THAPAR UNIVERSITY
STUDENT SATELLITE INITIATIVE

PROPOSAL

FOR

EMBASSY OF GERMANY, NEW DELHI

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Scientific Objective

The main mission is to be able ascertain the global distributions of carbon dioxide (CO2). The results of the analysis will not only contribute to a deeper scientific understanding of the behaviours of the causative agents of global warming, but will also provide fundamental information for refining climate change prediction and formulating global warming countermeasures.

Why measure CARBON DIOXIDE from space?

It has been noted by us that:

I. There are around 200 Carbon Dioxide measuring stations across globe.
II. These measuring station obtain local Carbon Dioxide gas concentration
III. The measurement of the Carbon Dioxide gasses is affected by local factors. Say for example, if the measuring station is situated near an industrial area, the reading will affected. But however, if the same station is situated near forest area, the same will be also being varied due to local conditions. Hence we cannot generalise the same over a given large areas like cities etc.
IV. Also, the measuring stations are varied across the globe, more in North America and Europe and very few in Africa and South America.

However, when we measure the Carbon Dioxide gas concentration from space, we will be able to cover the entire global with certain degree of accuracy which is still under review. Moreover, we will be able to revisit the same location many times over within a short period of time.

The measurement from space will also not be affected by local conditions on earth and will give us average column abundances of CARBON DIOXIDE which can be generalised for a large area.

BASIC METHODOLOGY

Principle

It is based on the fact that every molecule has a unique ‘spectral signature’, they are like the fingerprints of a molecule (which separates them from all other molecules).

When we pass IR light (containing a band of IR wavelengths) through a sample, its molecules, absorbs some particular wavelength light (depending on their unique bonding), so by observing the band of light transmitted from the sample means the spectrum, we can easily see which wavelength light is absorbed by the sample. From the maintained library of spectral signatures of molecules, we can easily find which molecules present in the sample.

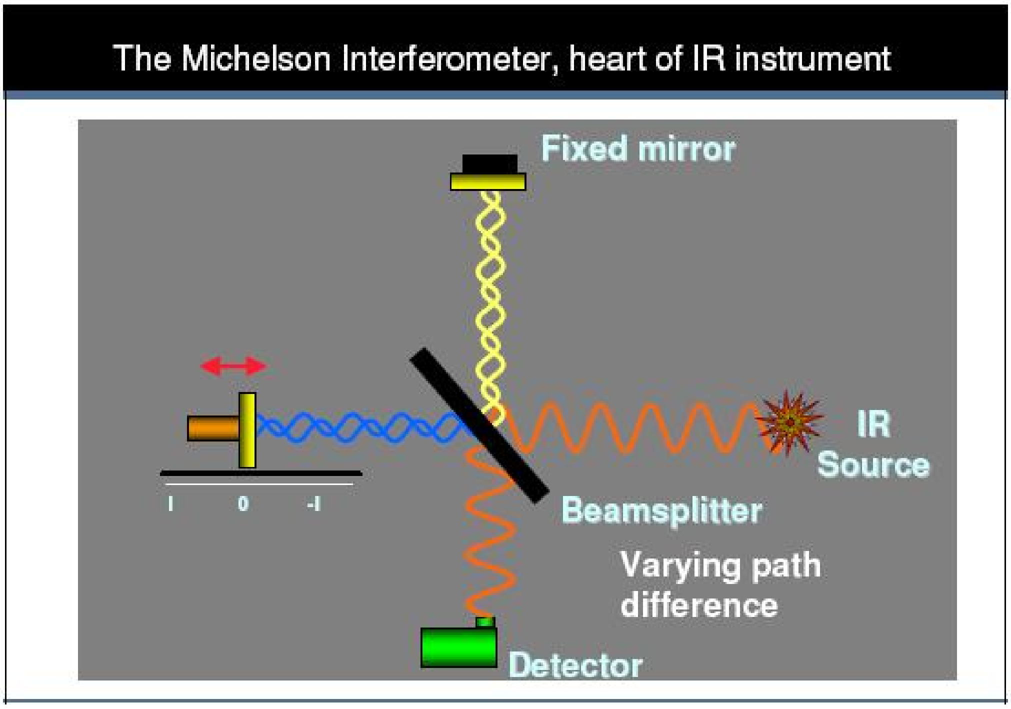
Here we need quantitative analysis too, that can also be done by FTIR. As from the spectrum obtained, we can see what is the amount of the absorption for different molecules present in the sample, from that we can easily find about the concentration of any constituent of the sample using a calibration curve. So we can measure the density of greenhouse gases as well as different types of gases present by the quantitative and qualitative FTIR analysis.

Working

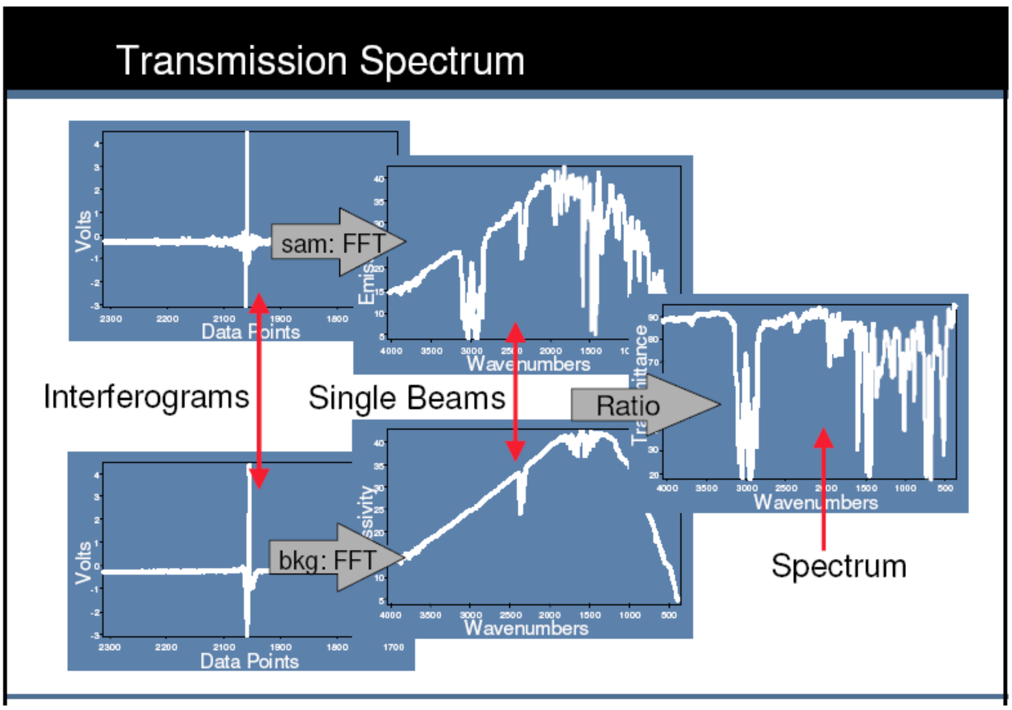
As we are using an FTIR (Fourier Transform Infrared Spectroscopy) instrument which works on the principle of Michelson Interferometer.

FTIR is an instrument that utilizes optical interference. Within the instrument the incoming light which has already passed through the sample and some specific wavelengths have been absorbed by it, is split into two beams using a beam splitter which propagates in two different optical paths to create an optical path difference between the two also in one of these paths there is a constantly moving mirror placed so that there is a continuous change in path difference. These beams are then recombined to cause interference and an Interferogram is produced.

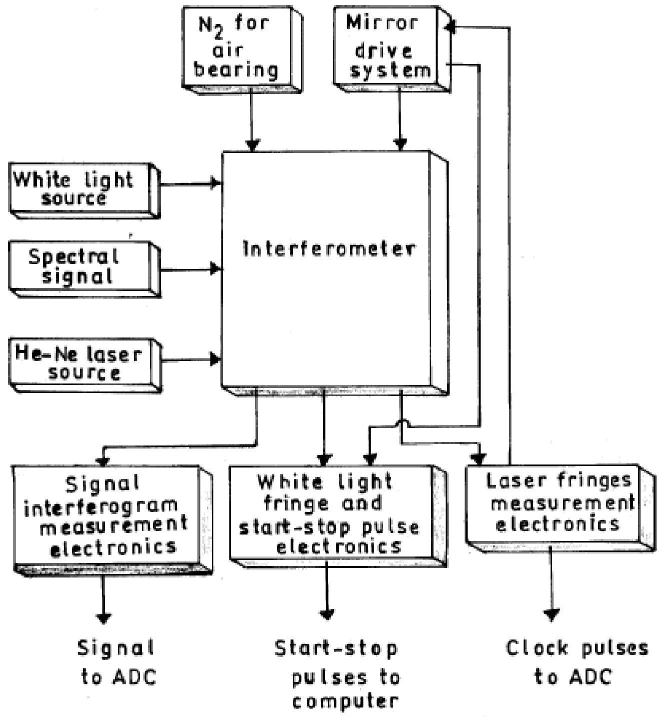
A distribution of light intensity over a range of wavelength (a spectrum) is obtained via performing mathematical operation called the Fourier transform on the observed signals.



Now the observed spectrum of the sample is divided at each wavelength with a calibration spectrum obtained with a blank sample to take care of instrument noise and other affecting factors. The transmission spectrum so obtained is now used measure the amount of various compounds absorbed using standard calibration tables available.



Column abundances of CO_2 and CH_4 are can be calculated from working on the band ranges of around 1.6 um and 2 um.



Block Diagram for working of FTIR Interferometer

Here the spectral signal is the IR rays emitted by the earth which have already passes through the atmosphere and have some specific wavelengths absorbed by it. He-Ne laser source is used for self calibration of the instrument so that we know the position of the moving mirror at each instant of time and the white light source is used to detect the completion of one cycle of measurement. Electromagnetic waves from all these three sources pass through the same beam splitter and the mirrors and later the analogue signals are converted into digital so that further processes transformations can be carried out on a computer. Also the moment of the mirror is controlled from the laser signals and the complete cycle from the white light.

FTIR Instruments have improved signal to noise ratio because there is a concurrent measurement of detector signal for all the resolution elements of the spectrum known as the multiple or ***Fellgett Advantage*** and of high optical throughput known as throughput or ***Jacquinot advantage***. The improvement in frequency accuracy of the FTIR instrument is because of use of a laser for calibration known as ***laser reference or Connes advantage.***

TUSSAT SPACECRAFT DESIGN

Technical Requirements:

- Exterior Dimensions: 270mm*270mm*270mm.
- Maximum Mass: 10kg.
- Internal temperature: -10°C to 50°C for proper working of all electrical and electronics components.

Functional Requirements:

- The satellite should have the capability to operate with full functionality for a minimum period of 6 months.
- The satellite should be able to download various data packets which include telemetry as well as the health monitoring data when it is within the ground station's communication window.
- Shall have the ability to store payload and status data when a link with the ground-station cannot be established.
- The satellite should be able to monitor itself and initiate preset protocols if any error occurs. (*Automated*).
- Try to design all critical systems should be designed with redundancy.
- Design should be kept simple. Emphasis on the main objective i.e. to have a working satellite up in space.
- Try to use commercial off-the-shelve components i.e. COTS components so as to reduce the cost as much as possible.

SUPPORT REQUIRED

- Technical Support from **German Aerospace Centre** on the Proposed Project.
    - A meeting can be arranged with the representative of German Aerospace Centre for briefing on the proposed project
    - Technical Mentorship for the Project Required
    - Assisting in Payload – Fourier Transform Infrared Spectrometer on the payload.

- Jointly working out Negotiation with **World Metrological Organisation and UNFCCC** for key measurement of global observations of the Essential Climate Variables

- Support from **Fraunhofer Institute for Photonic Microsystems , Dresden** on the development of FTS Spectrometer.
    - Meeting can be arranged with the FIPMS, Dresden
    - Technical Mentorship from the FIPMS , Dresden

- Support from **Max Planck Institute for Meteorology (MPI-M), Hamburg an** and **Atmospheric Chemistry department of the Max Planck Institute for Chemistry in Mainz** on the development of Payload which is related to obtaining global distribution of Greenhouse gas distribution and do a quantitative study on climate change.

- Support and Partnership from **Technical University of Berlin and University of Wurzburg** as they will be launching their small 1Kg Satellite with the help of ISRO in the month of September 2009.

- Financial Support from
    - **German Research Foundation**
    - **2+2 Programme**
    - **Federal Ministry for the Environment**, Nature Conservation and Nuclear Safety , Germany under **<u>International Climate Initiative</u>**