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Studies of PSF Intensities of Two Zone Apertures in Spherical Aberration

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Abstract: **The lateral resolution of the central peak is improved by the highest degree of the amplitude apodization parameter β. The presence of first minima with zero intensity necessary for Rayleigh criterion can be used to study two-point resolution. The point spread function of the optical system in the presence of defocus and primary, secondary and tertiary spherical aberration with Hanning and Connes amplitude filter is studied. A noted increase in the profile of the point spread function has been achieved. Employment of the Hanning and Connes amplitude pupil function under the higher degree of spherical aberration and defocusing effect helps the optical systems increases the resolution.**

Keywords: **PSF- point spread function, amplitude apodisation, primary, secondary and tertiary spherical aberration, defocus, two-zone aperture, Hanning function, Connes function, super-resolution.**

1. INTRODUCTION

The intensity around the focused fields can be totally suppressed or at least considerably reduced without increasing the dimensions of the pupil Apodization is the process for removal of secondary side-lobes or side-bands in the diffraction field also known as the point spread function (PSF) which is required for any optical system to act as super resolver. And this can be acquired by properly choosing the transmittance of the pupil function of the optical system. In the current study, the imaging characteristics of the diffracted field of rotationally symmetric optical systems with Hanning and Connes amplitude filters have been investigated in terms of the reduction of secondary side-lobes by modifying the two zone aperture with different degrees of amplitude apodization β using defocus and primary, secondary and tertiary spherical aberrations.

To study the imaging properties of the optical systems, the knowledge of the PSF is an important parameter in designing optical imaging systems. The present study provides a significant contribution to the resolution studies. 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.

2. THEORY

The point spread function is subjected to a higher degree of defocusing and primary, secondary and tertiary wave aberration effect. The current study is done to study the effect of the Hanning and Connes amplitude filter on the optical system which is under the combined influence of high Seidel aberration and maximum defect of focus. The Connes filter is placed in the inner zone and Hanning filter is placed in the outer zone of the two zone pupil of the anodized optical system.

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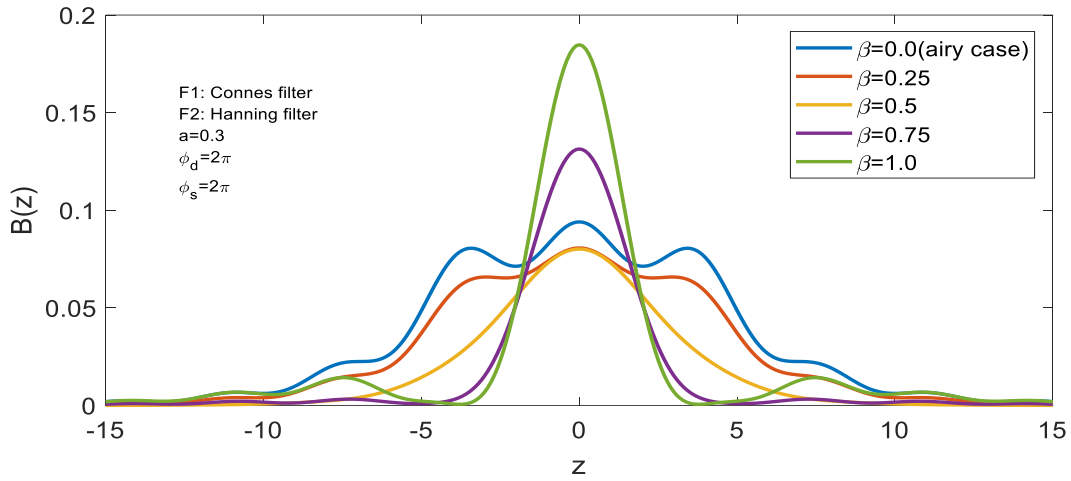

Figure 1

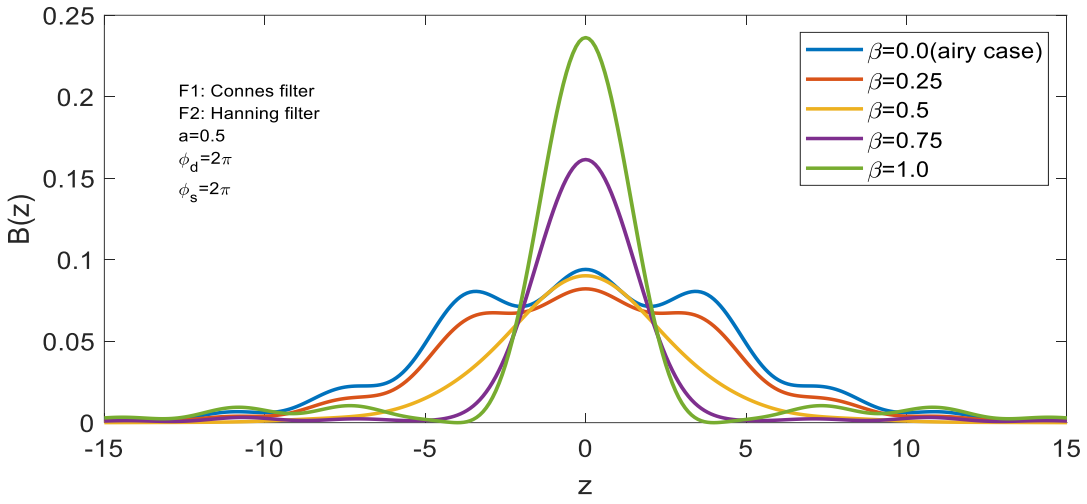

Figure 2

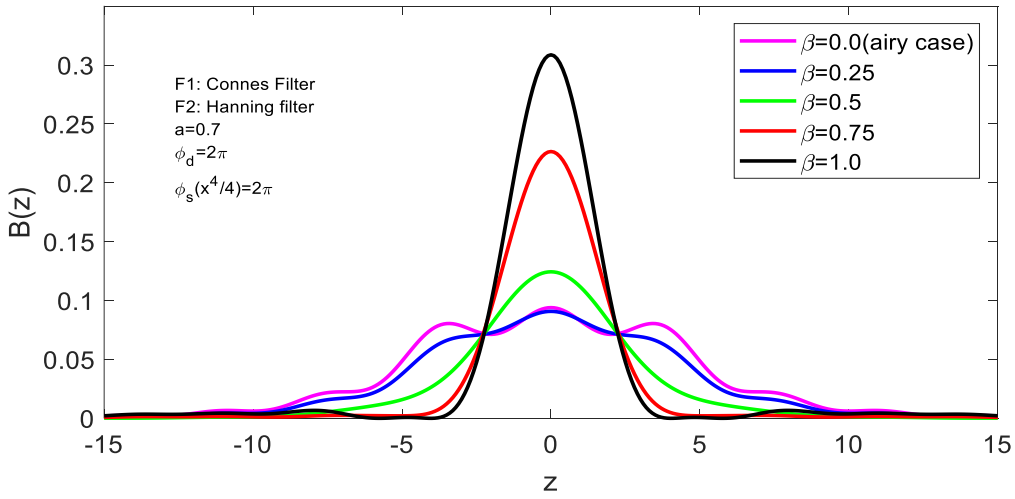

Figure 3

Fig.(1-3):Variation in the axial shape of the point spread function of two zone aperture for different degrees of Connes filter (first zone) and Hanning filter(second zone)apodization varying limits of 0.3, 0.5, 0.7.

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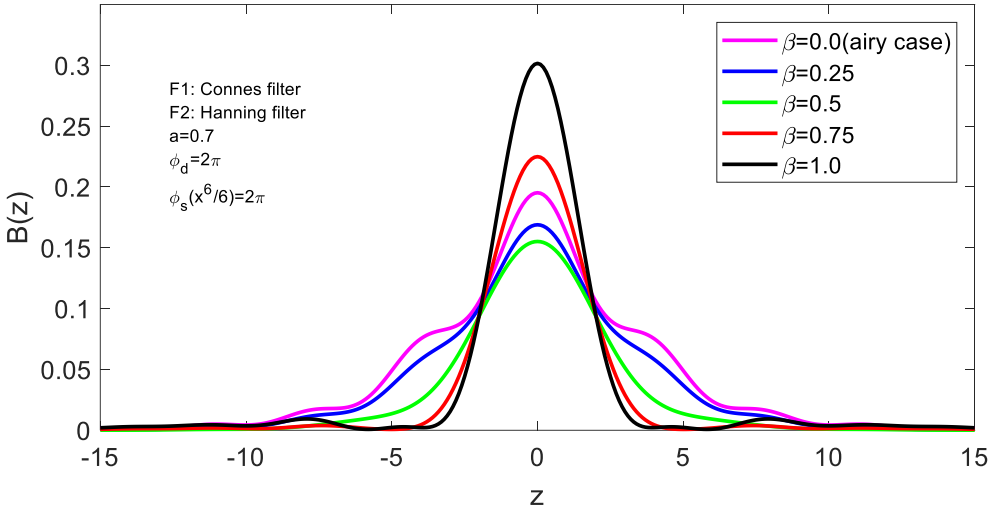

Figure 4

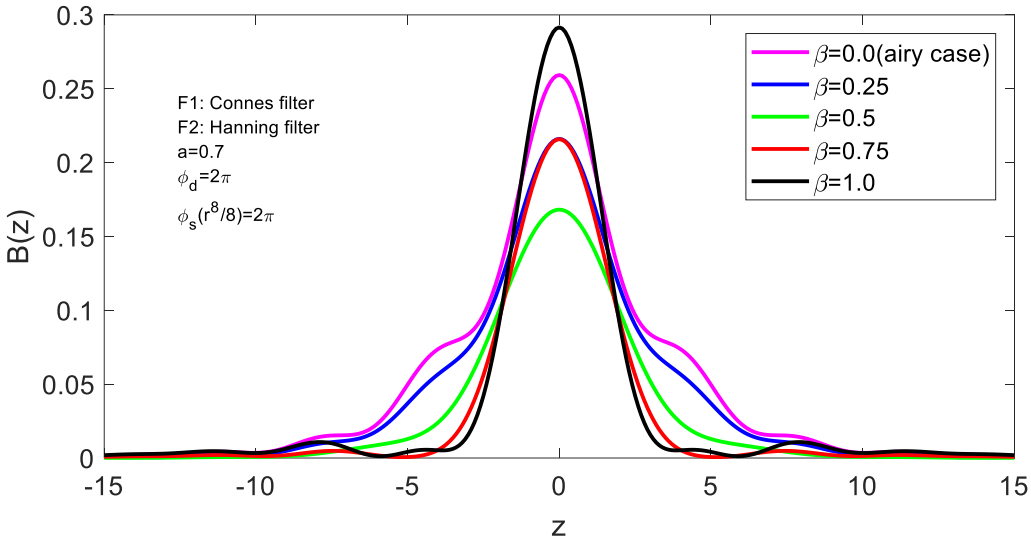

Figure 5

Fig.(4-5):Variation in the axial shape of the point spread function of two zone aperture for different degrees of Connes filter(first zone) (0-0.7)and Hanning filter(second zone) (0.7-1)apodization for primary, secondary and tertiary spherical aberration.

Table: 1

a= 0.7 φ_d =2π $\varphi_s(r^4/4)$=2π	**0**	0	0.0941	2.0177	0.0713	3.4264	0.0806	10.0073	0.0062	10.8592	0.0067
	0.2	0	0.0909	2.3067	0.0715	3.0494	0.0725	3.0494	0.0725	10.8341	0.0052
	0.4	0	0.1023	13.6941	0.0004	14.6655	0.0005	---	---	---	---
	0.6	0	0.1594	---	---	---	---	---	---	---	---
	0.8	0	0.2491	4.876	0.0011	7.5842	0.0029	9.4088	0.0016	10.9676	0.0022
	1	0	0.3087	4.0329	0	4.8212	0.0008	5.7595	0	7.9499	0.0068

Table 1: Maxima minima position and values of the point spread function of two zone aperture for different degrees of Connes filter (first zone) (0-0.7) and Hanning filter (second zone) (0.7-1) apodization for primary, secondary and tertiary spherical aberration.

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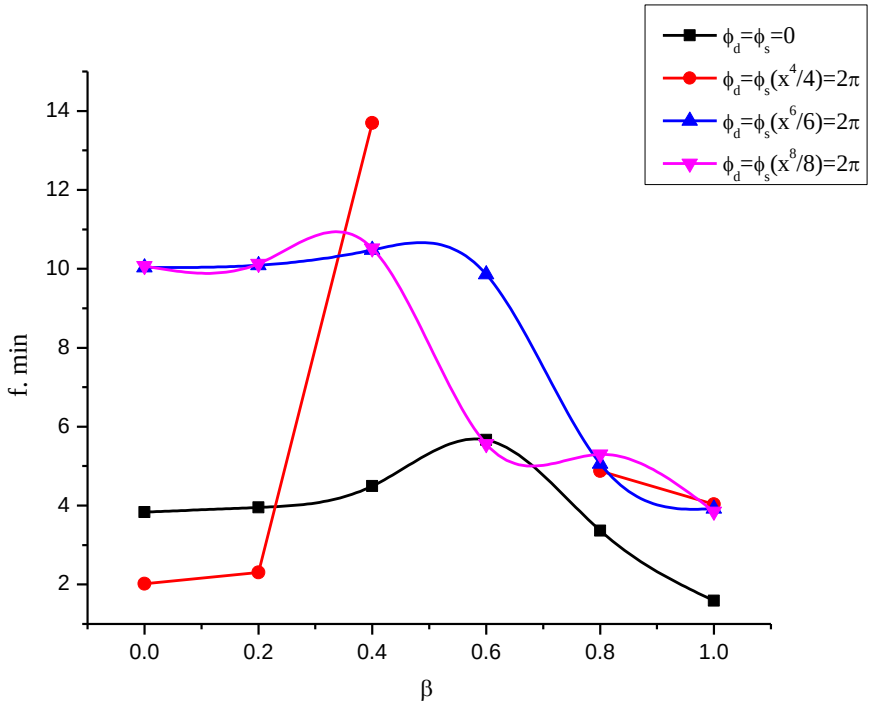
From fig.1-5 Table 1: It is observed that for β = 0 (Airy), in the presence of high degree spherical aberration ($\phi_s = 2\pi$) the peak intensity of the central maximum is decreased for the maximum out-of-focus plane ($\phi_d = 2\pi$). The Airy PSF lost its axial shape or resolution and non-zero first minima. Similar pattern results are noticed in the case of β = 0.25and β = 0.5. For β = 0.5, the main peak intensity starts to increase. Whereas for β = 0.75, the first minima and the side-lobes on the both sides of the main peak reaches to zero intensity and the intensity of the main peak is considerably improved. It helps in detection of the direct image of the faint companion in every direction around the bright companion, known as two-point resolution studies. In the presence of defocusing effect and primary spherical aberration, as the degree of apodization increases from 0.5 to1 (as shown in the Fig: **4-8**), there exists a consistent improvement in the lateral resolution of the main peak.

It is evident that for highest degree of apodization (β = 1), the central light flux exhibit maximum intensity compared to that of Airy case (β = 0) and along with zero intensity in the first minima is measured, resulting in super resolved point spread function. For the highest degree of amplitude apodization (β = 1), The FWHM of the main peak obtains lower value than any other case. Fig.6 concludes that the lateral resolution of the aberrations made PSF is technically improved by placing Connes filter in the first zone (0-0.7) and Hanning filter(0.7-1) in the second zone amplitude apodization under maximum defocus and primary spherical aberration.



3. RESULTS

On the whole it is emphasized that the two zone aperture with Connes and Hanning amplitude apodization filters has got good result in terms of the intensity for the two zone optical system under the combined influence of defocusing effect and the primary spherical aberration.

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