Seeing Measurements at Skinakas Observatory using the DIMM method

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Abstract

We present preliminary results from a study of the seeing at Skinakas Observatory in Crete, Greece. The measurements have been made during the years 2000 and 2001 using a two-aperture Differential Image Motion Monitor (DIMM). The results of both campaigns are extremely promising with the median seeing value being $0.''64$ and $0.''69$, respectively.

1 Introduction

The knowledge of the atmospheric turbulence, which limits the telescope's angular resolution, is very important for the correct design and work of Adaptive Optics systems. It is well known that when light is coming from a star, it crosses several turbulence atmospheric layers which results to beam degradation at the telescope focus. The common way to characterize image degradation, is to measure the full width at half-maximum (FWHM) intensity of a star (in arcsec) at the focus position, which is actually its angular diameter that we call "seeing" in astronomy. The method which is accepted as the most accurate for seeing measurements is called "the Differential Image Motion Monitor (DIMM)", which is the study of the differential motion of the image of a star. The same method with small differences was used at Skinakas Observatory to study the changes of the atmospheric turbulence in the area, hence the site's observational quality. In section 2, there is a description of the DIMM Optical configurations. Section 3 is dedicated to explain the method, while the observations and results are given in section 4 and 5, respectively.

2 DIMM Optical Configuration

The configuration used for the DIMM measurements at Skinakas Observatory is similar with the DIMM used by Wood et al (1995) and Vernin & Munoz-Tunón (1995). It is presented schematicly in Fig. 1, while, the technical equipment which have been chosen in the design and construction of the Skinakas DIMM are as follows: (1) Meade LX200 12" Telescope, (2) Equatorial Mount, (3) CCD camera SBIG ST-4, (4) Mask with two holes, (5) PC computer, (6) DIMM code, (7) Pointing program and (8) Autoguiding program. Also, the characteristics of the telescope, the CCD camera as well as the optical configuration (shown in Fig. 1) of the DIMM are given in Table 1.

3 DIMM Operation

The DIMM technique is to measure the relative motion of two images of the same star and based on this motion, the size of the holes and their separation, the seeing can be derived. The advantage of the differential method is that eliminates erratic

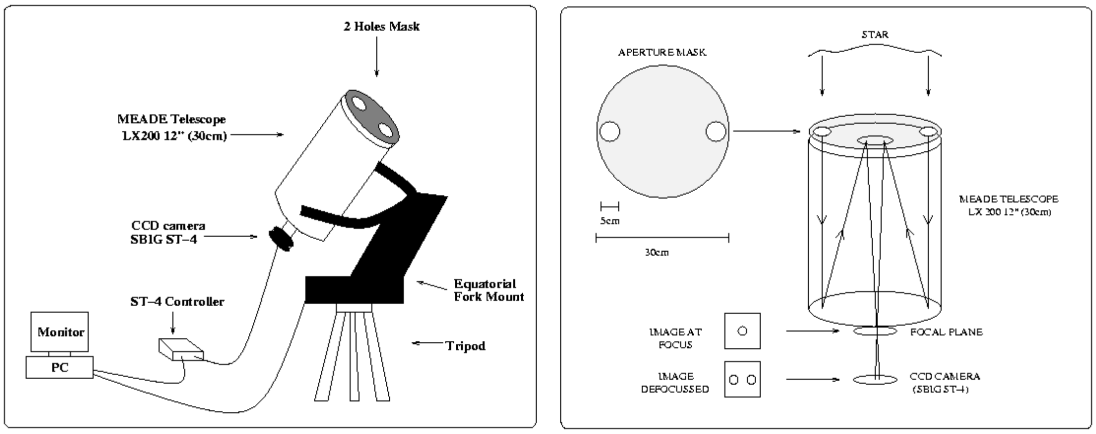

Figure 1. A sketch with the Dimm and the Optical Configuration

motion of the telescope, since it measures the angular differences between the two images and it is not affected by any other motion. The idea is that the light from a star passing through the two apertures, travels through slightly different atmospheric conditions procuding a tilt in the wavefront of one compared to the other. This results in a slight variation in the separation of the two images.

Table 1. DIMM Configuration

Meade LX200 12" Specifications	
Optical design	Schmidt-Cassegrain
Clear aperture	305 mm (12")
Focal length	3048 mm
Limiting visual mag	$\sim$15
Image scale	1.14 arcmin/mm
SBIG ST-4 CCD Specifications	
Pixel array	192×164 pixels^2
Total pixels	31,000
Pixel size	13.75×16 microns^2
Exposure time	0.01 to 300 seconds
Optical System Specifications	
Field of view	2.98×2.96 arcmin^2
Pixel size	0.93×1.08 arcsec^2

In order to get the two images at the correct focus, a thin optical wedge need to be used over one of the apertures, to produce a small deflection in one of the beams. At Skinakas Observatory we used a different method, to avoid using a wedge. The telescope was set slightly out of focus, which separates the two images, whithout causing any problem at the image quality in the appropriate level, since it is not affect the quality of the individual star images as the f/ratio is very high. In the case of the MEADE LX200 12", the telescope's f/ratio is f/10, while that of the two apertures is f/60. As a result, the image is not significantly blurred by a slight defocussing of the telescope.

The DIMM code is based on the mathematical equations used by ESO/DIMM (Sarazin & Roddier 1990). The parameters which must be specified in the code are:

1. The diameter of the two holes in the mask (5 cm)
2. The separation of the two holes - centre to centre (24.7 cm)
3. The pixel size of the telescope/CCD camera combination in both x, y dimensions ($\sim$1 arcsec)

while, the input data to start running the program are:

1. Coordinates of the observed star
2. Exposure time for the seeing measurements
3. Exposure time for testing images
4. A parameter which is correlated with the magnitude of the star

The basic part of the program is to calculate exactly the centres of the two images of the star in each exposure. After two subsequent exposures, any variation between the two images is calculated in both directions (parallel and perpendicular to aperture alignment), while after a specific number of exposures the longitudinal σ(l) and transverse σ(t) variance of the differential image motion can be deduced. The latter, in conjuction with the equations (1) and (2) estimate the Fried's parameters r_o(l) and r_o(t), which characterize the atmospheric condition at the site of observations. Finally, using the equations (3) and (4) the "seeing" can be derived.

$$\sigma(\mathrm{l})^2 = 2\lambda^2[0.179/\mathrm{D}_{\mathrm{HOLE}}^{1/3} - 0.097/\mathrm{d}_{\mathrm{SEP}}^{1/3}]\mathrm{r_o(l)}^{-5/3} \quad (1)$$

$$\sigma(\mathrm{t})^2 = 2\lambda^2[0.179/\mathrm{D}_{\mathrm{HOLE}}^{1/3} - 0.145/\mathrm{d}_{\mathrm{SEP}}^{1/3}]\mathrm{r_o(t)}^{-5/3} \quad (2)$$

where,
σ(l), σ(t) : longitudinal and transverse (parallel and perpendicular to aperture alignment) variance of differencial image motion
$\mathrm{D_{HOLE}}$: diameter of the holes
$\mathrm{d_{SEP}}$: separation of the two holes (centre to centre)
$\mathrm{r_o}$: Fried's parameter
λ : wavelength (550 nm)
and

$$\mathrm{FWHM(l)} = 0.98\lambda/\mathrm{r_o(l)} \quad (3)$$

$$\mathrm{FWHM(t)} = 0.98\lambda/\mathrm{r_o(t)} \quad (4)$$

4 Observations & Results

The Skinakas DIMM started at the end of April 2000 at the Physics Department of the University of Crete in Heraklion where all the apropriate tests took place. A month later it was installed to Skinakas Observatory (1750 m altitude) and the seeing measurements started. The latter, took place from the beginning to the end of each astronomical night in specific dates (dependent to Skinakas staff availability) from June to September 2000 and from May 2001 up to now. The place, where the telescope has been installed, is according to our requirements (not any thermal source close to the telescope, the inside-outside temperature difference was not larger than 1°C and continiously normal change of the air inside the dome) so the seeing that we measured was exaclty that caused by the atmospheric layers.

Part of the results (see Boumis et al. 2001) of the Skinakas DIMM measurements are presented in Fig. 2. The seeing is given in arcseconds in both directions (l,t - y axis) versus the local time (x-axis). Furthermore, a histogram and the median seeing value for each night is also given. It must be noted that all measurements are corrected to zenith. The diagrams show that the seeing usually does not change rapidly during the observing night (not more than 0.3″) at Skinakas. Of course, there are a few nights where a big difference occurred (up to 1.5″) and the reason was the rapid changes in the atmospheric conditions. Extremely good seeing values have been measured (0.4″) often, with the best value at ∼0.27″. Finally, in Fig. 3, histograms with the seeing measurements for the year 2000 and 2001 are given, where a median seeing value of 0.64″ and 0.69″ have been calculated, respectively.

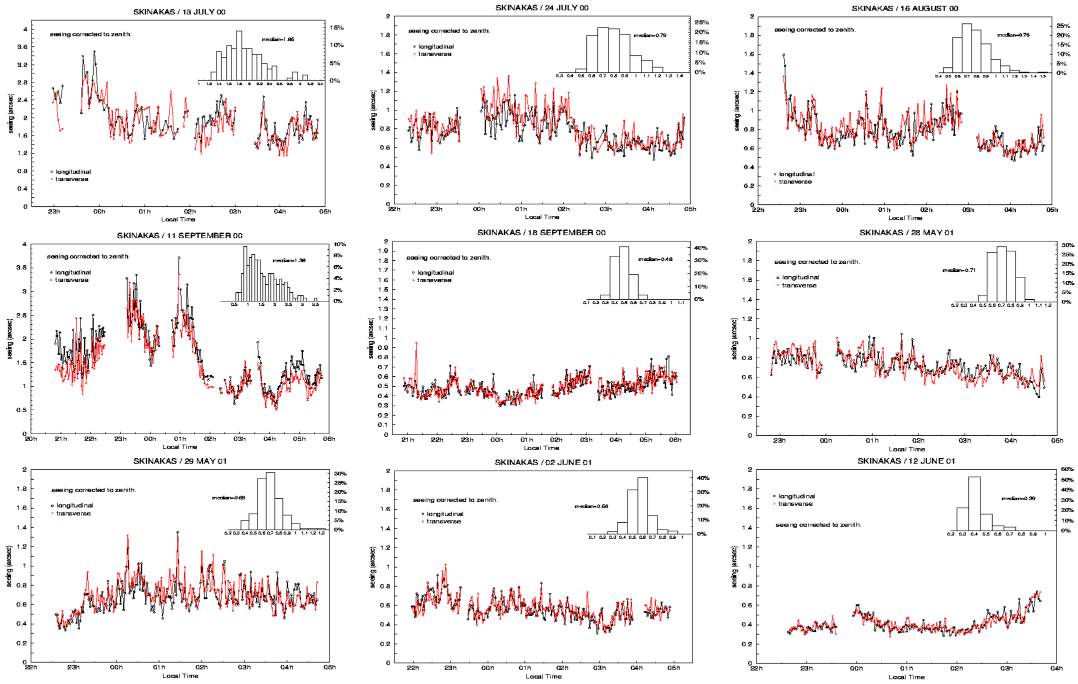

Figure 2. Part of the results for the seeing measurements at Skinakas Observatory for the years 2000 and 2001

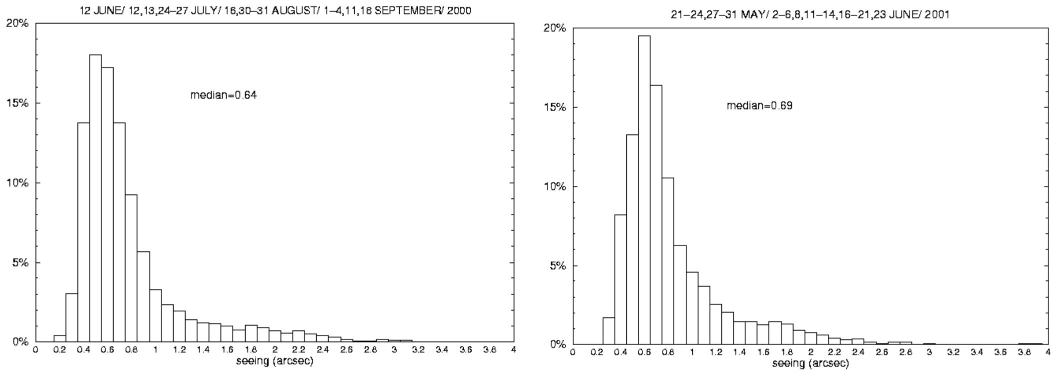

Figure 3. Histograms of the seeing distribution at Skinakas Observatory for the years 2000 and 2001.

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