Atmospheric Optics

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Abstract

The atmospheric turbulence is the biggest obstacle to terrestrial astronomical observations. It prevents us from obtaining precise images of equality precision of the space telescopes. In spite of the attempt to minimize this inconvenience by choosing a good site for creating new observatories, this is certainly not sufficient, it is indispensable to know with precision the state of the turbulence in order to correct it with adaptive or active optics

During these last years, scientists try to know the details and the characteristics of the atmosphere. Knowing of these characteristics such as the parameters: r0, L0, h is of a major interest in astronomical observation for angular high-resolution optimization of techniques (adaptive or active optics).

The objective of this study is to estimate these parameters the case of observation of the sun by the statistical analysis of arrival angle fluctuation and this can be directly obtained from the observations of the solar edge.

Process

Atmospheric optics

Fluctuation phase

the disruptions of light waves that originate at the crossing of the atmospheric turbulence.

Incident light wave passing through the atmosphere received on the ground at the point r0, is written in a complex form by: $\Psi(r) = A(r)\exp[i\varphi(r)]$

Where $A(r)$ fluctuations in the amplitude of $\varphi(r)$ the phase fluctuations.

The arrival of the wave front angle is proportional to the spatial derivative of the phase in the x and y directions that is given by:

$$\alpha(x,y) = -\frac{\lambda}{2\pi}\frac{\partial}{\partial x}\varphi_0(x,y)$$

$$\beta(x,y) = -\frac{\lambda}{2\pi}\frac{\partial}{\partial y}\varphi_0(x,y)$$

If the diffraction on the pupil of the telescope on the arrival of the stan -ding wave front angle

$$\alpha(x,y) = -\frac{4\lambda}{2\pi^2 D^2}\, G(x,y) * \frac{\partial}{\partial x}\varphi_0(x,y)$$

$$\beta(x,y) = -\frac{4\lambda}{2\pi^2 D^2}\, G(x,y) * \frac{\partial}{\partial y}\varphi_0(x,y)$$

Turbulence effects

the variance

Kolmogorov model

$$\sigma_{AA}^2 = 0.1698\,\lambda^2 r_0^{-5/3} D^{-1/3}$$

$$r_0 = 0.3451\lambda^{6/5} D^{-1/5}(\sigma_{AA}^2)^{-3/5}$$

$$r_0 = 8.25\ 10^5 D^{-1/5}(\sigma_{AA}^2)^{-3/5}$$

Von Kàrmà model

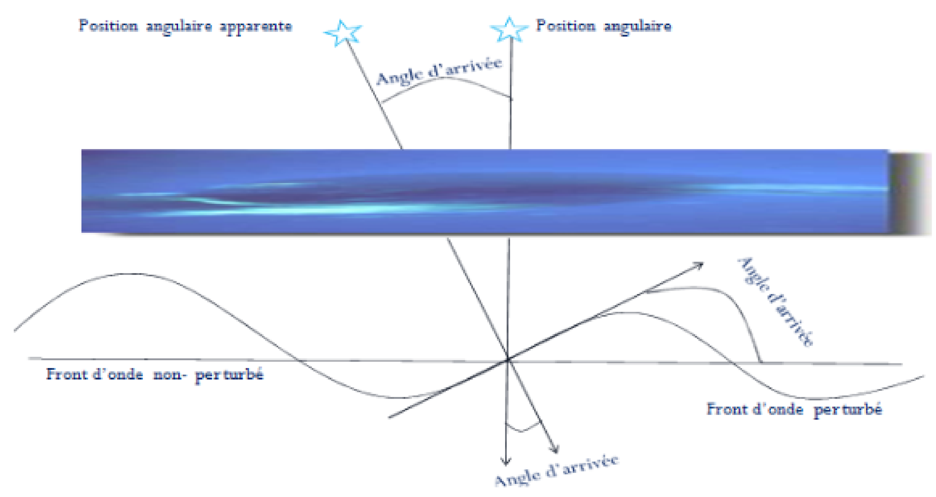
$$\sigma_{AA}^2 = 0.0229\pi\lambda^2 r_0^{-5/3}\int_0^{+\infty} df\, f^3 (f^2 + L_0^{-2})^{-11/6}\left|\frac{2J_1(\pi f D)}{\pi f D}\right|^2$$

covariance

$$C_{AA}(r_0, L_0, h, \theta) = 0.0716\lambda^2 r_0^{-\frac{5}{3}}\int_0^{+\infty} df f^3\left(\frac{1}{L_0^2}+f^2\right)^{-11/6}\left[J_0(2\pi f\theta h)+J_2(2\pi f\theta h)\right]\left|\frac{2J_1(\pi f D)}{\pi f D}\right|^2$$

Fluctuations in the angle of arrival (AA)

The arrival (AA) of the wavefront arriving angle ground r:



1-The arrival angle of the wavefront arriving at the floor

Characterization of wavefront

It should that well know optical coherence parameters characterizing the wavefront for the limitations of high angular resolution turbulence.

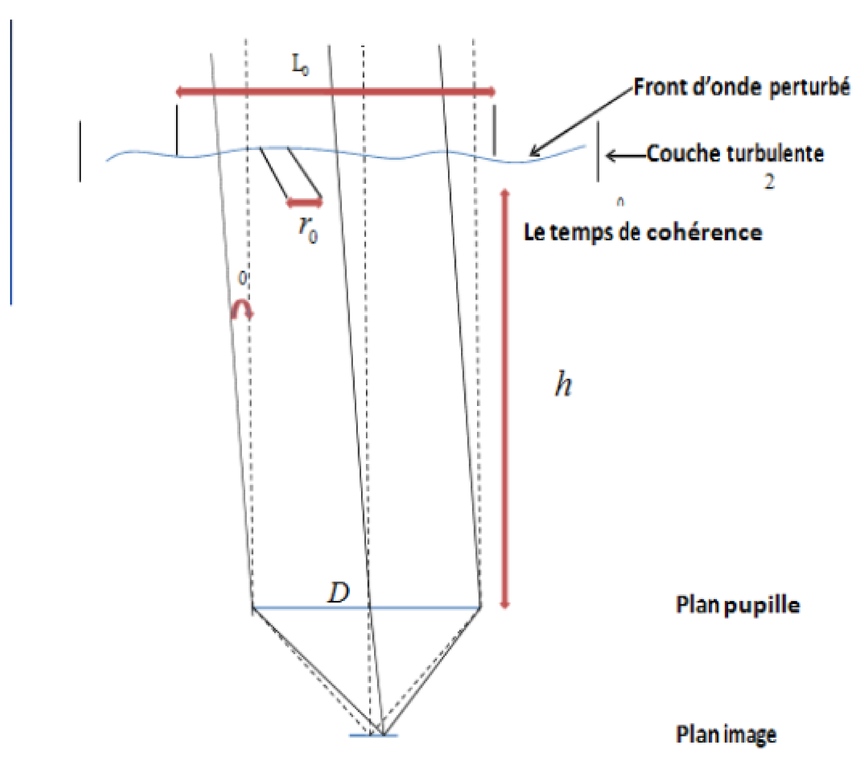
The parameter Fried r_0

$$r_0 = [16.7\,\lambda^{-2}\int_0^{+\infty} C_n^2(h)\,\delta h]^{-3/5} \qquad S = \frac{\lambda}{r_0}$$

The external scale L0 : It defines the maximum size of the wavefront perturbations that remain consistent

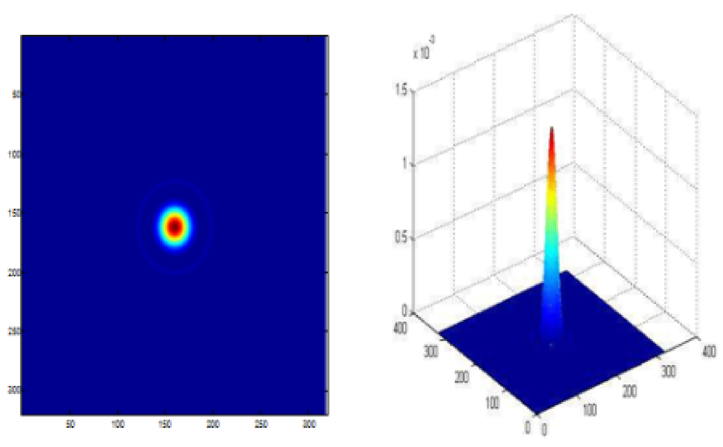
$$L_0^{-1/3} = \frac{\int_0^{+\infty} L_0(h)^{-1/3} C_n^2(h)\,\delta h}{\int_0^{+\infty} C_n^2(h)\,\delta h}$$

Isoplanarity field

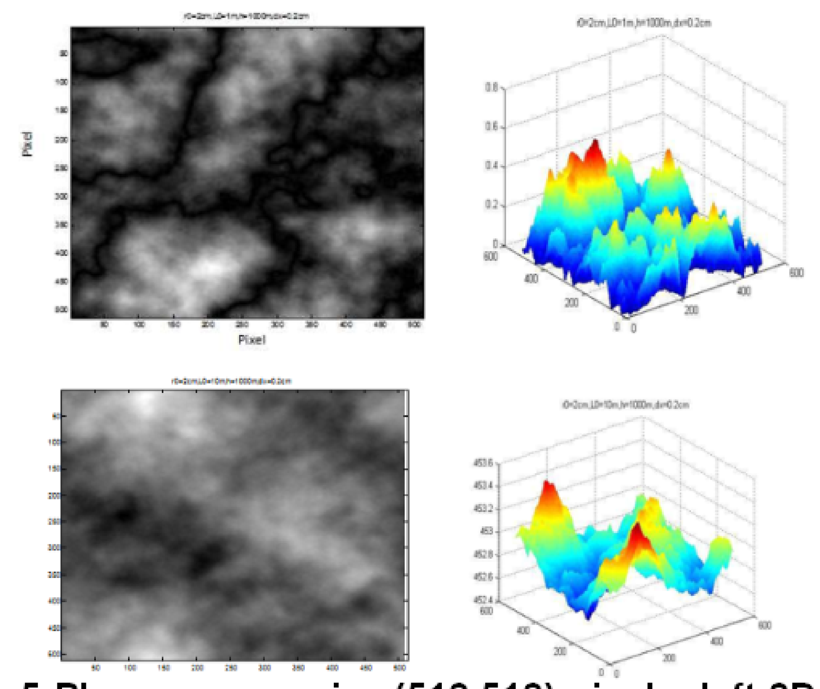


2-The parameters of the atmospheric turbulence

Simulation - MATLAB



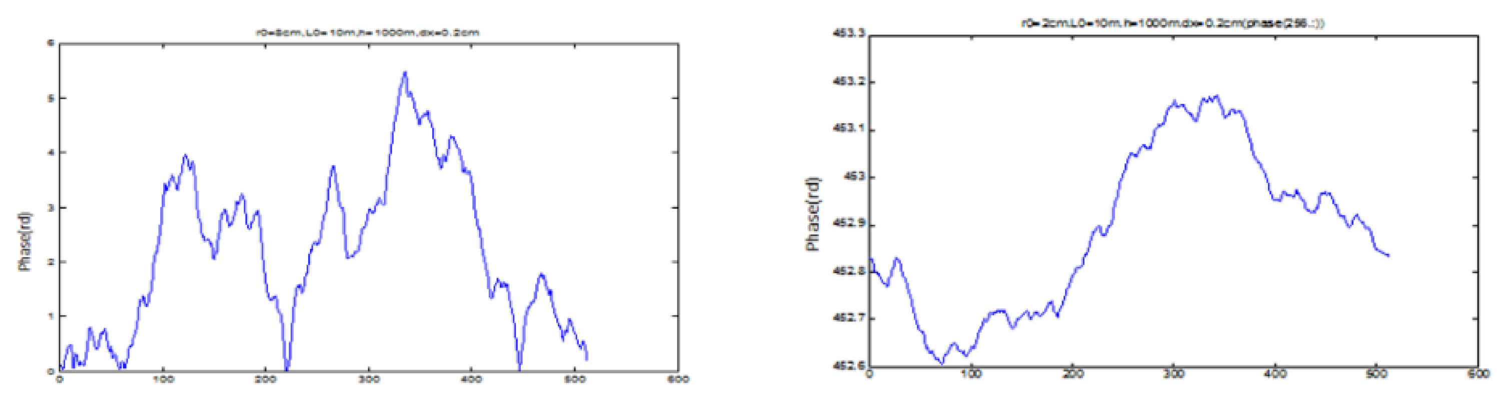
3-The response of a telescope (Airy task) left 2D and 3D line, (320?320) pixel



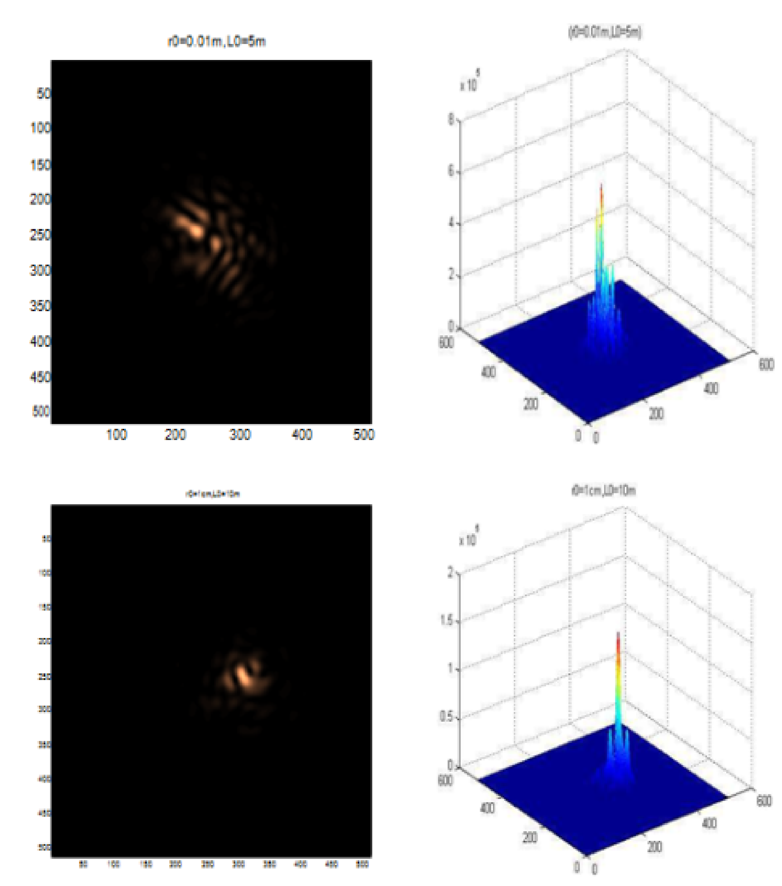
5-Phase screen size (512 512) pixels, left 2D droite3D for different values of r_0, h, dx

$r_0(cm)$	2	2	2	8	2
(m)	1	10	10	10	10
(m)	1000	1000	10000	1000	1000
$dx(cm)$	0.2	0.2	0.2	0.2	0.8

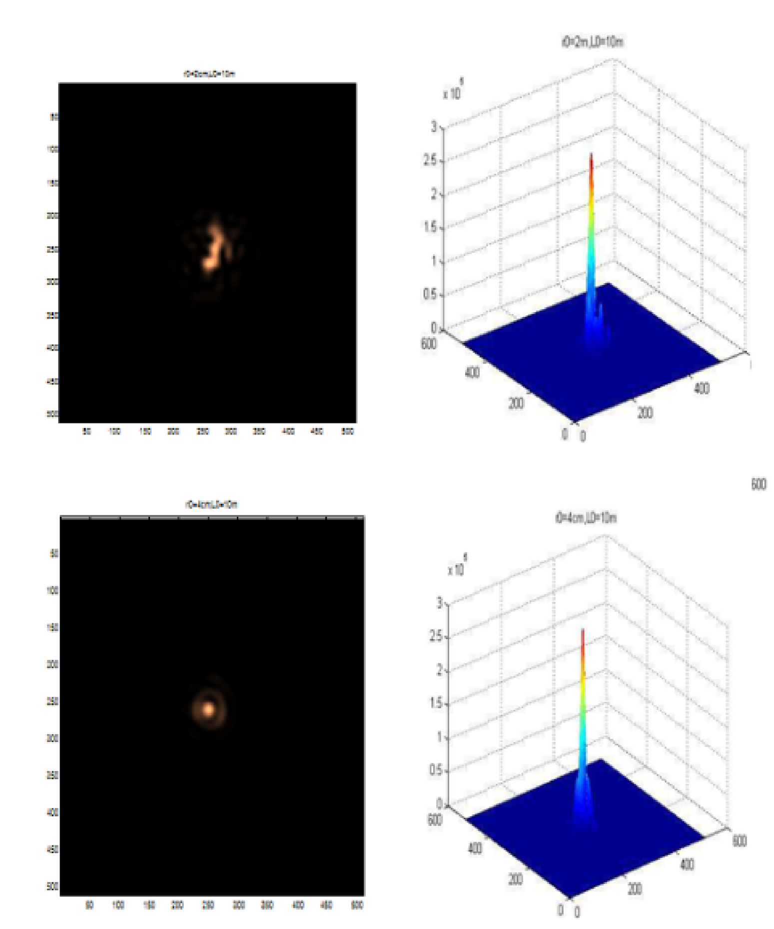
4-The influence of the parameters on the display phase



6-The influence on the r_0 display phase



7-Short exposure images simulation for different values of r0



8-Short exposure images simulation for different values of r0, L0.

References

[1] « Fresnel diffraction and polychromatic effects on angle- of-arrival fluctuations », J. Opt. A:Pure Appl,Opt.8: (2006)1-8.

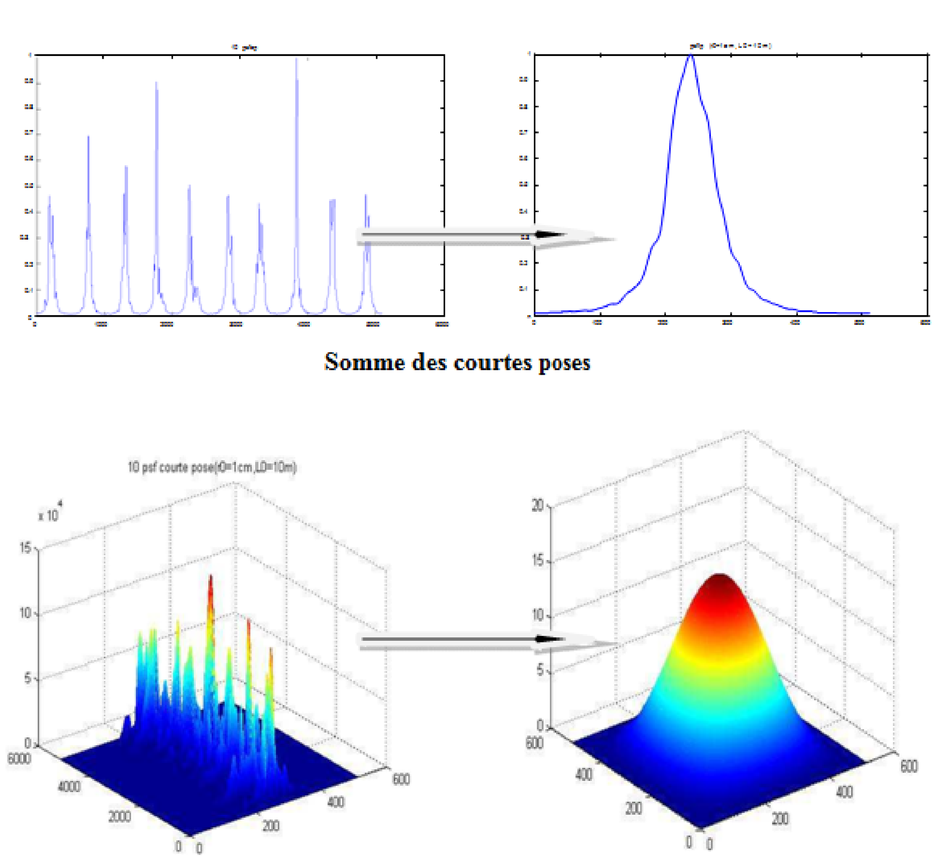
[2] "Measurements and Variations of the Solar Diameter,"Solar Physics 166, 211_229, 1996

[3] "Simulation of the Anisoplanatic Angle-of- Arrival Fluctuations Measured on the Solar Edge Images," SF2A 2002-Paris, EDPS Conference Series in Astronomy & Astrophysics, 205_206, 2002 207

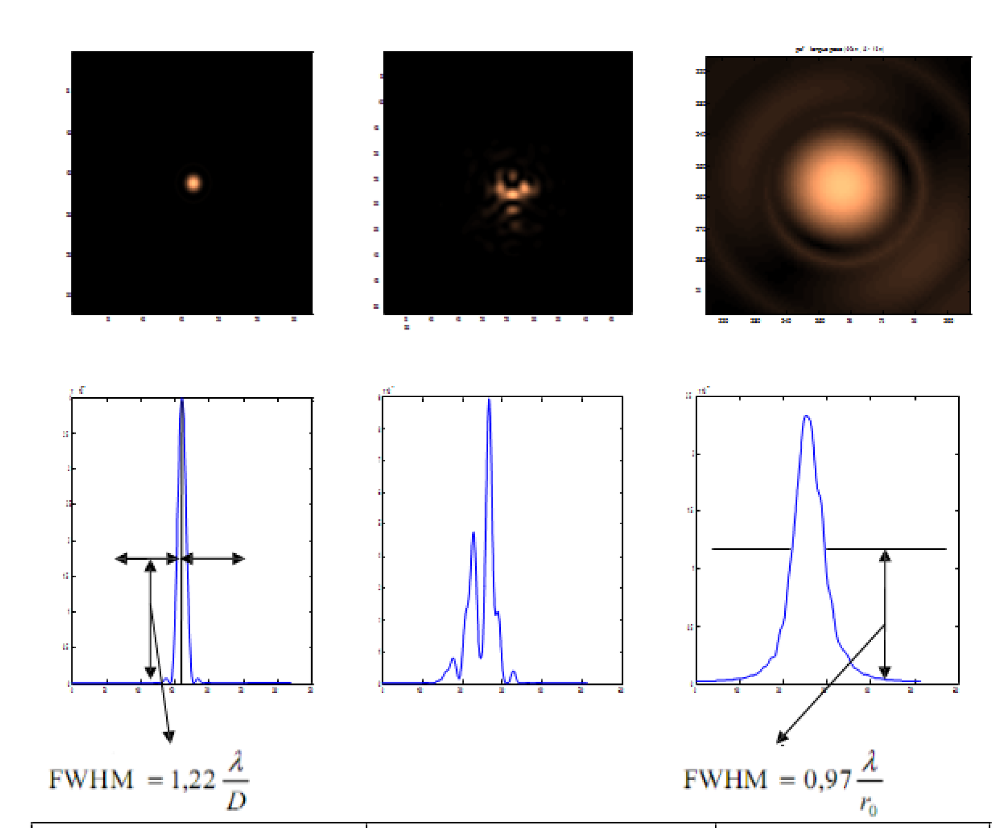
[4] D. Hestro_er & C. Magnan, "Wavelength Dependency of the Solar Limb Darkening," A&A 333, 338_342, 1998

[5] E.Aristidi. : « Reconstruction d'images astronomiques par analyse statistique du champ de speckles au foyer d'un grand télescope », thèse de doctorat, Université de Nice,(1992).

Result



10-Simulation of long pictures poses



11-Angular resolution

Conclusion

The study presented in this Work has shown the interest of the statistical analysis of angle of arrival fluctuations (variance and covariance) as effective and particularly well suited for the measurement of various parameters of the atmospheric turbulence.

The arrival angle can be measured directly from the image are solar limb on the telescope fluctuations.

The comparison between the theoretical covariance model and simulated covariance showed that the agreement between theory and simulation of covariance is not true for all parameters,but by adjusting various parameters can be obtained by agreement between theoretical and experimental entities

The main objective is to obtain a complete characterization of spatio-temporal parameters of turbulence where the estimation of various parameters of the atmospheric turbulence occurs essentially to identify the appropriate model in the atmosphere.