Chapter 4

Holographic Optical Elements based Two Channel Interferometer

4.1 Introduction

Most of the interferometers generally perform optical test studies on a single phase object at a time; therefore these are not suitable for comparative studies [1,2]. For comparative studies holographic interferometry is commonly employed [3-5] but is limited to compare two objects in real time. A multi-channel optical interferometer [6,7] for the study of many phase objects simultaneously has been reported recently. This waveguide structured interferometer, is however suitable only for testing microstructure phase objects and not for the macro-structure objects. In this chapter, a simple and cost effective method for making a compact and versatile holographic optical elements based two-channel interferometer, which is suitable for performing optical test studies of two different macro size phase (transparent) objects simultaneously and independently, has been presented [8]. The proposed interferometer set-up has utility for comparative test studies between two different phase objects in real time and may be useful in the studies of refractive index, wavefront measurements, thermal profiling, combustion, plasma diagnostics, atmospheric turbulence and flow visualization etc. The effect of misalignment of holographic optical elements on the interferograms has also been analyzed.

4.2 Holographic optical elements based two channel interferometer

The method reported for making a two-channel interferometer is based on the formation of multiple holographic optical elements on two different recording plates in two recording steps. The first recording step involves the formation of two spatially separated holographic optical elements (H11 and H12) on same recording plate H1. The H11 and H12 are formed by using two different sets of collimated beams, O1 with O2 and O3 with O4 respectively, in conjunction with a common collimated beam R (Fig.4.1).
The plate $H_1$, containing these two permanently recorded HOEs, upon illumination with a single collimated beam $R$ provides four inbuilt collimating beams $O'_1, O'_2, O'_3$ and $O'_4$ for subsequent recording. In the second recording step, the inbuilt collimated beam pairs $O'_1$ with $O'_3$ and $O'_2$ with $O'_4$ (generated from $H_1$) are used for the formation of two spatially separated holographic optical elements $H_{21}$ and $H_{22}$ on the second recording plate $H_2$ (Fig.4.2).

After processing, $H_2$ is repositioned at the same location at which it was recorded. These holographic plates $H_1$ and $H_2$ when placed in this configuration and illuminated with a single collimated beam $R$ serves as a versatile two-channel interferometer (Fig. 4.3). Here $H_1$
upon illumination with R provides four illuminating beams, $O'$ and $O''$ from $H_{11}$ and $O'$ and $O''$ from $H_{12}$ for $H_2$. In this case, the so generated beams $O'$ and $O'$ illuminate $H_{21}$ and similarly $O'$ and $O'$ illuminate $H_{22}$. The illuminating beams $O'$ and $O'$ on $H_{21}$ further provide undiffracted-order beam $O'$ and diffracted-order beam $O''$ (due to beam $O'$) overlapping each other and also undiffracted-order beam $O'$ and diffracted-order beam $O''$ (due to beam $O'$) overlapping each other at two separate locations. Similarly at $H_{22}$, the illuminating beams $O'$ and $O'$ further provide undiffracted-order beam $O'$ and diffracted-order beam $O''$ (due to beam $O'$) which are overlapping each other and also undiffracted-order beam $O'$ and diffracted-order beam $O''$ overlapping each other at two separate locations. This results in the generation of four different interferograms at separate locations in the observation plane OP, which can be viewed on a screen or with a video camera.

![Fig. 4.3: HOE base two channel interferometer](image)

Here $O_1$, $O_2$, $O_3$, $O_4$, $O'$, $O''$, $O'$, $O''$, $O'$, $O''$, $O'$, $O''$ and $R$ are the complex amplitude distribution of the respective wavefronts. For simplicity, it is assumed that the holographic plates are developed in the linear region of the transmittance Vs exposure curve. The amplitude transmittance of the processed $H_1$ [9] is given by

$$t_1 \sim k \left[ |O_1 + O_2 + R|^2 + |O_3 + O_4 + R|^2 \right]$$

(4.1)

where $k$ is a parameter dependent on the recording material used, exposure and the processing conditions. For forming two spatially separated $H_{21}$ and $H_{22}$ on another recording plate $H_2$, the $H_1$ is illuminated only with a single collimated beam $R$ (as was used in the first recording step). The complex amplitude of the transmitted field from $H_1$ is
U_1 = R \, t_1 \\
\approx k \left[ R \left( |O_1|^2 + |O_2|^2 + |R|^2 + O_1^* O_2 + O_1^* R + O_2^* O_1 + R O_2^* + O_1 R^* + O_2 R^* \right) \right. \\
+ \left. |O_3|^2 + |O_4|^2 + |R|^2 + O_4 O_3^* + R O_3^* + O_3 O_4^* + R O_4^* + O_3 R^* + O_4 R^* \right] \right] \quad (4.2)

It may be noted that the H_{11} and H_{12} are spatially separated and are recorded on a holographic recording plate H_{1} in the form of holographic gratings. On the right hand side of Eq. 4.2 the first three terms [i.e. kR \left( |O_1|^2 + |O_2|^2 + |R|^2 \right)] represent the un-diffracted beam and the 4th to 9th terms represent the diffracted beams from H_{11}. In a similar manner, 10th to 12th terms [i.e. kR \left( |O_3|^2 + |O_4|^2 + |R|^2 \right)] represent the un-diffracted beam and 13th to 18th terms represent the diffracted beams from H_{12}. All these beams are spatially separated from each other. Here |R|^2 can be considered constant across the plate H_{1}, as a plane beam R is used for the illumination of H_{1}. Thus, only the 8th, 9th, 17th and 18th terms on the right hand side of Eq. 4.2 are of interest to us as they represent the diffracted-order beams O_1' and O_2' generated from H_{11}; O_3' and O_4' generated from H_{12} respectively. Here O_1', O_2', O_3' and O_4' are identical to the original respective beams O_1, O_2, O_3 and O_4 as they possess all the properties of these and can be considered to be as replica of the original beams and can be represented as

kO_1|R|^2 + kO_2|R|^2 + kO_3|R|^2 + kO_4|R|^2 \approx O_1' + O_2' + O_3' + O_4' \quad (4.3)

The so generated beams O_1', O_2', O_3' and O_4' are further used for forming two spatially separated HOEs on another recording plate H_2 in the second recording step (Fig. 4.2). After processing, H_2 is repositioned at the same location at which it was recorded. By using a similar analysis as followed for H_{1}, the amplitude transmittance of the processed H_2 is

\begin{align*}
\dot{t}_2 & \approx k \left[ |O_1' + O_1|^2 + |O_2' + O_4|^2 \right] \quad (4.4)
\end{align*}

In this configuration, when H_{1} is illuminated with a collimated beam R, it provides four illuminating beams O_1', O_2', O_3' and O_4' for H_2 such that O_1' and O_3' illuminate H_{21} and O_2' and O_4' illuminate H_{22} respectively. The complex amplitude of the transmitted field from H_2 is given by

\begin{align*}
U_2 = & \left( O_1' + O_3' \right) \left[ k \left( |O_1'|^2 + |O_3'|^2 \right) + \left( O_2' + O_4' \right) \left[ k \left( |O_2'|^2 + |O_4'|^2 \right) \right] \right] \\
\approx & k \left[ |O_1'|^2 + |O_3'|^2 \right] + O_3'O_1^* + O_3'O_1^* + O_3'O_3^* + O_3'O_3^* + O_3'O_5^* + O_3'O_5^* + O_3'O_5^* + O_3'O_5^* \\
& + O_5'O_1^* + O_5'O_1^* + O_5'O_3^* + O_5'O_3^* + O_5'O_3^* + O_5'O_3^* + O_5'O_3^* + O_5'O_3^* \\
& \quad + O_5'O_5^* + O_5'O_5^* + O_5'O_5^* + O_5'O_5^* + O_5'O_5^* + O_5'O_5^* + O_5'O_5^* + O_5'O_5^* \right] \quad (4.5)
\end{align*}
On right hand side of Eq. 4.5, the first term represents the undiffracted-order beam $O'_1$ and the sixth term represents the diffracted-order beam $O''_3 = O'_3 k|O'_1|^2 \approx O'_1$ (due to beam $O'_3$) and superimposes the above undiffracted-order beam $O'_1$. The second term represents the diffracted-order beam $O''_3 = O'_3 k|O'_1|^2 \approx O'_1$ (due to beam $O'_1$) and the fourth term represents the undiffracted-order beam $O'_3$ and superimposes with the above diffracted-order beam $O''_3$. These spatially separated superimposed beam pairs generated from $H_{21}$ thus provide two different interferograms at two separate locations in the observation plane $OP$. Similarly, the $7^{th}$ term represents the undiffracted-order beam $O'_2$ and the $12^{th}$ term represents the diffracted-order beam $O''_2 = O'_2 k|O'_4|^2 \approx O'_2$ (due to beam $O'_4$) and superimposes the above undiffracted-order beam $O'_2$. The $8^{th}$ term represents the diffracted-order beam $O''_4 = O'_4 k|O'_5|^2 \approx O'_4$ (due to beam $O'_5$) and the tenth term represents the undiffracted beam $O'_4$ and superimposes the above diffracted beam $O''_4$. These spatially separated superimposed beam pairs generated from $H_{22}$ thus also provide two different interferograms at separate locations in the observation plane $OP$. These four interferograms generated in the observation plane $OP$ are spatially separated from each other. By applying a simple alignment procedure in repositioning of $H_2$ results in infinite-fringe (i.e. zero fringe) interferograms (Fig. 4.4) in the observation plane.

![Image](image.png)  

**(a)**  

**(b)**  

**Fig. 4.4: Infinite fringe interferogram in the both channel**

In this configuration, the portion of beams $O'_1$ and $O'_4$ generated between $H_1$ and $H_2$ can be used as two separate test arms for performing optical test studies on two different phase objects simultaneously. Typically, if a phase object $S = \exp[i\phi_1]$ is introduced in the first test arm $O'_1$ and a second phase object $P = \exp[i\phi_2]$ is introduced in the second test arm $O'_4$, then the complex amplitude of the transmitted field from $H_2$ is given by...
U₃ = (O'₁ S + O'₃) k [ |O'₁|^² + |O'₃|^2] + (O'₂ + O'₄P) k [ |O'₂|^² + |O'₄|^²]
≈ k [O'₁ S (|O'₁|^2 + |O'₃|^2) + O'₃ S |O'₁|^2 + O'₁ S O'₃ S + O'₃ (|O'₁|^2 + |O'₃|^2) + O'₃ O'₁] + O'₁ S O'₃
+ O'₃ S (|O'₁|^2 + |O'₃|^2) + O'₄ (|O'₂|^2 + |O'₄|^2) + O'₄ O'₂^2 + O'₄ P (|O'₂|^2 + |O'₄|^2) + P O'₄ O'₂^2
+ O'₂ P |O'₄|^2]  \quad (4.6)

On the right hand side of Eq. 4.6, the 1st term represents the undiffracted-order beam O'₁ (containing information about phase object S) and the 6th term represent the diffracted beam O''₃ (generated due to O'₃ illuminating beam). Similarly, the 10th term represents the undiffracted beam O'₄ (containing information about phase object P) and the 8th term represents the diffracted beam O''₄ (generated due to O'₂ illuminating beam). Here, the beams O'₁ and O''₃ generated from H₂₁ superimpose each other and similarly the beams O'₄, and O''₄ generated from H₂₂ also superimpose each other and generate two different interferograms at separate locations in the observation plane. It may be noted that by following a similar procedure, two more spatially separated interferograms (due to O'₁ and O'₃ overlapping beams generated from H₂₁ and also due to O'₂ and O'₄ overlapping beams generated from H₂₂) will be formed in the observation plane. For the sake of simplicity only the upper two interferograms are considered so as to explain the working phenomena. Thus due to above, the complex amplitude distribution for the H₂ is

U₄ ≈ k [O'₁ S (|O'₁|^² + |O'₃|^²) + O'₄ |O'₃|^²] + k [O'₄ P (|O'₂|^² + |O'₄|^²) + O'₄ |O'₂|^²] \quad (4.7)

The intensity distribution, due to these interference patterns, in the observation plane is

Iᵣ = I₁ + I₂
≈ [k² |O'₁ S|^² (|O'₁|^² + |O'₃|^²)^²] + k² |O'₁|^² |O'₄|^² + k² |O'₃|^² |O'₃|^² (S + S*) \quad (4.8)
+ [k² |O'₄ P|^² (|O'₂|^² + |O'₄|^²)^²] + k² |O'₄|^² |O'₂|^² (P + P*)
Iᵣ ≈ A + B \cos \phi₁ + C + D \cos \phi₂

where A, B, C and D are constants. It is thus seen that the intensity distribution of the interference patterns, recorded in the observation plane, depends only on the phase variation introduced by the phase objects S and P into the respective test beams O'₁ and O'₄ between H₁ and H₂.
In these studies, initially a burning candle was inserted in one of the test arm and no phase object was inserted in the other test arm. Typical interference patterns of heat flow caused by inserting a burning candle in one of the test arm and without inserting any phase object in the other test arm are shown in Fig. 4.5. It is seen from Fig. 4.5 that both the interferograms are independent of each other and any perturbation caused in any one of the test arms does not have any effect on the other test arm. Further studies are performed by inserting two different phase objects simultaneously and independently in both the test arms. Figure 4.6 shows typical interference patterns, in real time, obtained due to a burning candle in one of the test arm and a glass plate in the other test arm simultaneously and independently.

![Fig. 4.5: (a) Interference pattern of heat flow due to a burning candle in one channel while (b) second channel is without any object](image1)

![Fig. 4.6: Interference pattern of (a) heat flow due to a burning candle in one channel and (b) a glass plate in the second channel](image2)
Though in the above scheme both interferograms are separate to each other but they cannot be operated independently and also it requires number of collimating optics to form a compound HOE $H_1$. These difficulties can be removed by replacing $H_1$ with two diffraction gratings (Fig. 4.7) [10]. The gratings $G_1$ and $G_2$ upon illumination, with a collimated beam (consisting of two collimated beams $O_1$ and $O_2$ respectively) generates several diffracted order beams, of which undiffracted beam from $G_1$ (labeled as $O_{10}$) is used in conjunction with the +1st order diffracted beam from $G_2$ (labeled as $O_{21}$) to form HOE $H_{21}$ and -1st order diffracted beam from $G_1$ (labeled as $O_{1,-1}$) is used in conjunction with the undiffracted beam from $G_2$ (labeled as $O_{20}$) to form HOE $H_{22}$ on the same recording plate $H$. After processing $H$ is repositioned and $G_1$, $G_2$ are illuminated with beams $O_1$ and $O_2$ respectively, the configuration serves as versatile dual channel interferometer where both the interferograms can be operated independently and simultaneously.

![Fig.4.7: HOE base two channel interferometer](image)

In order to realize these interferometric set-ups, the processed HOEs are required to be repositioned at the same location at which these are formed. A slight misalignment in any of the HOE results in finite fringe interferograms in the observation plane. The effect of misalignment [11-13] in either of the HOEs, which results in finite fringe interferograms in the observation plane, is analyzed.

### 4.3 Alignment sensitivity

For simplicity, the effect of misalignment of one holographic optical element (say $H_{21}$) on $H_2$ is considered (Fig. 4.3). In this case, the interferogram gets formed due to
superposition of undiffracted-order beam $O'_1$ and diffracted-order beam $O''_1 \approx O'_1$ (generated due to beam $O'_3$) can be represented as

$$U \sim A^2 \psi O'_1$$

where 'A' is the amplitude of the beams $O'_1$ and $O'_3$; $\psi$ is the distorting phase term [14] and is given by

$$\psi \sim \exp i(k'_1 \cdot r' - k_1 \cdot r) + \exp i(k'_3 \cdot r' - k_3 \cdot r)$$

(4.9)

where $k_1$, $k_3$ and $r$ represent the wave vectors of the illuminating beams and the position of the $H_{21}$ in the recording condition, and $k'_1$, $k'_3$ and $r'$ are the corresponding values for the reconstruction condition. The effect of misalignment in either $H_1$ or $H_2$ is separately analyzed.

4.3.1 Misalignment in $H_2$

In this case (when $H_2$ is not properly repositioned after processing), the reconstructing beams are identical with the recording beams, i.e.,

$k'_1 = k_1$ and $k'_3 = k_3$, and the components (Fig.4.8) of the two vectors are

$k_1 \sim (0,0, k_1)$

$k_3 \sim (k_3 \sin \theta, 0, k_3 \cos \theta)$

(4.10)

Here the $H_2$ is assumed to be positioned perpendicular to the z-axis. This is not a general case; however it is sufficiently close to the practical case. A more general treatment is possible but interpretation of results might be difficult by the complicated expressions. Since the illuminating source is coherent, thus $k_1 = k_3 = k$ and the misalignment vector associated with the $H_2$ plate position is: $r' - r = \Delta r$
4.3.1.1 Lateral position misalignment

In case, the plate co-ordinates are misaligned by a parallel translation i.e. \( \Delta r = (\Delta x, \Delta y, \Delta z) \) then \( \psi \) can be written as

\[
\psi = \exp i k \Delta z + \exp i(k \sin \theta \Delta x + \cos \theta \Delta z)
\]

Thus, \(|\psi|^2 = 4 \cos^2 \frac{k}{2} \left\{ \sin \theta \Delta x + (\cos \theta - 1) \right\} \) \hspace{1cm} (4.11)

Here repositioning is critical in the x and z directions as \( k_1 \) and \( k_3 \) differ in their x and z components. No fringe will occur (in the interferogram) in the observation plane when \( \Delta x = \frac{(2n + 1)\pi}{k \sin \theta} \) and \( \Delta z = \frac{(2n + 1)\pi}{k(\cos \theta - 1)} \); where \( n \) is an integer. To minimize the sensitivity with respect to x and z positioning, the components in these directions should be as small as possible.
4.3.1.2 Rotation around x-axis

In case $H_2$ is rotated by an angle $\Delta \alpha$ along the x-axis then displacement vector

$$\Delta r = (0, -z\Delta \alpha, + y\Delta \alpha)$$

Eq. 4.9 can now be written as

$$\psi = \exp i k y \Delta \alpha (\cos \theta - 1) + 1$$

Thus, $|\psi|^2 = 4 \cos^2 \left[ k y \Delta \alpha (\cos \theta - 1)/2 \right]$ (4.12)

The sensitivity of $\psi$ with respect to the rotation around the x-axis is thus of the first order of the rotation angle $\Delta \alpha$. Equally spaced fringes will appear parallel to the x-axis with spacing of $\frac{2\pi}{k \Delta \alpha (\cos \theta - 1)}$. 
4.3.1.3 Rotation around y-axis

When $H_2$ is rotated by an angle $\Delta \beta$ along the y-axis then displacement vector $\Delta r = (z\Delta \beta, 0, -x\Delta \beta)$

Eq. 4.9 can thus be written as

$$\psi = \exp (i k \sin \theta z \Delta \beta) \cdot \exp [-i k x \Delta \beta (\cos \theta - 1)] + 1$$

Since the z-axis is perpendicular to the $H_2$ plane, thus only the projection of fringes onto the $H_2$ plane are observed

$$|\psi|^2 = 4 \cos^2 \left\{ k \left[ \sin \theta (\Delta \beta)^2 \right] - x \Delta \beta (\cos \theta - 1) \right\} / 2$$

(4.13)

The sensitivity of $|\psi|$ with respect to the rotation around the y-axis is thus of the second and first orders of the rotation angle $\Delta \beta$. Equally spaced fringes will appear parallel to the y-axis with a spacing of $2 \pi / \left[ k \Delta \beta \left[ \sin \theta \Delta \beta + (\cos \theta - 1) \right] \right]$. \[ \]

4.3.1.4 Rotation around z-axis

When $H_2$ is rotated by an angle $\Delta \gamma$ along the z-axis then displacement vector $\Delta r = (y\Delta \gamma, -x\Delta \gamma, 0)$

In this case, Eq 4.9 can be written as

$$\psi = \exp i (k \sin \theta y \Delta \gamma) + 1$$

Thus, $|\psi|^2 = 4 \cos^2 \left\{ k \left( \sin \theta y \Delta \gamma / 2 \right) \right\}$

(4.14)

The sensitivity of $\psi$ with respect to the rotation around the z-axis is thus of the first order of the rotation angle $\Delta \gamma$. Equally spaced fringes will appear parallel to x-axis with spacing of $2 \pi / \left[ \sin \theta \Delta \gamma \right]$. \[ \]
4.3.2 Misalignment in $H_1$

In case, when there is any misalignment in $H_1$ and the $H_2$ is perfectly repositioned (i.e., $r = r'$), then the two illuminating beams on $H_2$ gets modified as

$$k'_1 - k_1 = \delta k_1 \text{ and } k'_3 - k_3 = \delta k_3;$$

Eq. 4.9 can now be written as

$$\psi = \exp i (\delta k_1.r) + \exp i (\delta k_3.r)$$

Thus, $|\psi|^2 = 4 \cos^2 \left[ (\delta k_1 - \delta k_3).r/2 \right] \quad (4.15)$

Eq. 4.15 depicts the presence of finite fringes (in the interferogram) in the observation plane, which may be in any direction depending upon the directions of $k'_1$ and $k'_3$. By using a simple geometrical analysis, it is observed that by providing a suitable rotation to the $H_2$ through angles $\alpha$, $\beta$ and $\gamma$ with respect to the x, y, and z-axis (Fig. 4.9), the new coordinates $x'$, $y'$, $z'$ can be achieved in such a manner that the relative position of the $H_2$ with respect to the $k'$ vectors is almost identical to the initial position with respect to the $k$ vectors. This then facilitates in obtaining infinite fringe interferogram in the observation plane.

However, one cannot compensate by this procedure for changes of the angle between $k'_1$ and $k'_3$ with respect to the angle between $k_1$ and $k_3$. The effect of a symmetric change of the angle $\theta$ between $k_1$ and $k_3$ can be calculated from Eq. 4.15. Figures 4.8 and 4.9 show that the relevant difference between the old and the new wave vectors has only a component parallel to x axis, and therefore one gets

$$(\delta k_1 - \delta k_3).r = (k'_1 - k'_3).r - (k_1 - k_3).r$$

$$= 2k (\sin \theta/2 - \sin \theta'/2)x, \quad (4.16)$$

where $\cos \theta = (k_1, k_3)$ and

$$\theta' = \theta + \delta \theta \quad (4.17)$$

For small changes $\delta \theta$, Eq. 4.16 and 4.17 yield

$$|\psi|^2 = 4 \cos^2 \left( kx \frac{\delta \theta}{2} \cos \frac{\theta}{2} \right) \quad (4.18)$$
The sensitivity of the setup to inaccurate angular orientation of the reconstruction beams is thus a linear function of the half-angle variation \( \delta \theta \) and it is displayed as equally spaced fringes separated by 
\[
\frac{\pi}{k \frac{\delta \theta}{2} \cos \frac{\theta}{2}}.
\]

4.4 Experimental details

In these experimental arrangements, a 35 mW He-Ne laser system was used in the first and second recording steps of the method for the formation of two different sets of spatially separated holographic optical elements on two different holographic plates \( H_1 \) and \( H_2 \). A large-size collimated beam (R) and four small-size collimated beams (\( O_1, O_2, O_3 \) and \( O_4 \)) were generated by using a 100 mm-diameter and four 30 mm-diameter collimating lenses respectively. The shear plate interferometric technique was applied to ensure the optical quality of the collimated beams, which were used for forming the holographic optical elements on \( H_1 \) and \( H_2 \). Standard Kodak D-19 developer and R-9 bleach bath solutions are used with Slavich PFG-01 plates (having spatial resolution power of more than 3000 mm\(^{-1}\)) to give high efficiency and low noise holographic optical elements (grating holograms) [15] on \( H_1 \) and \( H_2 \). Holographic optical elements with almost uniform diffraction efficiency were generated using these holographic recording plates with exposure energies of the order of 100-120 \( \mu \)J/cm\(^2\). In order to realize the proposed interferometer set-up, the processed \( H_2 \) plate is required to be repositioned at the same location at which it was formed. However, since in our recording scheme the interfering beams have permanently been frozen on a single element (\( H_1 \)), the repositioning became much simpler. By using a simple alignment procedure, spatially separated infinite fringe interferograms are easily obtained in the observation plane (Fig.4.4). Optical test studies on two different phase objects were performed simultaneously and independently by inserting them in both the test arms between \( H_1 \) and \( H_2 \).

4.5 Discussion and conclusions

This chapter presents a simple and cost effective method for making a compact and versatile two channel interferometer based on holographic optics, which is suitable for performing optical test studies of two different phase (transparent) objects simultaneously.
and independently. The advantage of this method lies in the fact that the proposed optical arrangement of the interferometer involves a very simple alignment procedure and portions of any one of the collimated beams \( O'_1 \) or \( O'_3 \) and \( O'_2 \) or \( O'_4 \) generated between \( H_1 \) and \( H_2 \) can be used as test arms for studying the phase objects. The effect of misalignment in \( H_1 \) or \( H_2 \) has also been studied and the infinite fringe interferograms are easily obtained by mounting the \( H_2 \) on a holder having the capabilities of providing tilt motion to the plate in horizontal and vertical directions and by following a simple alignment procedure. Wavefront distortions caused due to emulsion shrinkage/swelling and substrate etc gets cancelled as the interfering beams pass through the same portions of the holographic optical elements on plate \( H_2 \). The interferometer is also suitable for performing comparison type studies of different phase objects in real time. It may be seen from figures 4.5 and 4.6 that the proposed interferometric method, in infinite fringe mode set-up, gives high contrast interference patterns on insertion of different phase objects in any one of or both the test arms. Further, the vital components of the interferometer could be produced in great numbers using hologram-copying methods [16].
References


