The power hyperspectral All sky camera

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ABSTRACT

Using

The Fish-Eye lens MAO-08 is intended for observations of weak extended objects (aurora, twilight and dawn phenomena, stratospheric clouds, etc.) in narrow spectral bands with variable passband filters VARISPEC and in white light.

Besides having high power this lens can be used for meteors observations.

It has been tested during the winter field conditions at temperatures from +5°C to - 28°C using a Stingray F-046B camera as a detector.

The main advantages are:

- a large aperture (f/value = 0.8),

-A high resolution, and

- the possibility to use an interference filter.

The lens has a field of view of 180º, a spectral range ~ 430… 750 nm and a resolution ~ 70-100 mm -1. The optical diagram and technical features of the lens are presented and discussed.

It has been tested during the winter field conditions at temperatures from +5°C to - 28°C using a Stingray F-046B camera as a detector.

The MAO-08 lens has proven to be an ideal lens for dark sky imaging including both aurora and airglow.

Main parameters

Layout

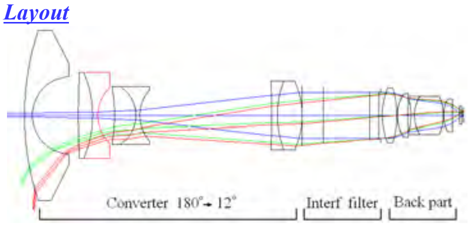


Fig. 1. Layout of the MAO – 08 lens.

The basic technical data

- **Paraxial focal length: 1.6 mm**
- **FOV: 180 degrees**
- **Linear FOV on detector plane: 4.2 mm diameter circle**
- **F/value: 0.82**
- **Spectral range: 430...750 nm**
- **Resolution: center - 100 1/mm; edge - 70 1/mm**
- **Mount: CS**
- **Back working distance: 5.8 mm**
- **Dimensions (with covers): length 235 mm and diameter 103 mm.**

Image quality and laboratory testing

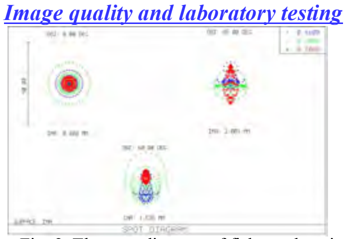


Fig. 2. The spot diagram of fish-eye lens in white light.

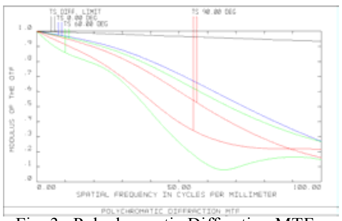


Fig. 3. Polychromatic Diffraction MTF

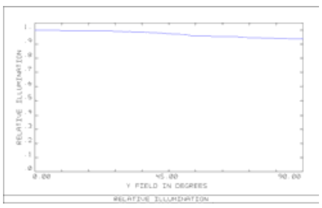
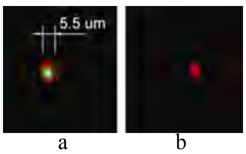


Fig. 4. Relative illumination versus FOV



a b

Fig. 5. (a) Images of artificial star created by the lens in laboratory tests in white light, (b) - at 650 nm

Design

The lens has a module design and consists of three units (Figures 6a and 6b):

- A forward part, which develops a FOV and determines the distortion;
- A Box for fixing optical filters;
- A back part, determining power and correcting the basic aberrations

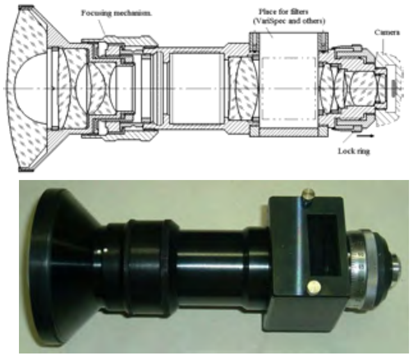
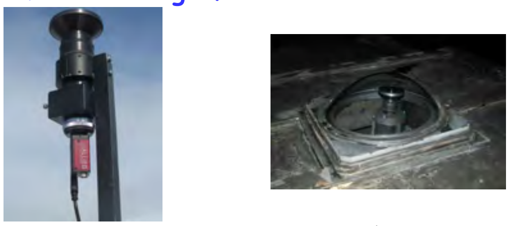


Fig. 6. General view of the MAO – 08: (a) - the assembled lens, (b) - lateral view of the lens

Field testing of the MAO – 08 lens



a b

Fig. 7. Field testing and working : a- the PGI observatories at Apatity (67.58°N, 33.31°E), b - Polar Geophysical Institute Research station Barentsburg (78.09° N, 14.21° E)

Testing in the white light

Lens tests in field conditions have confirmed high quality of images (Figure 8. (a)) Figures 8(a) is image of the ray auroral arc, obtained at Barentsburg in white light with exposure time ~ 0.9 seconds. There are a plenty of constellations and stars in this figure and even the Milky Way is seen.

Testing in the monochromatic light

Figure 8b shows the weak auroral folds in the emission at 557.7 nm, obtained with the exposure time ~ 9 seconds with narrow-band interference filter (Δλ ~ 2 nm).

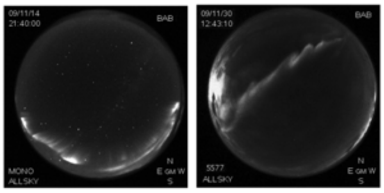


Fig. 8. All-sky images of aurora: (a) – in white light, (b) – at λ ~ 557.7 nm.

Real time observation

A first season of observations was spent during the period November 2011 - April 2012 in the Kjell Henriksen Observatory (KHO) in Svalbard located at the archipelago Svalbard 1000 km north of mainland Norway (78 ° N 16 ° E), and Barensburg research Station, PGI (78.093° N, 14.208° E).

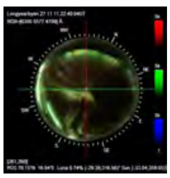


Fig. 9. All-sky images of aurora in RGB color

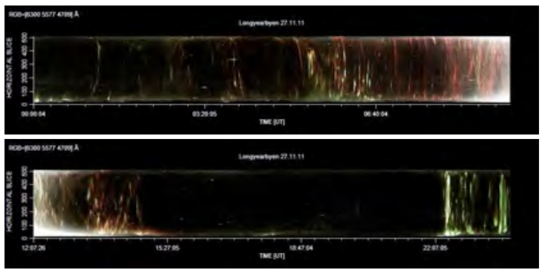


Fig.10. Keograms*: a – north-south direction, b- west-east direction

*A keogram is a time versus magnetic latitude plot of auroral intensity. By showing the latitudinal evolution of auroral motions, the keogram provides a quick way to find interesting time periods for more detailed studies.

Conclusion

The MAO-08 lens has a large aperture with f/value ~0.8, which exceeds this parameter of the other lenses, designed for auroral research. The design allows interference filters to be inserted directly into the lens. Pointed out is the possibility of obtaining simultaneously two images in two emissions of the same aurora by the single CCD camera.