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A Novel Miniaturised Infrared Imaging Spectrometer for the Measurement of Atmospheric Trace Gases

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A novel, ultra-compact Static Imaging Fourier Transform Spectrometer, SIFTS, with no moving parts has been developed for the remote and in-situ detection of atmospheric gases. This technique has previously been demonstrated in the visible spectral region (400 to 1100nm) using a CCD detector. This paper the author presents the results of the infrared version of the SIFTS instrument, which uses an uncooled microbolometer detector array to measure infrared spectra (7 to 14μm) with a resolution of up 4 cm^{-1} and temporal resolution of 30Hz.

The technique is based on a static optical configuration whereby light is split into two paths and made to recombine along a focal plane producing an interference pattern. The spectral information is returned using a detector array to digitally capture the interferogram which can then be processed into a spectrum by the application of a Fourier transform.

The novel optical design has reduced the optics required to only 3 optical components and the detector array, to generate and measure the interferogram. The experimental performance of the SIFTS instrument has verified the theoretical models, which has shown that the spectral resolution is for the infrared instrument is 4cm^{-1}. The Connes advantage, inherent to the Michelson spectrometer Fourier Transform Spectrometer (FTS), whereby the spectral wavelength accuracy is referenced to a stabilised laser has also been demonstrated in the SIFTS instrument. This has been implemented through the use of an expanded internal laser diode with Distributed Bragg Reflector (DFB) which acts as the calibration source used to maintain the wavelength stability of the SIFTS instrument.

As there are no moving components, the instrument is compact, light and insensitive to mechanical vibration, additionally the speed of measurement is determined by the frame rate of the detector array. Thus, this instrument has a temporal advantage over common Michelson FTIR instruments. For example, this technique has shown that by using a high speed Toshiba CCD line array, sensitive over the spectral region of 400 to 1100nm, spectra can be recorded at a rate of one every 0.1 milliseconds.

Using an NEC infrared detector array, sensitive over the spectral region of 7 to 14μm, low pressure gas cells of NH3 and CH4 have been measured to demonstrate the sensitivity and wavelength accuracy of the SIFTS instrument. It has been shown that the Signal to Noise of the SIFTS$_{(MIR)}$ is 524 using an integration time of 30 milliseconds.

This instrument has been developed for both remote sensing and in-situ measurements of atmospheric gases. Due to the low mass and compact size of the instrument system, the SIFTS instrument could be deployed as a remote sensing instrument onboard Earth observation satellites, Unmanned Aerial Vehicles (UAV's), or as an in-situ sensor for the measurement of atmospheric gases.