APERTURE SHAPING FOR TWO LINE RESOLUTION IN THE APODISED VARIABLE COHERENCE IN THE PRESENCE OF PRIMARY SPHERICAL ABERRATION

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Abstract:

Aperture is one of the most basic optical elements which are often encountered in optical systems. A plane wave diffracted by an aperture is a typical diffraction problem which has been widely treated and the propagation characteristics of a beam limited with an aperture are well revealed and understood. When the sizes of aperture are much larger than the light wavelength of the incident plane wave the scalar paraxial diffraction theory is usually useable because the scalar description of the diffracted plane wave is easy and acceptable.

Key words: *resolution, aperture, edge gradient, and coherence etc*.

1.INTRODUCTION:

The high angular resolution is only attained in one direction. Therefore, all simulations are one dimensional. The detector is a line - detector; the source is a linear luminosity distribution on the sky. The source that is used as an example in the simulation is depicted in above fig. This is the young galaxy UGC00597, as observed by the Hubble Space Telescope. The dimensions of the object are chosen to be 2 PSFs and the detector array to cover 3 PSFs. The dish diameter D = 3.5 m and a central wavelength λc = 10μm result in an angular PSF diameter of 7 μrad. The cross-section in the figure indicates the linear luminosity function that is actually used in the simulation.

The PSF size is indicated and the narrowest feature in the source is about 1/16th of this diameter. Therefore, the sampled baseline lengths will be limited to 16*D*.

The young galaxy UGC00597 (Hubble Space Telescope image). The dashed line indicates the position of the slice of the image of which the pixel values were used as linear luminosity distribution. The thick line represents this function. The angular dimension of this source was set to be twice the diffraction-limited spot size of a single telescope (indicated with a thick line), the resolution limit without interference.

2. Resolution of an imaging system

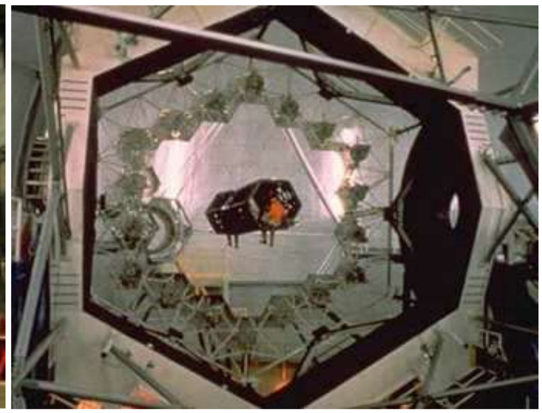
An extended stellar source can be considered to be self-luminous, meaning that it is made up of independently radiating point sources. For incoherent sources, the image that a lens system will form of them will be a distribution of partially overlapping Airy patterns. It should be stated here that this is true only for aberration-free lens systems.

Field of research related to long-baseline interferometer, but originating from a very different point of interest is the study of Multiple Aperture Optical Telescopes. These are also referred to as Multiple Mirror Telescopes or faceted telescopes.

A traditional telescope is limited to sizes of 10 meters, due to production accuracies for these sizes of optical surfaces. Atmospheric blurring also increases for larger areas of collecting surface, but that is not even considered here. For space applications, sizes of telescopes are typically limited to the size of the compartment in which they have to be transported to space. The famous Hubble Space Telescope had to fit in the Space Shuttle. Since resolution is related to the size of the primary mirror, the idea arose to build telescope primaries consisting of several separately produced parts. With production facilities of high accuracy and with the aid of computer controlled alignment while operating, Extremely Large Telescopes should be possible to build.

Fig(1) fig(2)

Fig(3)



fig(4)

Telescopes around the world. From left to right: the LBT at a construction site in Italy fig(1). four 8m telescopes of VLTI in Chile fig(2),the faceted 10m primary of one Keck telescope in Hawaii fig(3), Telescopes and lab of GI2T in France fig(4)

Currently, several multi-telescope Earth observers are being designed for space operation and the feasibility of the Over-Whelmingly Large telescope (OWL) is being studied for operation on the atmospherically favorable continent Antarctica.

The discussed spectral resolution would be a desirable observable for every resolution element. Given a detector array with a high number of sensors, even obtaining the spectral resolution element per pixel would already be interesting. However, spectral issues have not been pursued here. A discussion of retrieval of spatially variant spectra will follow after the full presentation of methods for detection and imaging. Since snapshots or measurements will have to be made along the flown path.

As a result, desired resolution can be balanced against desired observation time. If two rays of monochromatic light are combined and observed, the intensity as a function of path length difference can mathematically be described with a cosine function different terms for the coherence will have to be used to avoid confusion. Where present in an example or experiment, coherence will be mentioned as either applying to monochromatically coherent.

3. Expression for the image intensity of two lines:

The study of the capabilities of discriminating the arbitrary shapes and orientations is important for complex optical systems to evaluate their image quality. The theory of image formation where the response to signals with complex geometries is a necessity along with the classical coherent function is not fully characterized. One such case is the response of an optical system to double line images or two line images. The present section aims at deriving an expression for the intensity in the images of two such lines.

The images of two narrow lines can be considered as the superposition of the gradients of two edge response functions with a separation of 'u_o' on either side of the origin in the object plane. The simplicity in obtaining the intensity of two line objects from the combination of the squared modulus of two such edge gradients separated by 'u_o' on either side of the origin lies in the fact that the squared modulus of the gradient of the amplitude of the displaced edges was proved to give the images of two lines. The superposition these edge gradients results in the amplitude response of two lines given after the simplification, we obtain.

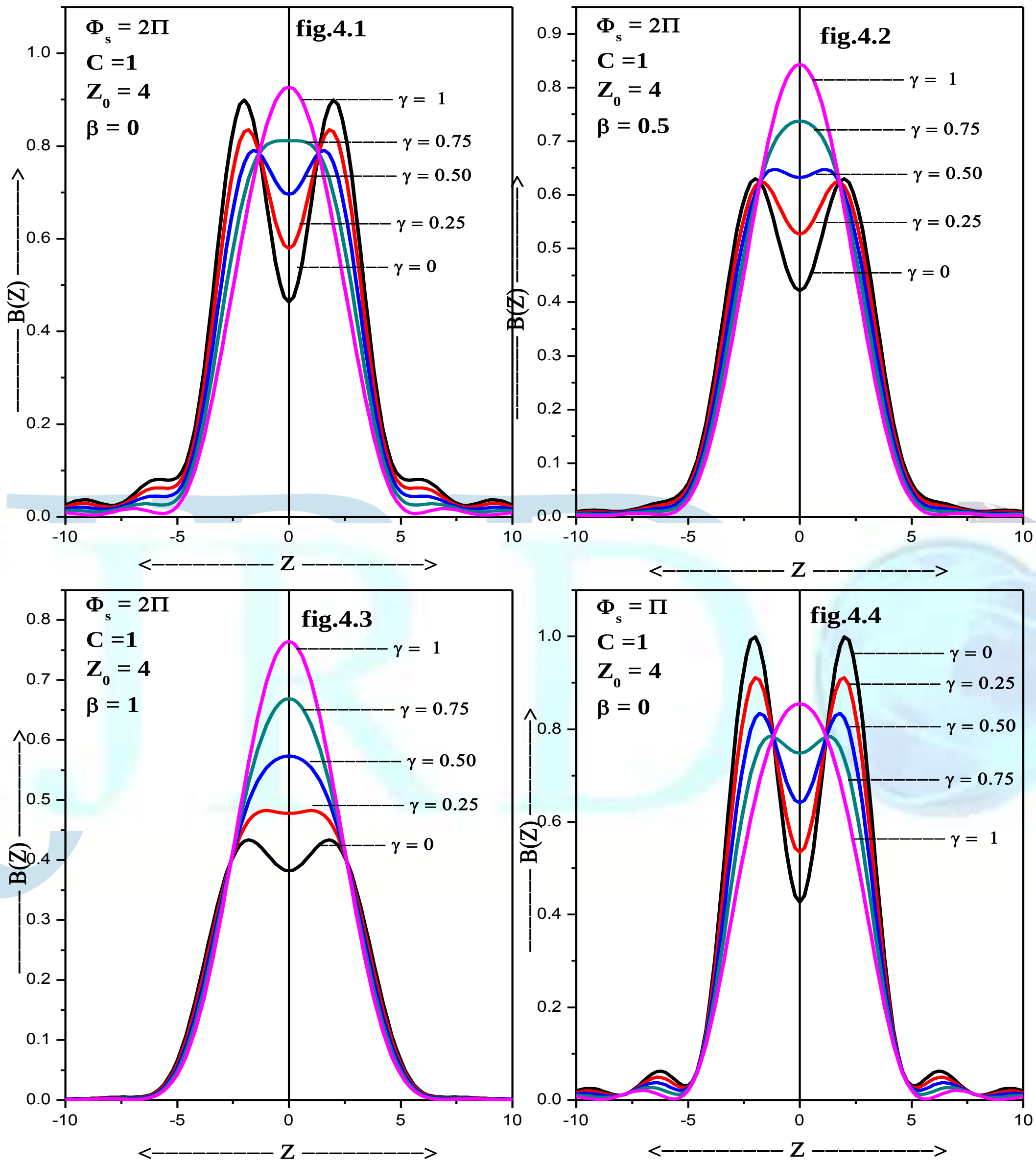
$$A_{LL}^{\square}(U\square, V\square) = 2\int_0^1 f(x,0)\, cos\{2\pi(u\square + u_0)x\}\, dx \;+\; 2\alpha \int_0^1 f(x,0) cos\,\{2\pi(u\square - u_0)x\}\, dx \text{--- (1)}$$

Where $A_{LL}^{\square}(U\square, V\square)$ is the amplitude response of the two lines. The squared modulus of equation (1) will result in the intensity distributions $B_{LL}^{\square}(U\square, V\square)$ in the image of the two lines. Thus,

$$B_{LL}^{\square}(U\square, V\square) = \left| 2\int_0^1 f(x,0)\, cos\{2\pi(u\square + u_0)x\}\, dx \;+\; 2\alpha \int_0^1 f(x,0) cos\,\{2\pi(u\square - u_0)x\}\, dx \right|^2$$

-------- (2)

Study of coherent optical systems has been in progress extensively in many imaging situations due to their narrow spectral width and high degree of collimation of the source. With the advantages it has, coherent imagery also leads to certain undesirable aspects such as in the image edge objects The concept of image formation is best illustrated mathematically in the following schematic representation of the image formation to be applied for obtaining the expressions of various objects. In the imaging situations encountered in optics the objects are in two dimensions.


Φs = 2Π
C =1
Z0 = 4
β = 0
fig.4.1
γ = 1
γ = 0.75
γ = 0.50
γ = 0.25
γ = 0
B(Z)
Z
Φs = 2Π
C =1
Z0 = 4
β = 0.5
fig.4.2
γ = 1
γ = 0.75
γ = 0.50
γ = 0.25
γ = 0
B(Z)
Z
Φs = 2Π
C =1
Z0 = 4
β = 1
fig.4.3
γ = 1
γ = 0.75
γ = 0.50
γ = 0.25
γ = 0
B(Z)
Z
Φs = Π
C =1
Z0 = 4
β = 0
fig.4.4
γ = 0
γ = 0.25
γ = 0.50
γ = 0.75
γ = 1
B(Z)
Z

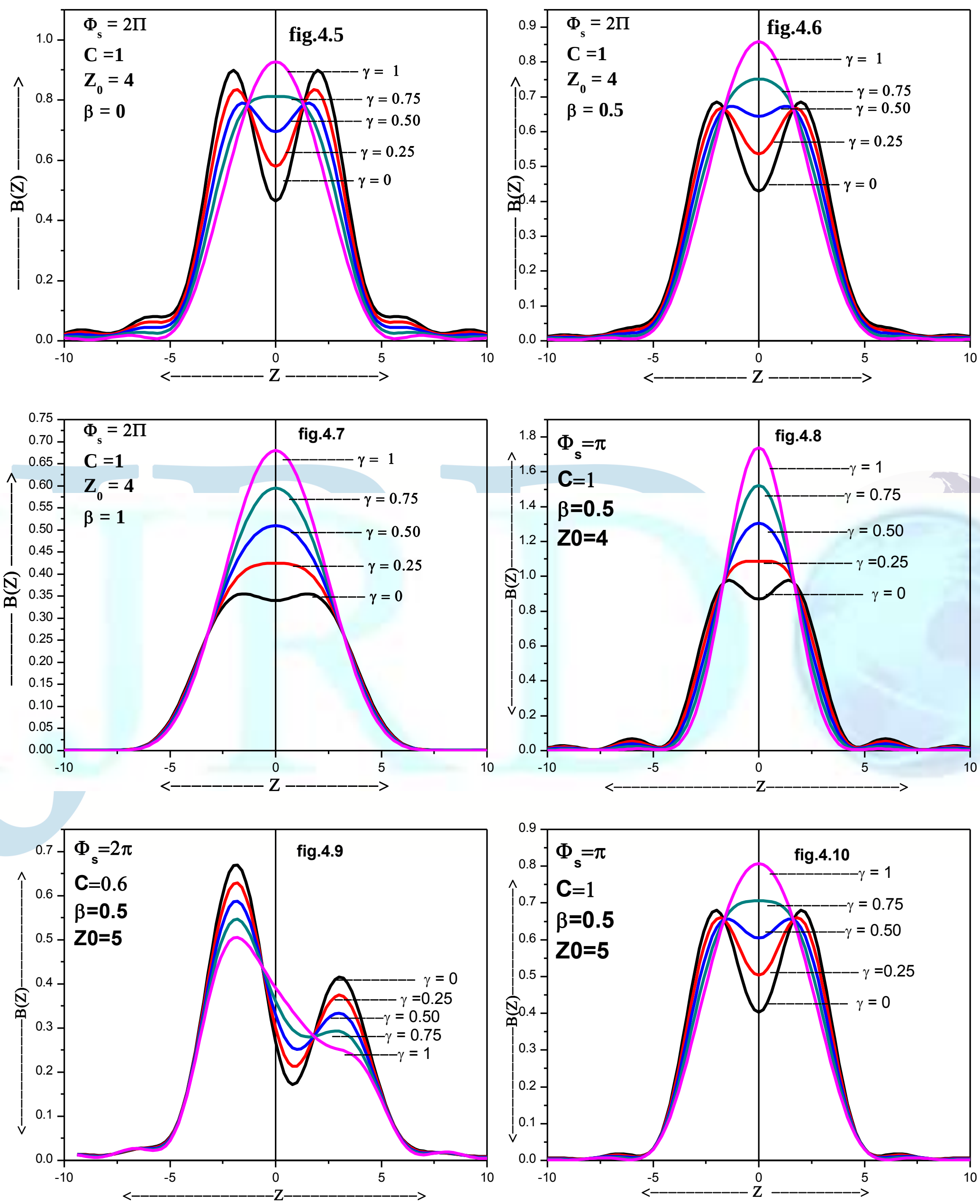


fig.4.5
Φs = 2Π
C =1
Z0 = 4
β = 0
γ = 1
γ = 0.75
γ = 0.50
γ = 0.25
γ = 0
B(Z)
Z
fig.4.6
Φs = 2Π
C =1
Z0 = 4
β = 0.5
γ = 1
γ = 0.75
γ = 0.50
γ = 0.25
γ = 0
B(Z)
Z
fig.4.7
Φs = 2Π
C =1
Z0 = 4
β = 1
γ = 1
γ = 0.75
γ = 0.50
γ = 0.25
γ = 0
B(Z)
Z
fig.4.8
Φs=π
C=1
β=0.5
Z0=4
γ = 1
γ = 0.75
γ = 0.50
γ =0.25
γ = 0
B(Z)
Z
fig.4.9
Φs=2π
C=0.6
β=0.5
Z0=5
γ = 0
γ =0.25
γ = 0.50
γ = 0.75
γ = 1
B(Z)
Z
fig.4.10
Φs=π
C=1
β=0.5
Z0=5
γ = 1
γ = 0.75
γ = 0.50
γ =0.25
γ = 0
B(Z)
Z

4.RESULTS AND DISCUSSIONS:

For the aperture shading the filter (1-βr^2).is applied to the optical system for the primary spherical aberration and for the two bright lines free from apodisation the resolution is started at partially incoherence which is depicted in fig (4.1). For the same situation the optical system is suffering with the partially apodised then we get the clear resolution for partially incoherence for the circular apertures. Which is depicted in the fig (4.2) In fig (4.3) for the optical system which is fully apodised if β=1 for the aperture shading (1-βr^2) for the circular apertures we get the clear resolution for the two bright image lines for only at incoherence.

When the optical system the shaded aperture sin ($\pi\beta$r)/ ($\pi\beta$r) is applied when the aberration free and the two bright line objects are kept at distance Z0=4 and they are under the primary spherical aberration at $\Phi s = \pi$ the resolution started at partially coherence $\gamma = 0.5$ and which is depicted in fig (4.4). For the shading of the aperture the optical system is under the filter sin ($\pi\beta$r)/ ($\pi\beta$r) the fig (4.5) depicts a clear resolution for the two lines which are separated by distance Z0=4 and which is free from apodisation i.e. $\beta = 0$ and completes under the primary spherical apodisation $\Phi s = 2\pi$ with the increased value of the coherence from $\gamma = 0$ to γ =1 with the increment of 0.25 we got the resolution at $\gamma = 0.75$ for the circular aperture.

In fig (4.6) for the same situation as at the optical system is under partially apodisation we got the better resolvement for coherence at γ = 1.As the apodisation increases i.e. $\beta = 1$ high apodisation the resolution started from the beginning of the incoherence and the values are incremented by 0.25 which is showed in the fig(4.7) In fig (4.8) when the optical system is under the partially incoherent and suffering with the primary spherical apodisation the two bright lines are best resolved at γ =0 i.e. at incoherence.

The fig (4.9) the primary spherical apodisation $\Phi s = 2\pi$ is applied to the optical system and the two bright image lines are separated at a distance Z0 = 5 and the intensity lines are at the ratio c=0.6 for a given circular aperture the first maxima falls on the second minimum of the resolved lines then we got a clear resolution increasing value of the coherence. In fig (4.10) as the intensity ratio is kept at c=1 and the optical system is at primary spherical aberration $\Phi s = \pi$ the two bright lines are best resolved at partially incoherence to coherence i.e. $\gamma = 0.5$ to $\gamma = 1$.

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