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Research Paper

Defocused Annular Apertures in Two Line Resolution

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Abstract:

Any optical system to act as super resolver this can be acquired by properly choosing the transmittance of the pupil function of the optical system, the intensity around the focused fields can be totally suppressed or at least considerably reduced without increasing the dimensions of the pupil. The point spread function of the optical system in the presence of defocus and primary spherical aberration with the complex Hanning filter with amplitude and phase has been investigated. A suitable aperture of shading is very helpful to correct the aberration effect in the image plane of the optical system. Based on the investigations done in the process, it can be inferred that the Hanning amplitude filter and 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 A sub-stained improvement in the intensity profile of the impulse response of the optical system has been achieved when the optical system is subjected to higher orders of aberration and apodizatin, the optical system behave like a super-resolver with resolution of the central peak being improved radically. The presence of first minima with zero intensity suits the optical system to be applied for two line resolution studies in terms of Rayleigh criterion.

Keywords: Amplitude Apodization, Defocus-of-focus and Hanning filter etc;

1.1 INTRODUCTION:

If the Pupil transmittance of an optical system is made different on the state of orientations in different apodizations. Therefore, by making suitable choice of the state of polarization and with proper orientation of the polarization masks one can simulate the conditions of different amplitude and phase coatings at different optical system the distribution of the light illumination at and near the focus of an optical system is highly desirable to give acceptable interpretation for the results obtained by the aberrated optical imaging systems consisting with the aid of large number of components. The importance of this subject was first recognized and studied by Airy in the year 1834 and subsequently Lord Rayleigh has investigated the light distribution in the discs in the presence of spherical aberration and evaluated the central intensity (BUXTON, 1921). LOMMEL (1885) has been developed the mathematical theory for the light distribution at and near the focus of an optical system by employing a circular aperture and it was verified experimentally. He has studied in detail the light distribution in the images of monochromatic point sources situated in the out of focus planes

1.2 MATHEMATICAL FORMULATION:

The apodisation function, defocusing function and aberration functions are considered factors of the pupil function f(r). Now, making use of the Fresnel – Kirchhoff diffraction integral formula to obtain the complex amplitude G_F (P) at 'P' as

$$G_F(P) = -\frac{i}{\lambda}\frac{A\,f(r)\exp(-iks)}{s}\iint_{\Sigma}\frac{\exp(ikd)}{s}ds \qquad (2.1)$$

The variation of the inclination factor have been neglected since the angles involved are small and also assumed that the amplitude of the wave is substantially constant over the wave-front, so that 'A' can be taken outside the integral. If q is the unit vector in the direction FQ, we can write to a good approximation

The shape and dimensions of the aperture and also the form of the pupil function, i.e., the apodiser, mainly determines the diffraction pattern. The expression (2.1) now becomes as shown below

$$G_F(\phi_d, \varphi_s, \Phi_a, Z) = 2\int_0^1 f(r)\exp\left[-i\left(\frac{1}{2}\phi_d r^2 + \frac{1}{4}\varphi_s r^4\right)\right]J_0(Zr)\,r\,dr \qquad (2.2)$$

For the clear aperture, f(r) = 1. The complex amplitude distribution in the neighbour hood of the focus is given by the expression

$$G_F(\phi_d, \varphi_s, Z) = 2\int_0^1 \exp\left[-i\left(\frac{1}{2}\phi_d r^2 + \frac{1}{4}\varphi_s r^4\right)\right]J_0(Zr)\,r\,dr \qquad (2.3)$$

It is convenient now to consider separately the real and imaginary parts of the integral. We get

$$2\int_0^1 \exp\left[-i\left(\frac{1}{2}\phi_d r^2 + \frac{1}{4}\varphi_s r^4\right)\right] J_0(Zr) r dr = M(\phi_d, \varphi_s, Z) - iN(\phi_d, \varphi_s, Z) \quad (2.4)$$

where $M(\phi_d, \varphi_s, Z) = 2\int_0^1 J_0(Zr) \cos\left(\frac{1}{2}\phi_d r^2 + \frac{1}{4}\varphi_s r^4\right) r dr$

$$N(\phi_d, \varphi_s, Z) = 2\int_0^1 J_0(Zr) \sin\left(\frac{1}{2}\phi_d r^2 + \frac{1}{4}\varphi_s r^4\right) r dr \quad (2.5)$$

$$G_F(\phi_d, \varphi_s, Z) = 2\int_0^1 Cos(\pi\beta r) \exp\left[-i\left(\phi_d \frac{r^2}{2} + \frac{1}{4}\varphi_s r^4\right)\right] J_0(Zr) r dr \quad (2.6)$$

For the Gaussian focal plane, $\phi_d = 0$. Hence the above expression becomes

Where β is the apodisation parameter which controls the degree of the non-uniform transmission of the exit pupil and r is the normalized distance of the point on the pupil from the center. Both β and r vary from 0 to 1.0 β=0 specifies the free aperture or Airy type of pupil. The expression for the amplitude PSF for the Hanning amplitude aperture is obtained from the above equations

$$G_F(0, \varphi_s, Z) = 2\int_0^1 Cos(\pi\beta r) \exp\left(-i\frac{1}{4}\varphi_s r^4\right) J_0(Zr) r dr \quad (2.7)$$

1.3 RESULTS AND DISCUSSIONS:

When the optical system is under the Defocus aberration at 2π the apodisation parameter β values are changing for variable filters in Fig -1; β=0 to 0.5 the resolution is appeared and this is depicted as well in the Fig-2 but in the case of Fig -3 it is not occurred there by we can conclude that the variable apodisation for optical system suffers maximum resolutions

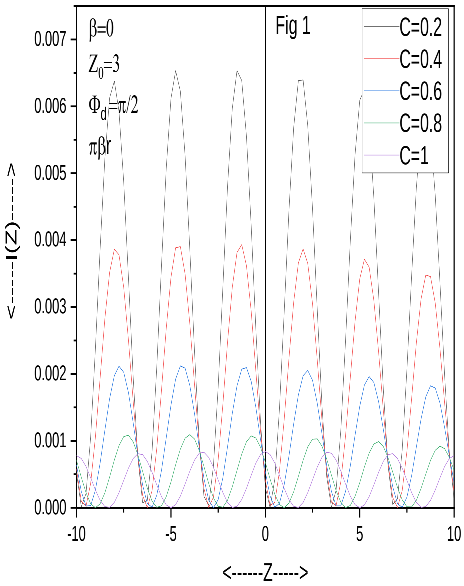
Fig 1
β=0
Z0=3
Φd=π/2
πβr
C=0.2
C=0.4
C=0.6
C=0.8
C=1
<------I(Z)------>
<------Z----->

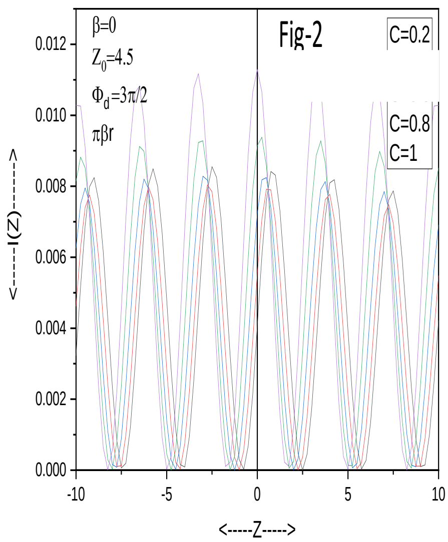
Fig-2
β=0
Z0=4.5
Φd=3π/2
πβr
C=0.2
C=0.8
C=1
<-----I(Z)----->
<-----Z----->

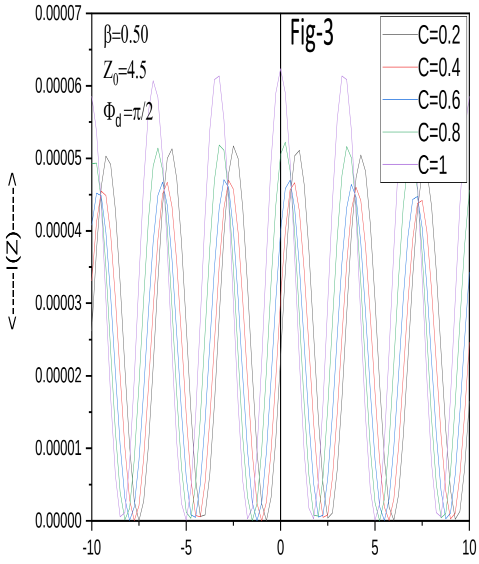
Fig-3
β=0.50
Z0=4.5
Φd=π/2
C=0.2
C=0.4
C=0.6
C=0.8
C=1
<-----I(Z)----->
<-----Z----->

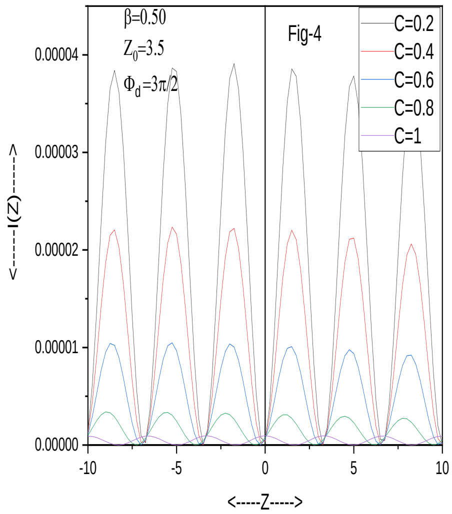
Fig-4
β=0.50
Z0=3.5
Φd=3π/2
C=0.2
C=0.4
C=0.6
C=0.8
C=1
<-----I(Z)----->
<-----Z----->

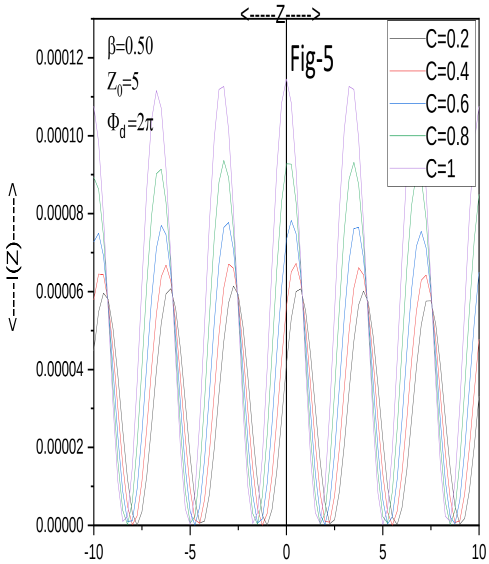
Fig-5
β=0.50
Z0=5
Φd=2π
C=0.2
C=0.4
C=0.6
C=0.8
C=1
<-----I(Z)----->

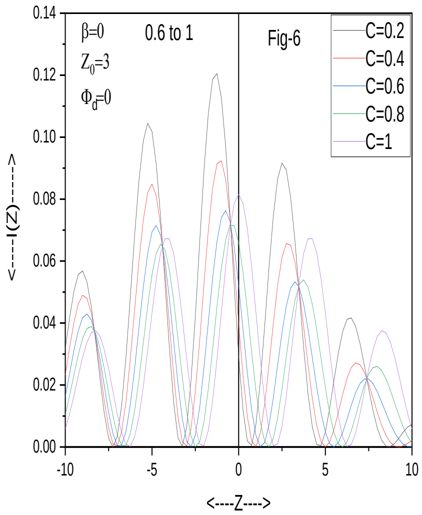
Fig-6
β=0
Z0=3
Φd=0
0.6 to 1
C=0.2
C=0.4
C=0.6
C=0.8
C=1
<-----I(Z)----->
<----Z---->

From the present investigations the limit of resolution of two lines separated by uo diffraction units about the origin is calculated by applying the Sparrow, Rayleigh and Conrady's criteria. The resolution limits for lines of different intensity ratios C= 0.2, 0.4, 0.6, 0.8 and 1. have been obtained using the Central contrast method for each value of the apodisation parameter β = 0.25, 0.5, 0.75, 1.0. The resolution limits for lines of equal intensity have been obtained using the Five-Point Finite difference approximation method for each value of the apodisation parameter C.

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