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A compact high resolution spectrograph for remote sensing of atmospheric trace gases

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Usually DOAS-type remote sensing of atmospheric trace gases in the UV and visible is performed at spectral resolutions of some hundreds of pm up to a nm. This is frequently sufficient, since many trace gases (e.g. SO_2, NO_2, H_2O, O_3, HCHO, CHOCHO, BrO, OClO, IO, etc.) exhibit structured absorption (due to vibro-electronic transitions) on a nm wavelength scale. The intrinsic spectral resolution of atmospheric trace gas absorption cross sections and also of spectral structures in the solar spectrum are, however, on the order of some pm in this wavelength range. Spectral artefacts resulting from measurements with low spectral resolution are corrected by using a recorded reference spectrum and highly resolved literature data of Fraunhofer lines and trace gas absorption cross sections. This type of measurements can be performed with compact grating spectrographs.
In some cases, however, higher spectral resolution is desired: 1) When absorption cross sections of different trace gases overlap on the nm scale they can still be distinguished on a higher resolution. 2) When the absorption cross section is only structured on higher resolution, e.g. single sharp absorption lines. 3) If evaluation without a recorded reference spectrum is desired, spectra on the intrinsic resolution of the Fraunhofer lines and absorption cross sections are required.
Grating spectrographs with resolution of a pm scale are typically very bulky instruments and hardly practical for field measurements. Here we report the development of a high resolution spectrograph based on a high finesse Fabry Perot Interferometer. A spectral resolution of about 2-5 pm is reached with an instrument design, which is comparable in size, weight and stability to widely used low resolution grating spectrometers. A series of applications for active and passive remote sensing are discussed, including precise water vapour measurements in the visible range and oxygen column measurements for the determination of atmospheric photon path lengths.