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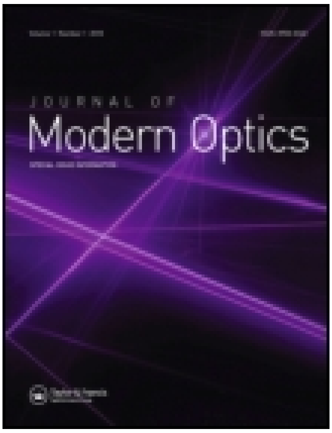

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Correlation of speckle due to partially coherent light

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Abstract. It is shown that under certain conditions the speckle due to transillumination of a diffuser under partially space coherent light recorded in two neighbouring planes remains correlated.

1. Introduction

Photographs of diffusely reflecting surfaces illuminated with coherent laser light consist of randomly distributed, highly contrasted speckles. The relation between the speckle contrasts generated in two neighbouring planes has been studied by many authors [1–8]. A correlation exists between these speckle patterns because one of the speckle patterns is radially displaced with respect to the other by an amount proportional to the radius of the diffuser; there is also dependency on the aperture of the imaging system and the distance between the two planes. It has been shown by Dzialowski and May [9] that when the object is transilluminated by a laser point source, there exists a plane with no decorrelation and which is not affected by magnification effects, whatever the angular size of the object (or aperture of the optical system). This correlation property of speckles was successfully exploited by Françon and co-workers [5, 6, 8] in their work in optical information processing.

It is now well known that speckle can also be generated with partially coherent light and that the properties of such patterns are less straight forward than those which are generated by perfectly coherent illumination [10, 11].

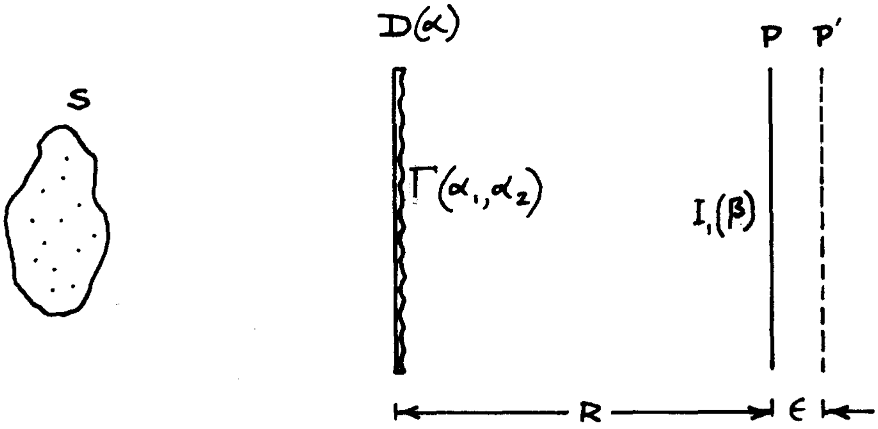
The purpose of this paper is to show that even when the object is transilluminated with partially coherent light, under certain conditions similar to those of the coherent case [7, 8], there exists a correlation between the speckles recorded in two neighbouring planes.

2. Theory

For mathematical simplicity we consider only a one-dimensional case. In the figure the ground glass D(α) is illuminated by a partially space coherent light source S. The mutual intensity function at the object plane is then given by $\Gamma(\alpha_1, \alpha_2)$.

Following Hopkins [12], we may write the mutual intensity function at the plane in which photographic plate is located as

$$\Gamma_1(\beta_1-\beta_2)=\iint \Gamma(\alpha_1,\alpha_2)D(\alpha_1)D^*(\alpha_2) \times \exp\left[\frac{ik}{2R}\{(\alpha_1-\beta_1)^2-(\alpha_2-\beta_2)^2\}\right] d\alpha_1\, d\alpha_2 \ldots, \qquad (1)$$



D is illuminated by a partially space coherent light source, S, and the resulting speckle is observed at P and P′ before and after translation of the photographic plate, respectively.

where $k = 2\pi/\lambda$, λ being the wavelength of light used and R the distance between the diffuser and the photographic plate.

The only observable parameter at this plane is the intensity which can be obtained from $\Gamma(\beta_1 - \beta_2)$ by letting $\beta_1 = \beta_2 = \beta$. Therefore the intensity $I_1(\beta)$ is given by

$$I_1(\beta) = \iint \Gamma(\alpha_1, \alpha_2) D(\alpha_1) D^*(\alpha_2) \exp\left[\frac{ik}{2R}(\alpha_1^2 - \alpha_2^2)\right] \times \exp\left[-\frac{ik}{2R}\beta(\alpha_1 - \alpha_2)\right] d\alpha_1\, d\alpha_2 \ldots . \quad (2)$$

If the photographic plate is axially translated by a distance ε (see the figure) the intensity function on the photographic plate becomes

$$I_2(\beta) = \iint \Gamma(\alpha_1, \alpha_2) D(\alpha_1) D^*(\alpha_2) \exp\left[\frac{ik}{2(R+\varepsilon)}(\alpha_1^2 - \alpha_2^2)\right] \times \exp\left[-\frac{ik}{(R+\varepsilon)}\beta(\alpha_1 - \alpha_2)\right] d\alpha_1\, d\alpha_2 \ldots . \quad (3)$$

If we assume that ε is small enough so that $1/(R+\varepsilon)$ can be written as

$$\frac{1}{(R+\varepsilon)} = \frac{1}{R}\left(1 - \frac{\varepsilon}{R}\right),$$

then under these conditions, we have

$$I_2(\beta) = \iint \Gamma(\alpha_1, \alpha_2) D(\alpha_1) D^*(\alpha_2) \exp\left[\frac{ik}{2R}\left(1 - \frac{\varepsilon}{R}\right)(\alpha_1^2 - \alpha_2^2)\right] \times \exp\left[-\frac{ik}{2R}\left(1 - \frac{\varepsilon}{R}\right)(\alpha_1 - \alpha_2)\beta\right] d\alpha_1\, d\alpha_2 \ldots . \quad (4)$$

It can be seen that $I_1(\beta)$ and $I_2(\beta)$ are homothetic in the ratio $(1-\varepsilon R^{-1})$. except for a decorrelation term $\exp[-ik\varepsilon(\alpha_1^2-\alpha_2^2)/2R^2]$ which appears in equation (4). This decorrelation term is similar to the one appearing in [7].

We can neglect this decorrelation term provided it obeys the inequality

$$b^2\varepsilon/R^2 \ll \lambda,$$

where $2b$ is the diameter of the diffuser. However, under this condition it is seen that each speckle recorded in the first exposure undergoes a radial displacement equal to $\varepsilon\rho/R$, where ρ is the radius of the speckle, and thus there exists a simple effect of magnification between the neighbouring planes separated by ε [7–8]. Hence the two speckles are related to each other by a radial magnification and remain correlated. On illuminating the processed photograph plate with a parallel beam, these speckles give rise to a ring system [2–4, 7, 8] following Newton's theorem.

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References

[1] Eliasson, B., and Mottier, F. M., 1971, *J. opt. Soc. Am.*, **61,** 5559.
[2] Mendez, J. A., and Roblin, M. L., 1974, *Optics Commun.*, **11,** 245.
[3] Archbold, E., and Ennos, A. E., 1972, *Optica Acta*, **19,** 253.
[4] Archbold, E., Burch, J. M., and Ennos, A. E., 1970, *Optica Acta*, **17,** 883.
[5] Fraçon, M., 1973, *Optica Acta*, **20,** 1.
[6] May, M., and Fraçon, M., 1976, *J. opt. Soc. Am.*, **66,** 1275.
[7] Mendez, J. A., and Roblin, M. L., 1974, *Optics Commun.*, **11,** 245.
[8] Fraçon, M., 1975, *Laser Speckle and Related Phenomena*, edited by J. C. Dainty (Berlin, Heidelberg, New York: Springer-Verlag), p. 179.
[9] Dzialowaski, Y., and May, M., 1976, *Optics Commun.*, **16,** 334.
[10] Parry, G., 1975, *Laser Speckle and Related Phenomena*, edited by J. C. Dainty (Berlin, Heidelberg, New York: Springer-Verlag), p. 77.
[11] Dainty, J. C., 1976, *Progress in Optics*, Vol. XIV, edited by E. Wolf (Amsterdam: North-Holland), p. 1.
[12] Hopkins, H. H., 1951, *Proc. R. Soc.* A, **208,** 263.