INVESTIGATION OF THE EFFECT OF FILTERS ON THE IMAGE INTENSITY FORMED BY COHERENT LIGHT

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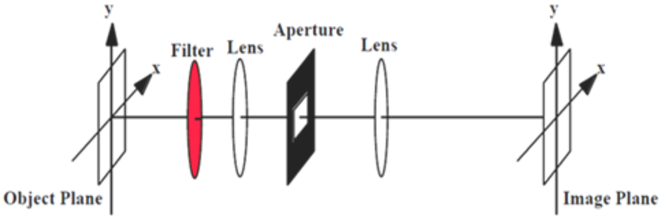
This research was carried out to study the distribution of intensity in the images of sharp edge objects by using coherent light in the case of using two types of filters. We derived equations for the sharp edge spread function when using the filters. These equations can be used for any quantity of aberration appears in optical systems by using the pupil function technique. The optimum balance values for any type of aberration that were studied in this research were calculated using a computer program In order to calculate the intensity of different amounts of aberration such as focal error and spherical aberration, the third and fifth degrees of coma aberration in the image of sharp edge object when using the filters. The main objective of this research is to test the best types of filters for use in optical systems that illuminated with coherent light. In this research, we found that the use of filters has a significant effect on improving the quality of images by increasing the intensity. Also, when using filters in optical systems with coherent light is effective for the ability of analysis.

(Received March 5, 2018; Accepted April 30, 2018)

Keywords: *filters – coherent light – focus error – spherical aberration – coma aberration.*

1. Introduction

The diffraction model generated by an optical system is free of the aberration for a point object when a circular aperture is used, it is a circular disk surrounded by dark, luminous circular rings that gradually fade away from the center of the image. These rings are fringes generated by the diffraction phenomenon at the circular aperture of the optical system. The energy contained in the central disk is (84%) of the total energy and the remaining energy (16%) is distributed on the rest of the luminous rings and usually, the share of the first ring is the largest of this ratio and then the second ring and the third and so on. The amount of energy contained in the rings is few compared to the contents of the central disk, but it leads to some problems in practical applications. The luminous rings are secondary peaks in the generated diffraction pattern and these peaks lead to a not good performance of the optical system. For this reason, a method was used called Apodization, a Greek term means the filtration, by removing the secondary peaks surrounding the resulting image or reducing its effect.



Scheme 1 Optical system with filter.

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In telescopes, for example, the filter improves the telescope's ability to detect the image of the low-light star (I) near the high-light star (II). Since without the filtration method, the image of the first star and specifically the central disk will be located within the secondary peaks of the second star, making it difficult to detect the first star. To illustrate the theoretical method of filtering showed an example of how to use the filter as a cosine function and to insert it into the original function, which represents the complex amplitude of a slit shape object [1].Confocal, multiphoton, and sectioning microscopes are powerful tools in biological imaging as they produce three-dimensional (3D) images of volume specimens. These images require the acquisition of a series of optical sections from a range of focusing depths [2] .The optics of the human eye is not static in steady viewing conditions and exhibit micro fluctuations. Previous methods used for analyzing dynamic changes in the eye's optics include simple Fourier transform-based methods, which have been used in studies of the eye's accommodation response. However, dedicated tools for the analysis of dynamic wave front aberrations have not been reported. We propose a set of signal processing tools, the combination of which uncovers aspects of the dynamics of eye's optical aberrations which were hidden from conventional analysis techniques [3].

The stationary phase method has been used to obtain a phase filter that, in principle, provides reduced sensitivity to coma and to astigmatism; in both cases the numerically calculated MTF (modulation transfer function) remains almost constant as the parameter for either astigmatism or coma is varied. Although the invariance to astigmatism offers a means for useful enhancement in performance for optical systems exhibiting coma useful invariance can also be achieved by a reduction in the aperture size [4] .The reduction in MTF [modulation transfer function] for the aberrated optical systems that occurs with these phase filters will nevertheless generally reduce the SNR[Signal-to-noise ratio] in the image although the lack of zeros means that, in general, deconvolution of images without loss of information, is still possible. The radially symmetric phase filters do not generally reduce the sensitivity to aberrations as efficiently as the cubic phase filter, but offer the advantage of low-cost manufacture· [5] .Multispectral cameras enable high-fidelity color image acquisition by separation of the electromagnetic spectrum with optical band pass filters mounted on a filter wheel between optics and imaging sensor. A multispectral image is acquired by capturing one gray scale image per wheel position and combining the images afterwards. Since the optical filters differ in their thicknesses and refraction indices, both transversal (geometric distortions) and longitudinal aberrations (blurring) occur. We present a physical model for the longitudinal aberrations and describe the resulting distortion effects [6] .Virtually all optical imaging systems introduce a variety of aberrations into an image. Chromatic aberration, for example, results from the failure of an optical system to perfectly focus light of different wavelengths [7] .

Optical aberrations of the human eye are currently corrected using eyeglasses, contact lenses, or surgery. We describe a fourth option: modifying the composition of displayed content such that the perceived image appears in focus, after passing through an eye with known optical defects The development of multilayer pre-filtered displays has the potential to offer an assistive device that may augment or eliminate the need for eyewear or surgery. For individuals with common lower order aberrations, such displays provide a convenient consumer technology: allowing a casual glance at a watch, phone, or other information display to be accomplished without eyewear [8].The filtration process appears to be more necessary for the imaging system resulting from the coherent illumination, which is accompanied by a series of parallel fringes of sharp-edged objects. A number of researchers have used the filter function to make improvements to the images of the extended objects. A new function added to treat the fringes associated with an image of linear object and a sharp edge object [9]. A filtration function is used for both point and linear sources [10]. A filtration of a linear source image based on the pupil function has been studied [11]. A various research projects have conducted in the field of filters includes both theoretical and practical methods [12].

In this research, two functions will be used for the purpose of filtering an image of an object with a sharp edge and coherent illumination. These functions were suggested (13) as follows:

1. The first filter of the function [COS (PI * (X / 2))].
2. The second filter is the exponential function [EXP (- $(X / 2)^2$ / C)].

2. Experimental

Fig. (1) shows a comparison between three curves, the first one of the sharp – edge object free of aberration and without filter, the second curve using the exponential filter and the third for the cosine filter, we noted that the exponential filter is better to improve the image of the sharp – edge object because of the intensity of the image resulting from the use of this filter. On this basis, the effect of factor (C) on the exponential filter was studied and different values were used within certain limits. It was found that by increasing the values of this factor the intensity of the image increased with an increase in the intensity of the fringes; by decreasing the value of factor (C) we noticed a decrease in the intensity of the fringes as shown in fig (2).

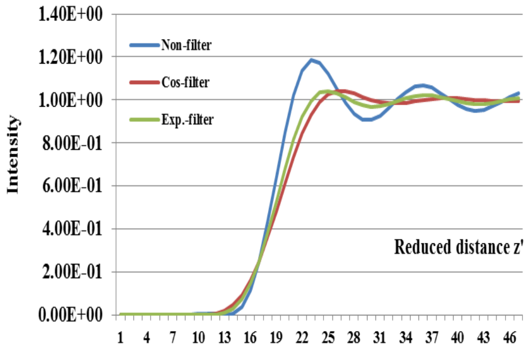

Fig. 1. Comparison between filters for apodized aberration free system

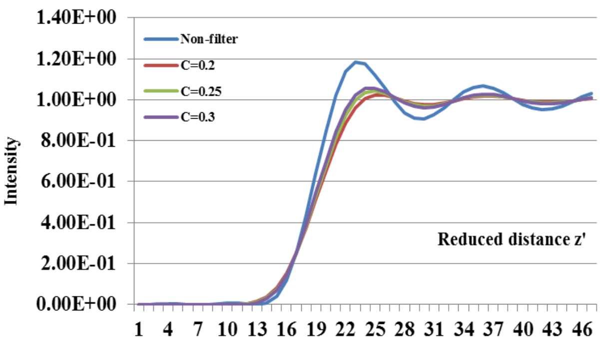

Fig. 2. The effect of different values for factor (C) on the (EXP) filter for free aberration system

The effect of the two filters on the optical system with a circular aperture and focal error of ($W_{20} = 0.25\lambda$) is also shown in Fig. (3) It is noted that the effect of the exponential filter is better than the cosine filter.

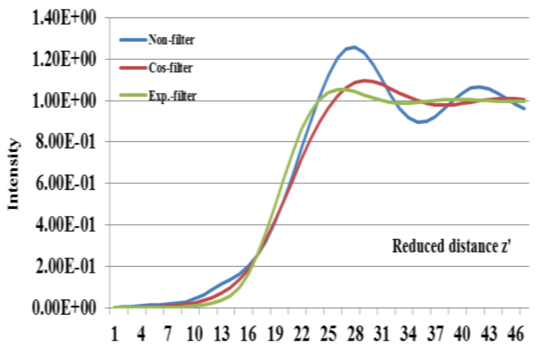

Fig. 3. The effect of the filters on optical system with focus error (0.25λ)

Fig. (4) shows the effect of the two filters on primary spherical aberration ($W_{40} = 0.5\lambda$). In this figure; the opposite is observed since the effect of the cosine filter is better due to the decrease in intensity of the fringes. This means that by increasing the amount of permissible aberration (0.25λ); the efficiency of the exponential filter decreases and the preference the cosine filter increases.

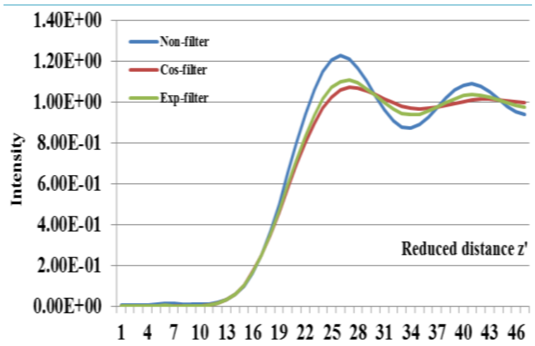

Fig 4. The effect of filters on the intensity distribution for optical system with spherical aberration (W40 = 0.5λ)

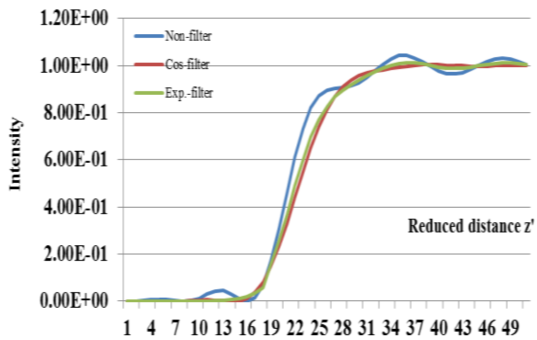

Fig. 5. The effect of filters on the intensity distribution for optical system with coma aberration (W31 = 0.5λ) and rotation angle (450)

For coma aberration, the Fig. (5) shows the effect of the coma aberration ($W_{31} = 0.5\lambda$) with rotational angle (45^o); the intensity of the image for the exponential filter will be similar to the intensity of the image resulting from the use of the cosine filter, Here we can say that the use of the filter leads to shifting of the image and this shift depends on the type of filter used.

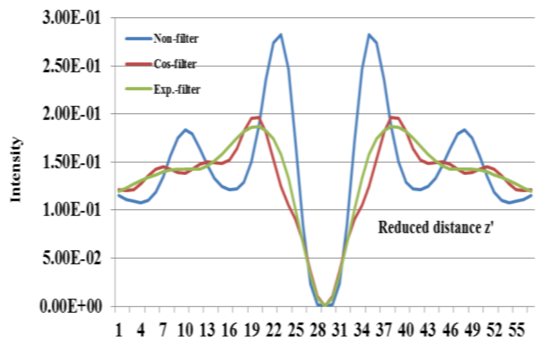

Fig. 6. The effect of filters on free aberration optical system with annular aperture (R = 0.05)

Fig. (6) shows the effect of the two filters on an optical system that is free of aberration and works with annular aperture, an improvement in the diffraction model is observed, the exponential filter is better than the cosine filter as shown by the intensity of their image.

3. Conclusions

The exponential filter contributes in the improvement of the image of the sharp – edge object because of the significant increase in the intensity of the image resulting from the use of exponential filter compared with cosine filter image.

The values of factor (C) in the exponential filter equation have a significant effect on the improvement of the image intensity resulting from the use of this filter. Increasing the values of this factor leads to increase the intensity of the image and the fringes and vice versa.

The effect of the cosine filter on the resulting image is better when the increase in the amount of permissible aberration is greater than (0.25 λ).

The use of a filter in the presence of coma aberration leads to shifting the image and this shift depends on the type of filter used.

When using an optical system with annular aperture, the exponential filter is the best in improving the resulting image.

The use of a square aperture or circular aperture leads to the same results of intensity in the case of coherence and this is confirmed by the scientist Barakat [14].

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