

# **Rotational Raman scattering through narrow-band interference filters: investigating uncertainties using a new Rayleigh scattering code developed within ACTRIS**

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Accurate simulation of Rotational Raman (RR) scattering from atmospheric molecules plays an important role in the design and data analysis of elastic, depolarization, extinction, and temperature lidar systems. Narrow-band interference filters (IFF) introduce a temperature dependence in the signals due to the different contribution of the rotational Raman lines to the signal. This effect is used to measure the temperature profile with Raman lidars. However, it introduces a bias in the calculation of the extinction, especially when using the rotational Raman method. Additionally, the strongly depolarizing RR lines lead to a shift in the detected molecular depolarization ratio with temperature. For the estimation of the systematic uncertainty of such measurements and its impact on the lidar products e.g. the particle extinction and depolarization profiles, it is important to be able to calculate the contribution of the Rayleigh scattering, i.e., the central Cabannes line and of the individual RR lines - mainly of the N<sub>2</sub> and O<sub>2</sub> molecules - to the lidar signal intensities. The uncertainty of the contribution depends on factors such as the uncertainties in the wavelength and angle dependent transmittance of the IFFs, the temperature of the backscattering volume, or the exact laser wavelength. Based on several codes existing in the ACTRIS community for the calculation of the O<sub>2</sub> and N<sub>2</sub> RR lines, we developed a new, state-of-the-art version written in Python for a wide range of laser wavelengths, e.g. between 355 nm and 1064 nm, and for all air temperatures. It has been tested against the existing codes, will be implemented in the ACTRIS lidar data analysis software Single Calculus Chain (SCC), and is publicly available for use and further improvement. We used this new code for the estimation of possible errors due to the above mentioned experimental uncertainties and estimate the overall error in the calculated molecular RR extinction coefficients and depolarization ratios. Finally, we demonstrate the importance of applying actually measured laser and IFF properties in the lidar retrieval.