

# Introduction to Spatial Heterodyne Observations of Water (SHOW) Project and its instrument development

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## Abstract

Water is a critically important constituent throughout the stratosphere and mesosphere. The SHOW project will develop a new instrument to measure water vapour from 15km to 85km height, on a global scale, using the unique capabilities provided by Spatial Heterodyne Spectroscopy (SHS). This work builds on Canadian expertise in fabricating solid Michelson interferometers to fill a significant niche in our current capability. The SHS setup the FTS with the mirrors replaced by diffraction gratings at Littrow configuration, wavelength depended Fizeau fringes are recorded by a 320\*256 CCD camera without any scanning elements, the high resolution spectral information along one detector dimension can be obtain from Fourier analysis, and the other dimension will provide the spatial information. At a limb view point, a field-widened SHS with half-angle of 6 degrees for water observations at 1364nm is desired, the resolution is 0.02nm within full bandwidth of 2nm, and the resolving power is about 68,000.

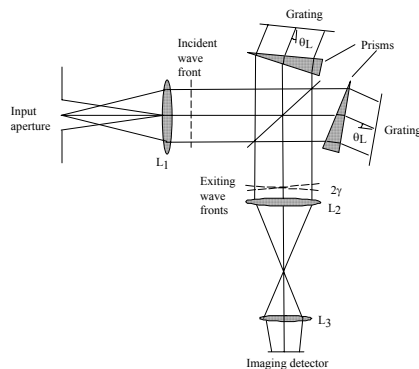
## Introduction

The primary objective of the SHOW project is to develop a new instrument designed to measure water vapour from the upper troposphere, through the stratosphere and into the lower mesosphere, on a global scale, using the unique capabilities provided by Spatial Heterodyne Spectroscopy (SHS). The development of the new SHOW instrument will enable us to address these important scientific objectives:

- To demonstrate the capability of long-term measurement of water vapour in the stratosphere.
- To study the process of water vapour entry to the stratosphere.
- To study the transport of water vapour in the stratosphere and mesosphere.
- To study mesospheric water vapour and mesospheric clouds.

## SHS and SHOW Instrument Design

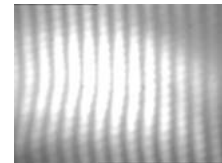
SHS (Spatial Heterodyne Spectroscopy) was developed to suit any application on any spectral regions for any species with high spectral resolution and large throughput over a relatively narrow band. A spatial heterodyne interferometer is similar to a Michelson interferometer with its mirrors replaced by fixed diffraction gratings. The interferometer does not require any moving parts.



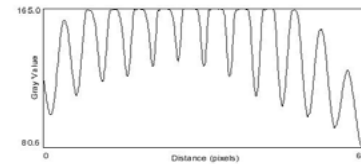
SHOW SHS SETUP

## Lab tests and Results

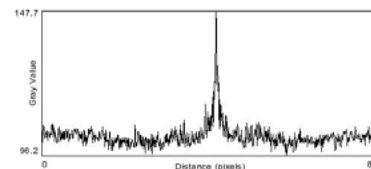
In general, a spatial heterodyne spectrometer can be tuned to operate in any spectral region and it is possible to control the trade off between spectral resolution and bandwidth. The SHOW laboratory breadboard work has demonstrated this with the development of both a visible and near IR test setup. After the successful design, setup and test of breadboards at 632.8 nm and 1264 nm, two emission lines from a Krypton and a Xenon lamp were used to demonstrate the SHS at water window (1364.5nm). All of these were implemented at minimal cost using off the-shelf components and existing equipment in the CRESS Space Instrumentation Laboratory (CSIL).



NIR SETUP at 1264nm and its SHS image



Slice Read of the fringes



FFT for the Emission line of 1265nm



Field Widened SHS System

## Conclusions and Future Work

The current work has clearly demonstrated that the SHS works well in the near infrared at 1264 nm. The SHS Design Engine was used to provide initial parameters for this work and the breadboard setup verified that the values were correct for the on-axis case. The SHS Design Engine has been used to develop parameters for an SHS design at 1364 nm, using off the shelf components.

Analysis software, used to process image data (FFT and so on), pass-band, resolving power and resolution, will be developed. InGaAs Camera will record the field widened image, and the Characteristic of the 1364 nm breadboard can be carried out soon.

Field work will also be carried out by mounting the SHOW instrument onto an aircraft to do real observation of water vapour at the altitude of the aircraft. The observation configuration can be either an air cell with a white source, or limb view of the local atmosphere. A prototype instrument will be built for this purpose, and design tools will help the setup, build and test.

## References

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