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Two-Line Resolution of Shrink Apertures in the Presence of Defocus

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Abstract:

Analytical investigations have been carried out on the intensity distribution of the two-line objects in the image plane by Defocus. The optical system having an apodised shrink aperture suffering from the effects of Defocus and aberrations. Studies were also made on the imaging characteristics of the optical systems subjected to Defocus aberration. The individual influences of the apodisation, Defocus on the Two Line Resolution have been examined.

Keywords:

- Two-line resolution,
- Shrink aperture,
- Defocus aberration,
- Point spread function,
- Apodisation,
- Optical imaging systems

Introduction

In the investigations on the general resolution problem in optical systems [RAMSAY et al 1940, 1941] extended the arguments of the theory of resolving power to include the intensity epoch slope. TORALDO DE FRANCIA [1955] introduced the sampling theorem criterion and ARSAC [1956] has discussed the problem with Fourier integral theory

Mathematical formulation

When the optical system is apodised, each point gives rise to a diffraction image whose normalized amplitude response to a unit amplitude in the object point the values of peripheral obscuration parameter ε will take 0.9, 0.8, 0.7 and f(r) is the chosen amplitude filter.

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In the present study the following filters are employed: f (r_1) = cos (πβr) Hanning Amplitude Filter, f (r_2) = (1-βr) –Bartlett Filter, f(r_3) = (1-βr2) – Shaded Aperture Filter and f(r_4) = sin (πβr) / πβr – Lancoz Filter and c is the intensity ratio between the Two Lines and Z0 is distance of separation

$$B(Z) = \left| 2\int_0^{\varepsilon} f(r)\ Cos\{(Z+Z_0)r\}dr + 2c\int_0^{\varepsilon} f(r)\ \ Cos\{(Z-Z_0)r\}dr \right|^2$$

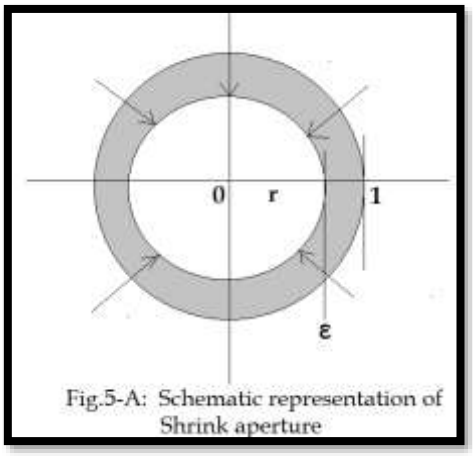

Fig.5-A: Schematic representation of Shrink aperture

They are represented mathematically as follows:

$$f(r_1) = \cos(\pi\beta r)$$

$$f(r_2) = 1 - \beta r$$

$$f(r_3) = 1 - \beta r^2$$

$$f(r_4) = \sin\frac{(\pi\beta r)}{(\pi\beta r)}$$

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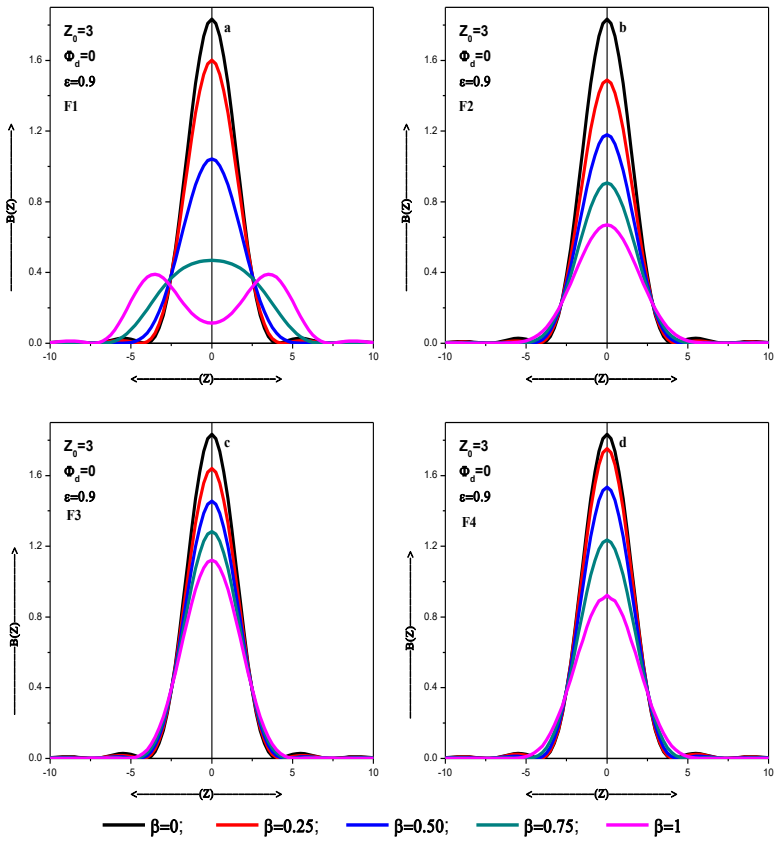

F1-Hanning amplitude filter; F2-Barlett filter; F3-Shaded aperture filter; F4-Lancoz filter

Results and Discussion

Fig. 5.1 depicts the intensity distribution profile of the two line objects in the Gaussian focal plane (Φ_d =0) when the two line objects of equal intensity (c = 1) are separated by a distance of Z_0 = 3 dimension less diffraction units in the case of shrink aperture (peripheral obscuration parameter) with ε = 0.9, when the optical system is apodised by all the four chosen filters.

Here the apodisation parameter β being varies from 0 to 1 in increments of 0.25. The intensity distribution curves shows that that two line objects are resolved for β = 1; this shows that the higher degree of apodisation the optical system is capable of resolving the two line objects only in the case of Hanning amplitude filter. However for low degree of apodisation there is no improvement in the resolution of the optical system.

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