3α+2δ Dual-LMRD multispectral lidar system (Raymetrics S.A., Greece), so-called ALHAMBRA, has depolarization and fluorescence capabilities. Both high-performance capabilities have been demonstrated to provide an enhanced characterization of atmospheric aerosols and clouds [1,2].

The ALHAMBRA system is currently operational at the UGR urban station in Granada, Spain (37.164° N, 3.605° W), as part of the AGORA (Andalusian Global Observatory of the Atmosphere). The system has two modules. The near-field (far-field) module emits laser radiation at 355, 532 and 1064 nm at 120 (230) mJ per pulse and frequency of 10 (20) Hz. Combining both modules, the full overlap height is about 200 m a.g.l., providing information from very low heights. The near-field subsystem includes detection in the Raman vibrational channels of 532 (607) and 355 (387) nm, and the far-field system includes detection in the 1064 (1056), 532 (530.2) nm, and 355 (353.9) nm Raman rotational channels. Signals are split into parallel and perpendicular components relative to the polarized plane of the emitted laser beam at 355 nm in the far-field module and at 355 and 532 nm in the near-field module, so depolarization capabilities of near-field subsystem allow the determination of the linear particle depolarization ratio and, thus, its spectral dependence. This feature has recently attracted interest in the scientific community not only for aerosol typing but also for microphysical retrieval and identification of physical processes such as hygroscopicity [3] and aerosol-clouds interactions [4]. It can provide information on the shape and/or thermodynamic phase of scatters, including aerosol particles, droplets, and ice crystals.

ALHAMBRA system also has fluorescence capability for the near-field subsystem, which detects signals in the 420-520 nm range using a broadband interferential filter. Both subsystems focus via optical fiber to HORIBA 1250M imaging spectrometer with two exchangeable gratins of 1200 and 300 g/mm. Using the 1200 g/mm grating, together with a 32-multi-anode PMT detector, allows the observation of a 20-nm spectral range with a resolution of 0.625 nm/channel.

The synergistic combination of depolarization and fluorescence measurements will allow an accurate atmospheric characterization, overcoming the difficulty due to the variability of aerosol properties [5,6].

Keywords: aerosol, clouds, depolarization, fluorescence, spectrometry, Raman Lidar, remote sensing

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References

[1] Veselovskii, I et al., 2022. *Atmospheric Measurement Techniques*, *15*(16), 4881-4900.
[2] Veselovskii, I. et al., 2022. *Atmospheric Chemistry and Physics*, *22*(8), 5209-5221
[3] Granados-Muñoz et al., 2015. *Atmospheric Measurement Techniques*, *8*(2), 705-718.
[4] Ansmann et al., 2019. *Atmospheric Measurement Techniques*, *12*(9), 4849-4865.
[5] Tatarov, B et al., 2021. *Optics Letters*, *46*(20), 5173-5176.
[6] Veselovskii, I. et al., 2023. *Atmospheric Measurement Techniques Discussions, 1-24.*