SF2A 2001- Lyon, May 28- June 1st
Société Française d'Astronomie et d'Astrophysique (eds)
EDPS Conference Series in Astronomy & Astrophysics

MISOLFA : A GENERALIZED SOLAR SEEING MONITOR

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Abstract

The statistical analysis of angle-of-arrival (AA) fluctuations appears to be well adapted to monitor the optical effects induced by the atmospheric turbulence on the images observed using ground-based telescopes. In daytime, these fluctuations may be easily observed on solar limb images. In the context of the comparison planned between solar diameter measurements performed from ground (Solar astrolabe and DORaySol experiments) and space (PICARD experiment), a Generalized Solar Seeing Monitor (M.I.Sol.F.A) is proposed. It is based on simultaneous observations in the image and the pupil planes of the AA fluctuations leading, in the framework of the Von Karman model, to the estimation of the coherence parameters characterizing the wave-fronts. The optical turbulence profiles $C_n^2(h)$ are also deduced.

1 Introduction

Observations of the Sun at High Angular Resolution using ground-based telescopes need an accurate modelling of the optical effects induced by atmospheric turbulence. A seeing monitor is then useful and MISOLFA (still under construction) is built in this goal. MISOLFA is a generalized daytime seeing monitor that will observe together with experiments based at Calern Observatory (Observatoire de la Côte dAzur) and dedicated to solar diameter measurements (solar astrolabe, DORaySOL and soon SODISM II, replica of PICARD experiment, which will observe in space in 2006). MISOLFA will give in real time estimations of the coherence parameters characterizing wave-fronts degraded by atmospheric turbulence (Fried's

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parameter r_0, size of the isoplanatic patch θ_0, spatial coherence outer scale $\mathcal{L}_0$ and atmospheric correlation times). The monitor will also estimate optical turbulence profiles. It is founded on the statistical analysis of angle-of-arrival (AA) fluctuations.

2 Atmospheric models

The tranverse covariance of AA fluctuations using the Von Karman theory and in case of the one-layer model, is given by (Seghouani *et al.* 2000):

$$\mathcal{C}_\alpha(\theta) = K\int_0^{+\infty} df f^3 (f^2 + \frac{1}{\mathcal{L}_0^2})^{-\frac{11}{6}} [J_0(2\pi f(\theta h)) + J_2(2\pi f(\theta h))][\frac{2J_1(\pi D f)}{\pi D f}]^2 \quad (2.1)$$

where $K = 0.0716\lambda^2 r_0^{-\frac{5}{3}}$. $C(\theta)$ is a function of r_0, $\mathcal{L}_0$ and the height h of the equivalent impulse layer. The isoplanatic angle can be deduced by $\theta_0 = r_0/h$.
The structure function in case of multilayer model is given by (Bouzid *et al.* 2000):

$$d_\alpha(\theta) = 2.4\int_0^{+\infty} dh C_n^2(h) \int_0^{+\infty} df f^3 (f^2 + \frac{1}{\mathcal{L}_0(h)^2})^{-\frac{11}{6}} [1 - J_0(2\pi f\theta h) - J_2(2\pi f\theta h)][\frac{2J_1(\pi D f)}{\pi D f}]^2 \quad (2.2)$$

3 AA fluctuation observations

For daytime observation, AA fluctuations $\alpha(\theta)$ observed in the image are estimated from solar limb analysis. The AA transverse covariance is computed from the fluctuations by : $\mathcal{C}_\alpha(\theta) = <\alpha_1(\theta_1)\alpha_2(\theta_2)>$
Temporal analysis of AA fluctuations is performed in the pupil plane. Observing the telescope pupil through a rectangular slit placed on the solar limb image leads to transform AA fluctuations into intensity fluctuations. The temporal covariance is estimated from intensities given by photodiodes placed behind diaphragms of different sizes. The decorrelation time of the fluctuations is then deduced

4 Parameter estimation from solar images recorded in the focal plane

Equation 2.1 leads to estimate r_0, $\mathcal{L}_0$ and θ_0 by fitting data with models. Optical turbulence profiles $C_n^2(h)$ are estimated using equation 2.2 and appropriate inversion techniques (Bouzid *et al.* 2000).

References

Seghouani, N. *et al.* Marrakech Site 2000, Astronomical Site Evaluation in the Visible and Radio Range, Marrakech - Morocco, November 13-17, 2000

Bouzid, A. *et al.* Marrakech Site 2000, Astronomical Site Evaluation in the Visible and Radio Range, Marrakech - Morocco, November 13-17, 2000