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Fringe localization

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The technique for locating the region of fringe localization for an interferometer used with a spatially incoherent source is well known. For each light ray going into an interferometer, two or more rays will emerge. The fringes are localized in the region where these emerging rays derived from a single input ray intersect. The proof most often given for the above result involves a large amount of geometry and algebra.[1,2] The purpose of this short Letter is to point out that the proof follows directly from the van Cittert-Zernike theorem.

The van Cittert-Zernike theorem[3] states that for a quasi-monochromatic spatially incoherent source, the magnitude of the degree of spatial coherence $|\mu_s|$ between two points $P(x_1,y_1)$ and $P(x_2,y_2)$ is given by the magnitude of the normalized Fourier transform of the intensity distribution of the source. That is,

$$|\mu_s| = \left| \frac{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} I(x',y') \exp i\left\{\frac{2\pi}{\bar{\lambda}}[\theta_x x' + \theta_y y']\right\} dx'dy'}{\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} I(x',y')dx'dy'} \right| , \quad (1)$$

where $I(x',y')$ is the intensity distribution of the source, $\theta_x = (x_2 - x_1)/R$, and $\theta_y = (y_2 - y_1)/R$. x_1, y_1, x_2, y_2, and R are illustrated in Fig. 1. In arriving at Eq. (1) it is assumed that the separation R is much greater than both the extent of the source and $[(x_2 - x_1)^2 + (y_2 - y_1)^2]^{1/2}$.

It can be easily shown that the magnitude of the coherence function is a maximum when $\theta_x = \theta_y = 0$.[4] If in an interferometer the light at P_1 is interfered with the light at P_2, the fringe visibility is equal to the value of $|\mu s|$ given by Eq. (1). Since for maximum fringe visibility $\theta_x = \theta_y = 0$, the fringe viewing surface for an interferometer should be the surface that is the locus of points of intersection of the rays which originate from one incident ray coming from the source. That is, for maximum fringe visibility, light propagating in the direction of a single ray should interfere with itself. If this surface for ray intersection depends upon the particular ray coming from the source, there may be no region for which good visibility fringes exist. However, if the surface does not depend upon the ray selected, good visibility fringes will exist if the fringes are observed on a surface conjugate to this ray intersection surface.

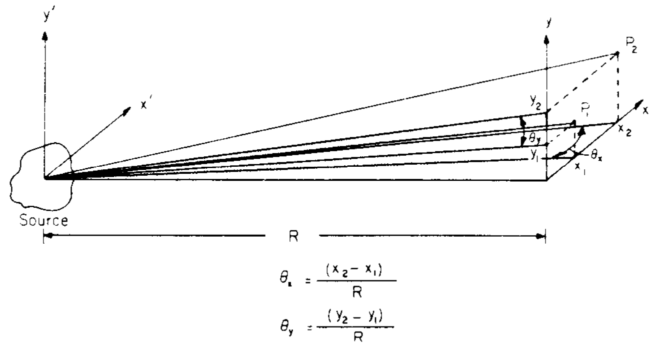

Fig. 1. Illustrating the van Cittert-Zernike theorem.

References

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3. R. J. Collier, L. Burckhardt, and L. Lin, *Optical Holography* (Academic, New York, 1971), p. 140.
4. J. D. Gaskill, *Linear Systems, Fourier Transforms and Optics* (Wiley, New York, 1978), p. 174.