EGU21-2504
https://doi.org/10.5194/egusphere-egu21-2504
EGU General Assembly 2021

Towards DOAS measurements with a picometre spectral resolution

Jonas Kuhn[1,2], Nicole Bobrowski[1,2], Thomas Wagner[2], and Ulrich Platt[1,2]
[1]University of Heidelberg, Institute for Environmental Physics, Department of Physics and Astronomy, Heidelberg, Germany (jkuhn@iup.uni-heidelberg.de)
[2]Max Planck Institute for Chemistry, Mainz, Germany

Differential Optical Absorption Spectroscopy (DOAS) has proven to be very useful to study the composition and dynamics of Earth's atmosphere. Compact grating spectrographs (GSs) with moderate spectral resolution (ca. 1nm) allow to quantify the absorption of many trace gases along atmospheric light paths from ground to space borne platforms.

Since the width of a rovibronic absorption line of a small molecule in the UV to near IR spectral range is in the picometre range, increasing the spectral resolution of DOAS measurements largely increases their selectivity and in many cases also their sensitivity. In addition, further trace gases (e.g. OH radicals) or isotopes of trace gases could be detected, while common problems due to Fraunhofer line undersampling were reduced. However, since high resolution GSs are bulky (immobile) instruments with a strongly reduced light throughput, hardly any high resolution DOAS measurements have been performed.

Since more than a century, Fabry Pérot Interferometers (FPIs) have been successfully used for high resolution spectroscopy in many scientific fields, where their light throughput advantage over grating spectrographs for higher resolving powers is well known. However, except for a few studies, FPIs
received hardly any attention in atmospheric trace gas remote sensing. We examine the light throughput of GSs and FPI spectrographs regarding spectral resolution and spectrograph size (i.e. mobility). We find that robust and mobile high resolution FPI spectrograph implementations can be by orders of magnitude smaller than GSs with the same spectral resolution. A compact high resolution FPI spectrograph prototype was already successfully tested in the field. Further, the light throughput can be optimised to allow for passive scattered sunlight measurements with similar SNR as moderate resolution DOAS measurements while, at the same time, attaining spectral resolutions in the picometre range.

High resolution FPI spectrographs might allow for a multitude of applications in atmospheric remote sensing. A few examples include scattered sunlight absorption measurements of many atmospheric trace gases and their isotopes, the quantification of tropospheric and volcanic OH radicals, high resolution O2 measurements for radiative transfer investigation and aerosol studies, and solar induced chlorophyll fluorescence quantification using Fraunhofer lines.