**Overview:**

MIADI (Figure 1) is a ground based field widened and fully compensated (thermally and achromatically) scanning Michelson interferometer (Figure 4) that is optimized for observation of LOS Doppler wind fields and irradiances using the mesospheric airglow emissions: 0 (5) at 557.7 nm and OH (6, 2) P1 (3) at 843.01 nm. The intensity and background wind and associated perturbation quantities will be obtained and used to diagnose gravity wave signatures in the mesosphere region.

- The Mirror position and orientation is controlled to sub angstrom precision with the Multi-application Low voltage FZT Control Electronics (MALICE) developed by COM DEV Ltd.

The instrument has been tested in the lab (Langille, 2012) using the optical system shown in Figure 6 for imaging and the setup shown in Figure 7 to produce LOS Doppler shifts. The results from this testing are shown in Figure 8 and 10.

Intended field Application:

- MIADI sky viewing is shown in Figure 11.
- FOV is 30 degrees square ~ 50km x 50km.
- 4 look directions are viewed using a rotating wedge prism pointing 10 degrees off the local vertical with the center of the sky as a common point.
- Each region is sectioned into 5km x 5km bins and the sky is imaged through the MIADI optical system onto a CCD detector.
- Each bin on the CCD will correspond to a 5km x 5km region of the sky (some flexibility here).

- Using the instrument parameters and the expected source parameters the expected wind precision for each bin in the image is plotted versus SNR in Figure 12. Typical interference fringes are shown in Figure 13 and Figure 14 for the lamp and airglow emissions respectively.

**Measurement of Doppler Winds:** The field widened Michelson interferometer and the field widened birefringent delay plate are amplitude splitting two beam interferometers. The optical path variation $D$ between the two beams varies with incident angle for MIADI and with incident angle and azimuth for the BIDWIN. If collimated light is passed through the interferometer and a lens is used to focus this field onto a CCD detector then each point on the detector corresponds one-to-one to a particular incident angle and azimuth through the interferometer. For a spectrally isolated and thermally broadened emission the irradiance measured at each bin on detector has the form given by Eq. 1.

\[
I = I_0 + UV \cos(\theta(\phi)), \quad \text{Eq. 1}
\]

In this equation $I$ is the phase of the interference fringes where $I_0$ is the visibility and $I_0$ is mean intensity. If the source is in motion relative to the observer then the centerline is Doppler shifted along the LOS (Figure 3). This Doppler shift results in a phase shift in the interferogram (Eq. 2). The fringe parameters ($I_0$, $UV$ and $\phi$) in Eq. 1 can be determined bin by bin on the CCD by sampling the interference fringes at several phase steps corresponding to a full fringe and applying the LMS algorithm developed by Word (1980). These fringe patterns will also include a zero wind background phase, $\phi_0$, associated with a motionless source and a thermal phase drift, $\phi$, associated with thermal expansion of the components (Eq. 3). These terms can be calibrated using a calibration lamp emitting wavelengths close to the interference wavelength (Eq. 3).

\[
D = \Delta \phi \times \phi_0 + \phi
\]

Using this approach the LOS Doppler winds can be determined to a precision given by Eq. 4.

\[
u_0 = \frac{\sqrt{2} \times \Delta \phi + \phi_0}{\Delta \phi + \phi_0}
\]

In this equation $c$ is the speed of light, $\alpha$ is the number of steps in a scan and SNR is the Signal to Noise Ratio.

**Field widening:** The path variation generated between the extraordinary and ordinary waves depends on the incident angle and azimuth through the element (see Figure 15). In the ideal configuration the two LUNO3 plates are oriented with their optical axes crossed. A /2 waveplate is located between the two with its fast axis at 45 degrees to the LUNO3 axes: The effects of misalignments of the LUNO3 plates and the waveplate are depicted in Figure 18.

**Preliminary Analysis:**

An instrument model using Jones matrices has been developed that allows the effect of misalignments to be examined. This required the development of a Jones matrix framework which is valid for a field widened birefringent element. For single birefringent elements this has been done by Zhu (1994). This matrix is written with simple dependence on incident angle and azimuth through the element. The output is computed using Eq. 5 where $J$ is the Jones matrix of the field widened birefringent element $L$ is the matrix of a linear polarizer and $P$ is a rotation matrix. The irradiance is given by $E[4]$. The results produced using the model are compared to the measured irradiance distribution using the BIDWIN prototype in Figure 18 for a crystal misalignment of 15 degrees and a half waveplate misalignment of 7.5 degrees.

\[
E = \frac{1}{2} (1 + \cos \theta) \times \sin \theta \times (1 + \cos \phi)
\]

Field widening: The path variation generated between the extraordinary and ordinary waves depends on the incident angle and azimuth through the element (see Figure 15). In the ideal configuration the two LUNO3 plates are oriented with their optical axes crossed. A /2 waveplate is located between the two with its fast axis at 45 degrees to the LUNO3 axes: The effects of misalignments of the LUNO3 plates and the waveplate are depicted in Figure 18.

**References:**


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