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TWO LINE RESOLUTIONS WITH CIRCULAR APERTURES AND BAND PASS APERTURES IN THE PRESENCE OF DEFOCUSING ABERRATION.

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Abstract:-
The defocus aberration can be applied to the optical system it was observed that deviations from this treatment must be expected in the immediate neighbourhood of the boundaries i.e., shading of the apertures in the regions where a large number of rays meet. Several attempts have been made to obtain the homo-centricity in the direction of minimizing the aberrations by assigning different values to the constructional parameters of the lens systems, resulting in the design of several refined optical systems. Even though a great deal of success was obtained in two line resolution of optical system, in certain regions the simple geometrical treatment of the aperture found to be inadequate.

Keywords: - *Defocus, shading, band pass, resolution and apodisation etc.*

1. INTRODUCTION:

Apodisation is the technique that modifies the imaging properties of an optical system by manipulating its entrance pupil. It is one aspect of the wide range technique of spatial filtering (HECHT and ZAJAC, 1987). Apodisation is similar to pulse shaping in electrical engineering (PAPOULIS, 1968). Apodisation 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 apodisation 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 apodisation.

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 non-periodic 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.

The resolving power of the system for point objects of equal brightness is diminished by apodisation (JACQUINOT and ROIZEN-DOSSIER, 1964)

2 Theory

The gradient of the edge response function (ERF) with respect to u' will result in the amplitude $A_{L1}'(u'-u_o, v')$ and $A_{L2}'(u'+u_o, v')$ in the images of two lines [HOPKINS and ZALAR ,1987] resulting in a combination of two line spread functions given by a separation 'u_o'' respectively.

$$A_{L1}'(u'-u_0, v') = \frac{d}{dx}[A_1'(u'-u_0, v')]$$

$$A_{L2}'(u'+u_0, v') = \frac{d}{dx}[A_2'(u'+u_0, v')]$$

If the amplitude of transmission in one of the lines can be controlled by a parameter unity for maximum amplitude in the image then the amplitude in the image of such a line of variable amplitude is given as

$$A_{L1}'(u'-u_0, v') = \alpha \frac{d}{dx}[A_1'(u'-u_0, v')]$$

$$A_{L2}'(u'+u_0, v') = \frac{d}{dx}[A_2'(u'+u_0, v')]$$

Where α = 1.0, 0.75, 0.50, 0.25 can be termed as the intensity ratio of the two lines. The superposition of these edge gradients results in the amplitude response of two lines given after simplification as

$$A_{LL}'(u', v') = 2\int_0^{+1} \frac{(1+C\cos(\pi x2))}{(1+C)} \cos\{2\pi(u' + uo)x\}\, dx +$$

$$2\,\alpha \int_0^{+1} \frac{(1+C\cos(\pi x2))}{(1+C)} \cos\{2\pi(u' - uo)x\}\, dx$$

Where ALL'(u', v') is the amplitude response of two lines. The squared modulus of will result in the intensity distribution BLL'(u', v') in the image of the two lines.

$$B_{LL}'(u', v') = \left|\; 2\int_0^{+1} \frac{(1+C\cos(\pi x2))}{(1+C)} \cos\{2\pi(u' + uo)x\}\, dx +\right.$$

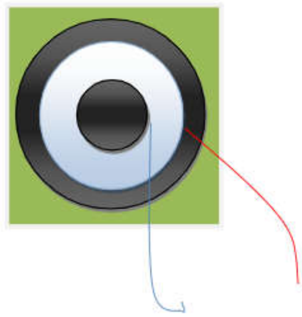
$$\left. 2\,\alpha \int_0^{+1} \frac{(1+C\cos(\pi x2))}{(1+C)} \cos\{2\pi(u' - uo)x\}\, dx \right|^2$$

Where BLL'(u', v') is intensity of two lines and it can be written as

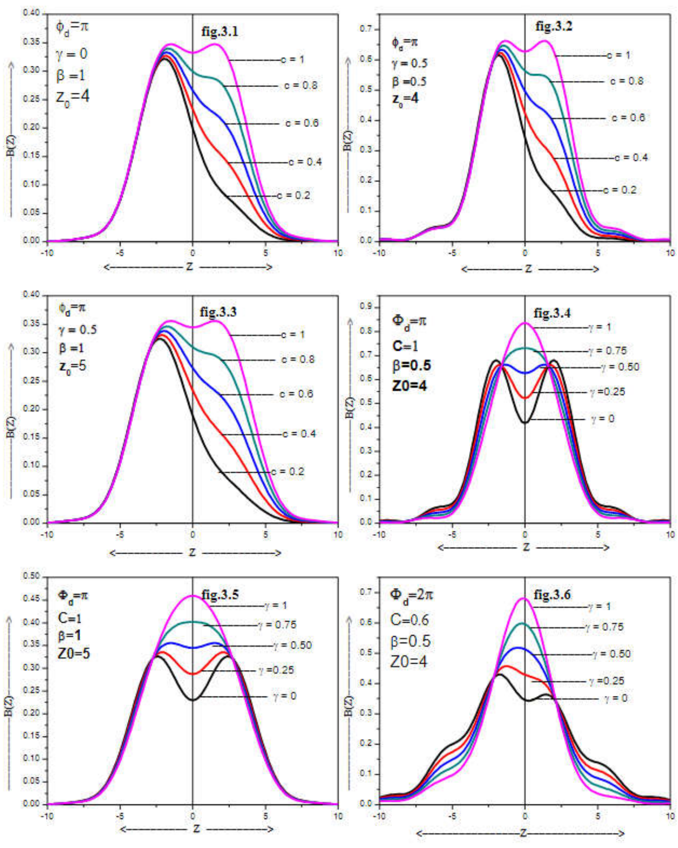
$$I(u') = \left| 2\int_0^1 \cos(\pi\beta r)\cos[2\pi(Z+Z_0)x]\, e^{-i\left(Y\frac{x^4}{4}\cos\theta + Y_1\frac{x^2}{2}\right)} dx + 2\alpha\int_0^1 \cos(\pi\beta r)\cos[2\pi(Z-Z_0)x]\, e^{-i\left(Y\frac{x^4}{4}\cos\theta + Y_1\frac{x^2}{2}\right)} dx \right|^2$$

The above equation reveals for the circular aperture as the limit values are from 0 to 1
For the band pass apertures we will change the limit values.0.4 to 0.8 such that the aperture shaping can be done through the above equation as fallows.

$$I(u') = \left| 2\int_{0.4}^{0.8} \cos(\pi\beta r)\cos[2\pi(Z+Z_0)x] e^{-i\left(Y\frac{x^4}{4}\cos\theta + Y_1\frac{x^2}{2}\right)} dx + 2\alpha\int_{0.4}^{0.8} \cos(\pi\beta r)\cos[2\pi(Z-Z_0)x] e^{-i\left(Y\frac{x^4}{4}\cos\theta + Y_1\frac{x^2}{2}\right)} dx \right|^2$$



Where the lower limit ε1 = 0.4 & ε2 = 0.8 for the band pass aperture. So Band pass aperture allows only a selected range of frequency components



3. Results and Discussions:
Fig 3.1 depicts the intensity ratio distribution curves for two line objects in the image plane for a circular aperture apodised with the filter sin (πβr)/ (πβr) when the optical imaging system is suffering with defocusing aberration for two equally bright line objects placed under incoherence illumination. As the intensity ratio curves are distributed at high apodisation (β =1) of the two bright image lines are separated by a distance z0=4 resulting we get the resolution at c=1.In fig 3.2 depicts for the same intensity ratio distribution curves for two bright lines objects in the image plane placed for the circular aperture and the separation of the distance between the two lines are kept at z0=4 the resolution between the two lines were occurred from the intensity ratio c=0.6 to c=1 In fig 3.3 when the optical system is apodised with the filter sin (πβr)/ (πβr) and is suffering with the high degree of apodisation i.e. β=1.In fig 3.4 when the optical system is at defocus aberration and the apodisation is partial the two lines are separated by a distance z0=4 the intensity distribution lines are

depicted for the coherence of the light source the resolution started at complete coherence. In fig 3.5 when the optical system is at defocus aberration and the apodisation is at high degree the two lines are separated by a distance is increased from z0=4 to z0 = 5 the intensity distribution lines are depicted for the coherence of the light source the resolution started at complete coherence.

As the apodisation parameter is decreased to 0.5 i.e. β=0.5 when the optical system is partially apodised first maxima of the intensity lines are falls on the second minima of the two lines thereby a well resolved two lines are depicted in fig 3.6

4. References:

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