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# THE 2D APODIZATION OF RECTANGULAR TELESCOPE APERTURE USING MICHELSON INTERFEROMETER AND MONOCHROMATIC LIGHT

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**Abstract.** In this laboratory experiment study, we present a two dimensional apodization approach for rectangular apertures by using an interferometric assembly. We used a He-Ne Laser source to simulate a star and two cascaded classical Michelson interferometers in order to perform the apodization in two perpendicular directions. The goal is to study the performences of the assembly and fined out the optimal configuration leading to the best apodization.

## 1 Introduction

The development of methods for direct detection of exoplanets is one of the most popular subjects in astronomy. The apodization, possibly associated with coronography, occupies a prominent place among the current methods of observation. The interest of the apodized apertures in the imaging of exoplanets was reported for the first time by Nienson & Papaliolios (2001) in their proposal of apodized square aperture. The basic idea is to use a telescope with a variable aperture transmission to reduce sharply the wings of the diffraction point spread function (PSF). The technique reported in this document is based on the proposal of Aime et al. (2002) where they suggest using a Michelson interferometer or Mach-Zehnder interferometer. The first experiments using a Michelson interferometer were conducted by Soummer (2002) and El Azhari et al. (2005). Recently, the result of using a Mach-Zehnder was proposed by Carlotti et al. (2008). In this work, we will present an interefrometric apodization approach. Our aim is to study the performences of the cascaded classical Michelson interferometers assembly and fined out the optimal configuration leading to the best square apodization.

## 2 Experimental assembly and results

The experimental assembly is presented in figure 1, the lens $L_2$ allows us to light up the interferometer ($MI_1$) with a plane wave and forms an image of the telescope pupil (P) on the mirror $M_2$ of ($MI_1$). The lens $L_3$ allows us to obtain an image ($P_2$) of the plane ($P_1$). The lens $L_4$ allows us to light up the interferometer ($MI_2$) by a plane wave and it forms an image of the mirror $M'_2$ on the mirror $M_2$. The lens $L_5$ forms the final image of the telescope pupil (P) at the plane ($P_4$) and forms the image of the telescope focal plane ($P_1$) at the plane ($P_3$). The resulting PSF in the plane $P_3$ is:

$$\psi(X,Y) = \frac{4}{\pi^2}\frac{\cos(\pi X)}{1-4X^2}\frac{\cos(\pi Y)}{1-4Y^2}$$

Figures 2 and 3 show a typical example of tow dimensional cosine and one dimensional $cos^2$ apodization for rectangular aperture.

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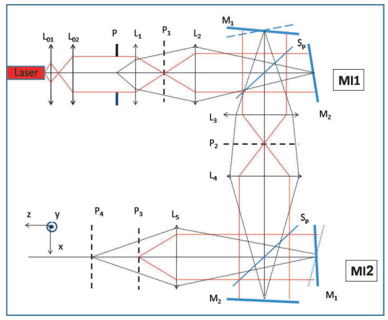


**Fig. 1.** Experimental assembly of two dimensional apodization. Michelson interferometers (MI1) and (MI2) are represented by mirrors $M_1$ and $M_2$ and beamspliters $S_p$. The lens $L_1$ represents the telescope of focal plane $P_1$ and a rectangular pupil (P). The afocal system formed by the lenses $L_{01}$ and $L_{02}$ allows us to obtain a large parallel light beam of the He-Ne laser ($\lambda = 632.8$ nm).

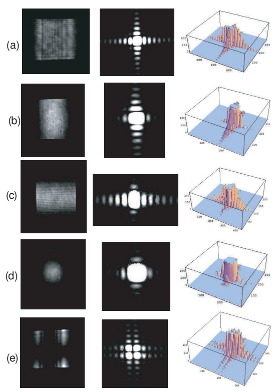


**Fig. 2.** Tow dimensional cosine apodization: The left column shows the pupil plane and the middle column shows the focal plane and the right column the 3D repartition of intensity in the focal plane. (a): case of the unapodized pupil. (b): case of the cosine apodized pupil along X axis. (c): case of the cosine apodized pupil along Y axis. (d): case of the 2D apodized pupil by CosX*CosY transmittance function. (e): case of the anti-apodized pupil.

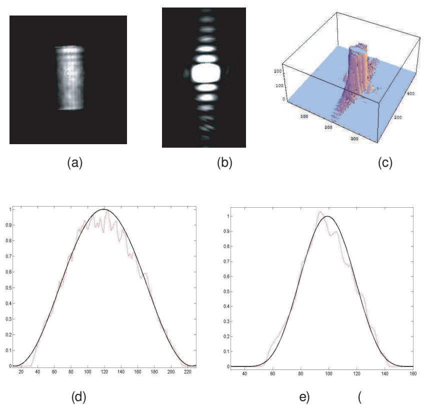


**Fig. 3.** One dimensional $\cos^2$ apodization along X axis: (a) the pupil plane. (b) the focal plane. (c) the 3D distribution of intensity in the pupil plane at the focal plane.(d) cut of the apodized pupil in the case of the cosine apodization. (e) cut of the apodized pupil in the case of the $\cos^2$ apodization.

## 3 Conclusions

This experimental work will be followed by another study on the effect of non-monochromaticity of light on apodization interference. Indeed, the interference phenomena and the transmission function depend on wave length. These results could be very useful in high angular resolution applications.

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