High Altitude Observatory

FPI Instrumentation Control Software

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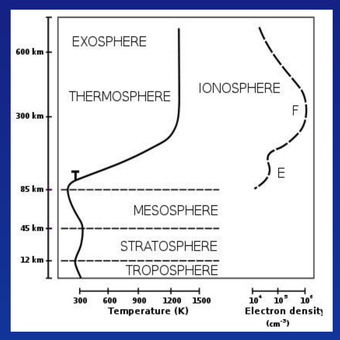
Abstract

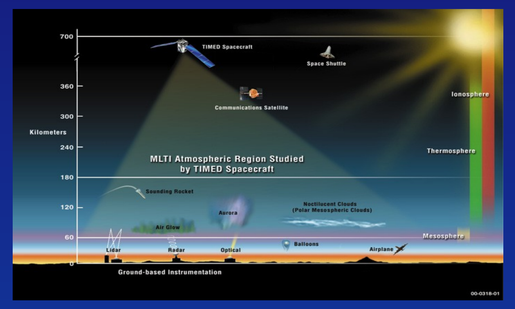
The FPI-Antarctica project was designed to develop software interface to control the Fabry-Perot Interferometer (FPI) instrumentation to be installed at Palmer Station, Antarctica. The FPI instrument is designed to measure mesospheric and lower thermospheric tidal waves. The FPI-Antarctica project will continue the long-term observations of neutral winds in the mesosphere and lower thermosphere to study tides, ion-neutral interactions, and magnetospheric-ionospheric couplings. The FPI consists of a Sky Scanner, Filter Wheel, Focus Mechanism, Etalon Chamber, and a CCD camera. The software to control FPI-Antarctica was developed at NCAR using C++. Similar software exists from the previous FPI-China project so modifications for the camera and filter wheel were incorporated. The camera used for this project is a Princeton Pro-EM 1024B CCD camera. One of the features of this camera is that it has an electron amplification circuit to multiply the number of the electron in each pixel so to reduce the readout noise. Code was written to utilize this feature multiplying the amplification of the Camera by a default factor of 150. In addition to the camera, the Focus Mechanism automatically adjust to a different focal length for one of the eight filters on the Filter Wheel, since each filter has a different wavelength of light adjustments are needed. For FPI-Antartica, the software interface now controls all hardware and handles all data collection autonomously.

Earth's Atmosphere and Temperature Profile

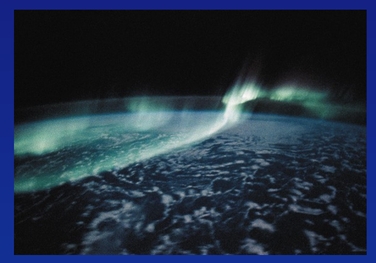


For the FPI-Antarctica experiment we are mainly concerned with the Mesosphere and the Lower Thermosphere.
Looking at the Ionosphere's F2-layer, neutral meridional winds can be derived from the F2-layer peak height and peak density. This is caused by the relationship between the winds and the variable peak height.

The Upper Atmosphere



The Experiment?



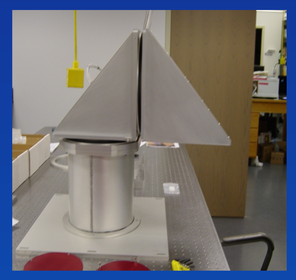
The Fabry-Perot interferometer Antarctica (FPI) has been made to take observations of vertical winds and two-dimensional atmospheric motions in the lower thermosphere and the mesosphere region by the measurement of Doppler shift and the expanding of airglow emission lines. This instrument will be installed in October 2010 at the Palmer Station on the Antarctica Peninsula. There is also a collaboration with the University of Alaska.

Why do we need to know upper atmosphere neutral wind tide?

- Tides are generated in the stratosphere and strongly affected by changes in the upper atmosphere such as:
  - -Quasi-biennial oscillation (QBO) in the equatorial region
  - -Sudden stratosphere warming at high latitudes
- Long term trends in tides may be linked with changes in the stratosphere.
- Tides also have a great impact on the equatorial ionosphere through dynamo effect.

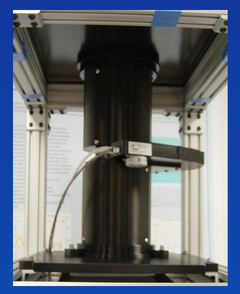
Sky Scanner

-The Sky Scanner steers the instrument to different directions with two rotating mirrors.
-Rotation of one mirror changes the zenith angle, and rotating both changes the azimuth angle.
-Calibration of the sky scanner brings the pointing accuracy of 1 degree.



Sky Scanner

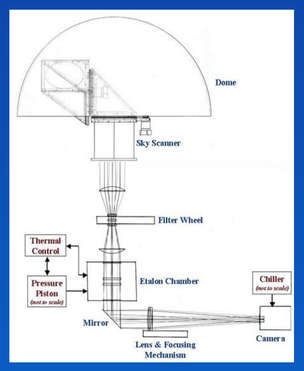
Filter Wheel



Filter Wheel

An 8-position Filter Wheel has been installed on the FPI. The emission lines in the filter wheel we are measuring at include:
- -OH^- at 8920 Å
- -O^- at 6300 Å
- -O^- at 5577 Å
- -O^+ at 7320 Å for ion drift (mostly used during twilight)
- -NA at 5893 Å
- -Laser
- -Dark (nothing)

The Fabry-Perot Interferometer



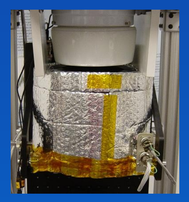
Major Components
- Sky scanner
- Filters & filter wheel
- Etalon & chamber
- Thermal & pressure control
- Focusing lens
- Detector
- Computer system

Highlights
- Computerized micrometer
- Daily laser calibration
- High degree automation
- Michigan heritage

Etalon Chamber

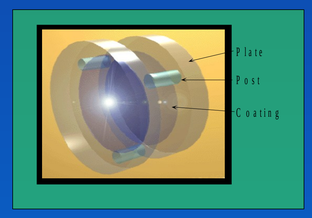
The Etalon is mounted and placed inside a temperature and pressure controlled chamber.

When calibrating the Etalon Chamber a pressure piston is moved to change the pressure inside the chamber.

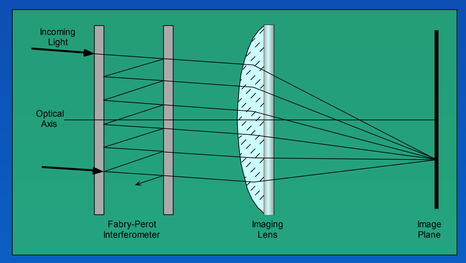


Etalon Chamber

The Coating Reflectivity of the Etalon is 80% +/- 4.5% over 500-900nm.
The three etalon spacers are made of zerodur with 15mm diameter and 20mm length.

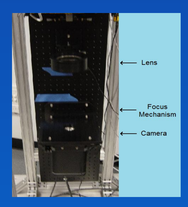


Etalon

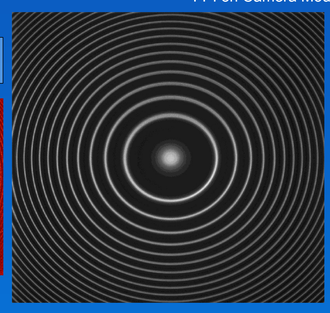


Princeton Pro-EM 1024B CCD Camera

FPI Camera



FPI on Camera Mount



One of the features of this camera is that it has an electron amplification circuit to multiply the electron count in each pixel in order to reduce the readout noise.

FPI Operational Mode

Emission	Integration time	Wind Errors	Altitude
OH 8920 A	3 minutes	6 m/s	87 km
O 5577 A	3 minutes	1 m/s	97 km
O 6300 A	5 minutes	2-6 m/s	250 km

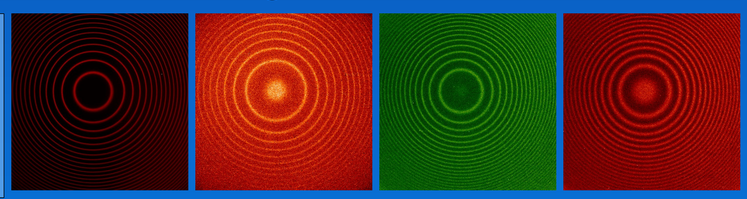
What has been done?

- ✓ Debugged previous test code to work with the updated camera.
- ✓ Wrote hardware code to convert the camera from comm port to usb port.
- ✓ Debugged the software for the filter wheel.
- ✓ Improved the user interface of the display.
- ✓ Wrote software to increase the multiplicative factor of a single electron as it hits the camera by any percentage (default is 150%).
- ✓ Tested the software successfully with each component of the FPI.

FPI Fringes

How do these fringes work?

From measuring the diameter between the rings we can calculate the wavelength.
Once a wavelength is calculated, we can look at the Doppler shift to find the neutral wind tide's speed.



What is left?

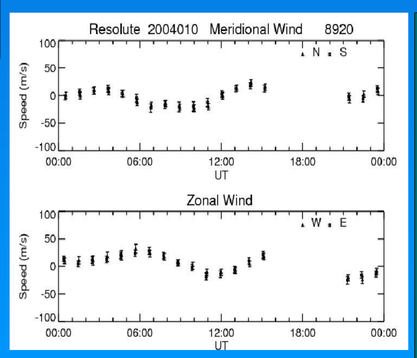
- **Testing**
  - **Simulating real time events with the FPI will output data that will determine if the instrumentation is running properly. Adjustments to the FPI will be accommodated at this time.**
- **Transportation and Instillation**
  - **October 2010, the FPI will be taken to Palmer Station in Antarctica. Here the instrument will be installed and will start taking observations.**

Neutral Wind Output Data

What is the importance of this data?

The Antarctica Peninsula has had some strange Ionosphere variations, which are thought to be caused by thermospheric winds. The FPI-Antarctica project was created in order to answer these questions. Therefore, having the instrument installed at the Pamler station is crucial because the station is located in the middle of the Antarctic Peninsula.

Mesospheric Wind Semidiurnal Tide



Why do we measure the Mesosphere?

The Mesosphere is a region of the atmosphere we know very little about. It is strongly influenced by tides from the troposphere and stratosphere.

These wind tides that reach the mesosphere become amplified due to the low air density. Hence, variations in the mesosphere can be a manifestation of changes in the lower atmosphere with an amplification.

The FPI measures the emission lines of the 8920 and 5577 for themesospheric and lower-thermospheric winds.

Lower Thermospheric Wind Semidiurnal tide

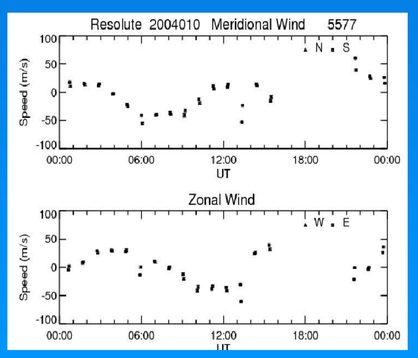
Why do we measure the Thermosphere?

Because we are trying to understand the variations in the Ionosphere, we need to know the variations in the thermosphere.

This is because thermospheric winds can push the ionosphere up and down along the geomagnetic field lines; thus, changing the ionosphere.

Therefore, in order to understand the ionosphere, we must know the thermsopheric winds.

The FPI measures the emission line 6300 for thermospheric winds and, the FPI measures the emission lines of the 8920 and 5577 for the thermospheric winds.



Acknowledgments

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- **My programming guide: Alice Lecinski**
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