Shaded Amplitude Filter in the Sl And Rl of the Aperture

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Abstract

We know that by employing suitable apodization function, the point spread function in the maximum out-of-focus image plane can be modified according to the axial shape requirements. A suitable aperture of shading is very helpful to correct the Seidel aberration effect in the image plane of the optical system. Based on the investigations done in the two zone apodization process, it can be inferred that the Hanning amplitude filter in the outer zone and Connes amplitude filter in the inner zone could be the solution for modifying the point spread function of the optical system under the strong combined influence of defect-of-focus and primary spherical aberration. In the present study, we studied the two-zone aperture with the second order Hanning and Connes amplitude mask, to modify the distribution of light radiation in the focal plane of an aberration made optical systems.

Key words: Defocus, Frequency, Defocus and Annular etc.

1.1 INTRODUCTION:

Viewed in this framework, the lens system is a low-pass spatial frequency filter. Its effects on the image quality can, therefore, be specified in terms of a spatial frequency band-pass curve. The subject of image formation and analysis took qualitative turn with the applications of communication theory to optics. This resulted in a mathematical tool of Fourier analysis being used in the field of image science. Currently, image formation is described in terms of the impulse response of the imaging systems or in terms of the system transfer functions

Key words: Filters, Annular, Pupil & Defocus etc.

Diffraction theory is mainly concerned with the field in these spatial regions; such regions signify greater practical importance as they include that part of the image space in which the optical image is situated. In the neighborhood of the focal plane, the light distribution will be much more complex in nature than the one suggested by geometrical optics. To describe the object, the diffraction pattern can be used since it is related to the shape, size and orientation of the object. The diffraction theory of image formation is the foundation in many modern applications of optics.

J. B. Joseph Fourier laid the foundation of modern optical processing by proposing what is now known as ‘Fourier theory’. His theory is a basic mathematical tool that we shall use very often to explain many optical phenomena (LIPSON and LIPSON, 1969). The importance of this theory is that it is applicable to both periodic and nonperiodic functions; also, it leads to a much better understanding of the formation of optical images in various situations like coherent, incoherent, or partially coherent illumination.

Apodization is similar to pulse shaping in electrical engineering (PAPOULIS, 1968). Apodization may be defined as the deliberate modification of the pupil function so as to improve some measure of the image quality (WETHERELL, 1980). Straubel may be considered as the founder of apodization theory (BARAKAT, 1962). A complete or partial suppression of the side-lobes at the cost of enlarging the central part of the diffraction pattern by modification of the entrance pupil of an optical device is known as apodization. The resolving power of the system for point objects of equal brightness is diminished by apodization (JACQUINOT and ROIZENDOSSIER, 1964). Thus, apodization improves some selected properties of an imaging system at the cost of some others. This process is employed to detect the presence of a faint object nearby a bright object. The apodization technique was originally employed by astronomers to detect the presence of faint star by the side of a very bright star.

1.2 MATHEMATICAL FORMULATION:

For our studies on variable apodization we have chosen the following mathematical equation in which f(r) is the filter with $1-\beta r^2$ and cos (πβr) by varying these filters the anodizing of the optical systems is studied the combination of Co-sinusoidal amplitude filter in the first zone and Gaussian amplitude filter in the middle zones with (-π/4) and (π/3) phase filter. The general expression for diffraction field of two amplitude filters. However, in practice such an ideal transformation is not possible with the real lens systems but necessarily an approximation. Such a perfectly collinear transformation is limited only to a very restricted region surrounding the central ray of the bundle where the laws of reflection and refraction are valid. It means collinear transformation takes place only by the paraxial rays, which are making infinitely small angle with the axis and of crossing a reference surface perpendicular to the axis is given by:

$$S(\O_d, Z) = 2\left[\int_0^a (f_1(x) J_0(Zx) x\,dx + \int_a^b (f_2(x) J_0(Zx) x\,dx + \int_b^1 (f_3(x) J_0(Zx) x\,dx\right] \ldots\ldots..(1)$$

Here f_1 (x) is Co-sinusoidal, f_2 (x) is Gaussian, and f_3 (x) is Hanning mask pupil functions for the amplitude apodization of the pupil transmission. Z is the reduced dimensionless diffraction coordinate in the image plane.

The generalized expression for the amplitude and phase impulse response of the pupil function in the presence of three zone aperture:

$$S(\O_d, Z) = \int_0^a 2\left[f_1(x) e^{-\O d} J(Zx) x\,dx - (\pi/4)\int_a^b (f_2(x) e^{-\O d} J_0(Zx) x\,dx + (\pi/3)\int_b^1 f_3(x) e^{-\O d} J_0(Zx) x\,dx\right] \ldots.(2)$$

Haning-f1=cos(πβx) ……. (3)

Gaussian-f2=exp.($-\beta r/2x^2$) ……... (4)

C0-sinusoidal-f3= 1+βcos(πr^2)/1+β. ……... (5)

In which J_0 *(Zx)* is the zero order Bessel function of the first kind and zero order, β is the apodization coefficient, this controls the degree of apodization.

$$B(z) = 2\int_0^{0.4} f(r)\exp(-i(\O a)) J_0(zr) r\,dr + 2\int_{0.4}^{1} f(r)\ \exp(-i(\O a)\,) J_0(zr) r\,dr$$

1.3 RESULTS AND DISCUSSIONS:

Below Fig. depicts the intensity distribution profiles in the case of Shaded amplitude filter when the optical system is subjected to primary spherical aberration and defect-of-focus for various degrees of apodization parameter (β = 0, 0.2, 0.4, 0.6. 0.8 and 1; when the parameter ‘a’ = 0.30, parameter ‘b’ = 0.60 and parameter ‘c’ = 0.80 are chosen. The intensity in the central maxima decreases with apodization for all values of defocus as well as primary spherical aberration.

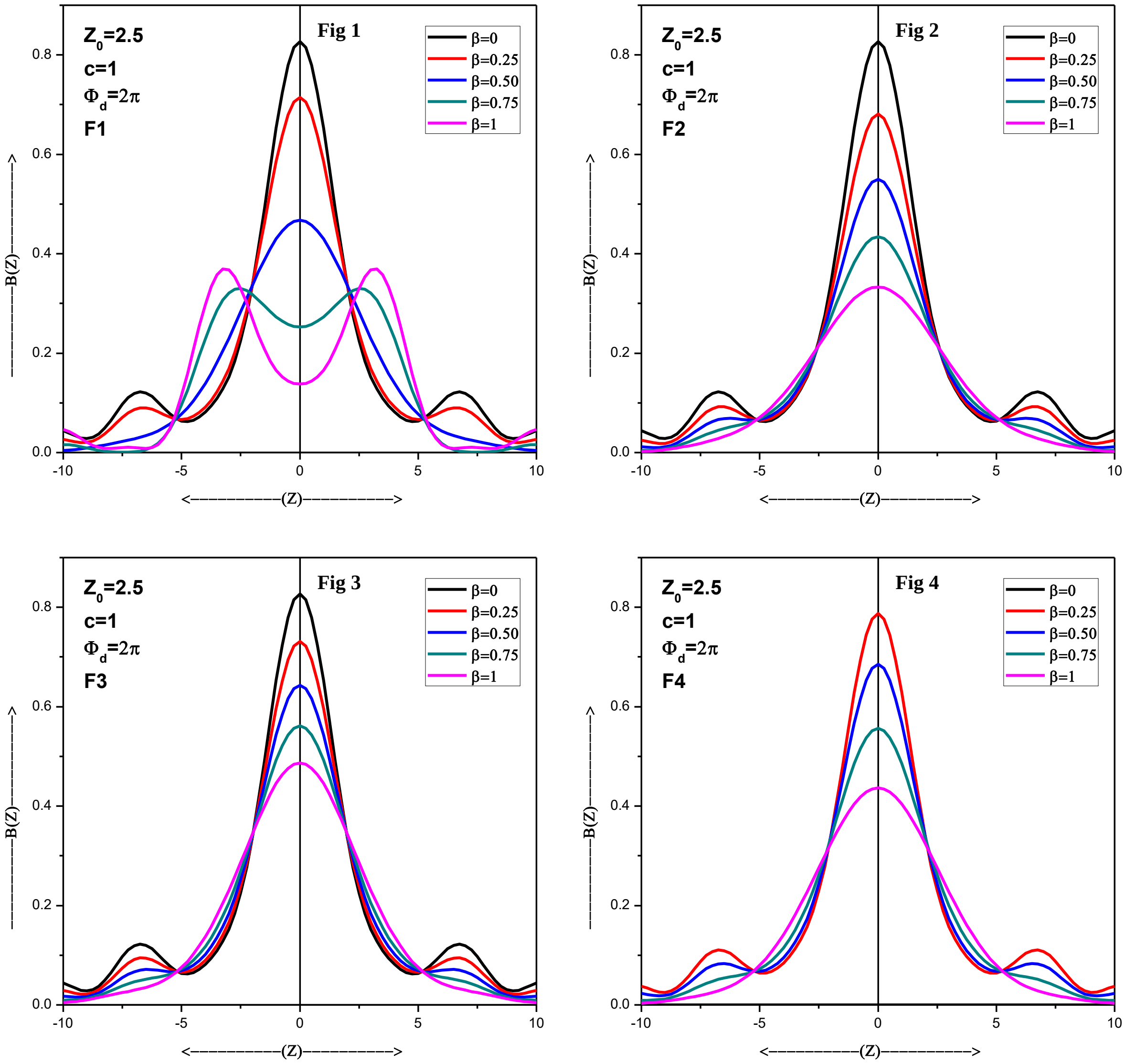
For different amplitude filters the four graphs were drawn When the optical system is under extreme conditions of defocus and primary spherical aberration the intensity in the central-lobe degrades with apodization.

By using MATLAB program to study the effects of the Hanning and Connes amplitude apodization, defect-of-focus and the primary, secondary, tertiary spherical aberration on the imaging efficiency of optical imaging systems. The apodization parameter β varies from 0 to 1 in steps of 0.25. With β = 0 the optical system is said to be un-apodized optical system. β = 0, corresponds to the Airy case (perfect lens) and for the values of β ≠ 0 represents the apodised system. The influence of defect-of-focus (ϕ_d) on the optical system aberrated with the primary, secondary and tertiary spherical aberration (ϕ_s) is investigated analytically for various degrees of the apodization parameter β.

Among these the phenomenon of diffraction and aberrations are the primary contributors in the degradation of image quality and affecting the performance of the optical system. The general feature of all the optical systems is the presence of optical aberrations. Even in most well corrected systems, there are some residual aberrations present. Aberrations results in phase errors in the wave front as it traverses the optical system. The presence of aberrations introduces undesirable results and unnecessary degradation in the performance of the optical systems.

The Table -1 gives the study of imaging properties of optical systems suffering from aberrations from the knowledge of the point spread function has become an important method in the design and testing of such systems. For the coma aberration, the **Sparrow Limit (SL)** and **Rayleigh Limit (RL)** values has been executed and tabulated for the various values of

apodization parameter. These reasons have incited to explore the possibilities in enhancing the performance of the optical systems



F1-Hanning Filter F2-Barlet filter F3-Shaded aperture filter F4-Lancoz filter

INTENSITY DISTRIBUTION CURVES

Table:1

				Sin(πβr)/(πβr)				0.1 TO 1			
		C = 0.2		C = 0.4		C = 0.6		C = 0.8			C = 1
	β	RL	SL	RL	SL	RL	SL	RL	SL	RL	
	0	4.3200	2.8000	4.4860	2.3000	4.4540	1.8000	4.3610	1.3000	4.1620	0.2000
Φc= 0	0.1	4.3290	2.8000	4.4940	2.3000	4.4610	1.8000	4.3660	1.3000	4.1670	0.2000
	0.2	4.3620	2.8000	4.5170	2.2000	4.4800	1.7000	4.3830	1.3000	4.1800	0.2000
	0.3	4.4190	2.8000	4.5570	2.2000	4.5130	1.7000	4.4110	1.3000	4.2050	0.2000
	0.4	4.5000	2.9000	4.6160	2.2000	4.5630	1.7000	4.4550	1.3000	4.2410	0.2000
	0.5	4.6210	2.8000	4.7000	2.2000	4.6320	1.7000	4.5160	1.3000	4.2930	0.2000
	0.6	4.7800	2.8000	4.8150	2.1000	4.7300	1.7000	4.6020	1.3000	4.3670	0.2000

	0.7	4.9890	2.7000	4.9730	2.1000	4.8670	1.7000	4.7240	1.2000	4.4710	0.2000
	0.8	5.2700	2.6000	5.1970	2.1000	5.0630	1.7000	4.9000	1.2000	4.6230	0.2000
	0.9	5.6590	2.6000	5.5240	2.1000	5.3560	1.7000	5.1660	1.3000	4.8590	0.2000
	1	6.1960	2.7000	6.0150	2.2000	5.8160	1.8000	5.6000	1.3000	5.2540	0.2000

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