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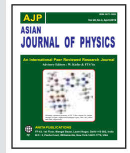

On the algorithms in phase-shift interferometry

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A number of phase-shift algorithms exist in literature. These are categorized as 3-step, 4-step, 5-step etc. with different but constant values of phase steps. In this paper, it is shown that many of them can be deduced from the generalized theory under each category in literature.

Keywords: Algorithms, Interferometry, Interferogram, Aberrated wavefront

1 Introduction

One of the important applications of interferometry is in testing of optical components and systems [1]. Aberrated wavefront from the optical system under test is made to interfere with a reference wave creating an interferogram from which the wavefront error is calculated. Let the aberrated wavefront be defined as

$$w(x,y) = w_0(x,y)\, e^{i\delta(x,y)}$$

where $\delta(x,y)$ is the phase error of the wavefront and $w_0(x,y)$ is the amplitude of the aberrated wave. The reference wave is either a plane wave or a spherical wave and is represented by

$$r(x,y) = r_0\,(x,y)\, e^{i\delta_r\,(x,y)}$$

where $\delta_r(x,y)$ is the phase of the reference wave and $r_0(x,y)$ is the amplitude of the reference wave. For a plane wave, the amplitude of the reference wave is constant. In speckle interferometry, the amplitude of the reference wave may also be varying [2]. The irradiance distribution $I(x,y)$ in the interference pattern is obtained as

$$I(x,y) = r_0^2(x,y) + w_0^2(x,y) + 2r_0(x,y)\, w_0(x,y) \cos[\delta(x,y) - \delta_r]$$

This equation can be rewritten as

$$I(x,y) = a(x,y) + b(x,y) \cos[\delta(x,y) - \delta_r]$$

where $a(x,y) = r_0^2(x,y) + w_0^2(x,y)$ and $b(x,y) = 2r_0(x,y)\, w_0(x,y)/[r_0^2(x,y) + w_0^2(x,y)]$.

There are three unknowns in this equation, which can be obtained if we could set up minimum of three equations by changing the phase of reference wave. This forms the basis of phase-shift interferometry (PSI). Using CCD/CMOS camera and a phase shift assembly in the reference arm, three or more interferograms are captured for discreet but equal phase shifts of the reference wave and the phase $\delta(x,y)$ at each pixel is then computed using appropriate algorithm: this is the wrapped phase. The wrapped phase is then unwrapped; the unwrapped phase is related to surface figure or some other physical variables. Further, the phase of the reference wave can also be continuously varied over an interval but we here consider discreet and equal phase change between interferograms. In order to obtain the unwrapped phase $\delta(x,y)$, several phase shift-algorithms have been proposed and researched along with error analysis and applications [3, 4]. Applications of PSI include testing of optical components and systems, measurement of deformation of an object using

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hologram interferometry and speckle interferometry, 3-D profiling of objects using moiré phenomenon etc. The purpose of this paper is to revisit these algorithms and bring out some salient features. It is emphasized that all the algorithms in a particular category can be obtained from its generalized description.

2 Algorithms

The algorithms are called by the names like 3-step, 4-step etc., which determine the number of interferograms captured in a 2π phase interval by changing the phase of the reference wave by equal amount. In another technique, the irradiance of the interferogram is integrated by linearly varying the reference wave phase over the phase interval [5]. This changes the modulation of the fringe pattern. Hence, all the algorithms apply equally well to this technique as well.

A:Three-step phase algorithm

Since three equations are to be set up to obtain the values of three unknowns in the irradiance distribution of an interference pattern, three-step phase algorithm is an obvious choice. The phase of the reference wave is taken as $-\alpha$, 0, α and the corresponding irradiance distributions are written as

$$I_1(x,y) = a(x,y) + b(x,y)\cos[\delta(x,y) - \alpha]$$

$$I_2(x,y) = a(x,y) + b(x,y)\cos\delta(x,y)$$

$$I_3(x,y) = a(x,y) + b(x,y)\cos[\delta(x,y) + \alpha]$$

The phase $\delta(x,y)$ is obtained as

$$\tan\delta(x,y) = \frac{1-\cos\alpha}{\sin\alpha}\,\frac{I_1 - I_3}{2I_2 - (I_1 + I_3)} = \tan(\alpha/2)\,\frac{I_1 - I_3}{2I_2 - (I_1 + I_3)}$$

Usually the first interferogram would be taken for the reference wave phase 0. In order to obtain interferograms at $-\alpha$ and α, the phase-shifter is to be reversed that may result in an error due to hysteresis. It would, therefore, be better if the phase of the reference wave is stepped up as 0, α, 2α. In this case, the phase $\delta(x,y)$ is given by

$$\tan\delta(x,y) = \frac{(I_1 - I_3)(1-\cos\alpha) - (I_1 - I_2)(1-\cos 2\alpha)}{(I_1 - I_2)\sin 2\alpha - (I_1 - I_3)\sin\alpha}$$

This expression appears complicated. It is, however, reduced to a simpler form as above, if the phase $\delta(x,y)$ in above equation is replaced by $[\delta(x,y) - \alpha]$. In other words, the phase of reference wave can be stepped as 0, α, 2α and the expression for phase $\delta(x,y)$ can be taken corresponding to reference wave phases $-\alpha$, 0, α: the computed phase $\delta(x,y)$ is then to be replaced by $[\delta(x,y) - \alpha]$. This is equivalent to a constant phase-shift and has absolutely no relevance when strain values are computed. But for length interferometry, this needs to be accounted for.

Several three-step algorithms have been developed and used in PSI. Some of these algorithms are briefly described below:

A-1: $-\frac{\pi}{3}, 0, \frac{\pi}{3}$

The phase of the reference wave is shifted by $\pi/3$ with the initial phase taken as $-\pi/3$. The phase $\delta(x,y)$ is obtained as

$$\tan\delta(x,y) = \frac{1}{\sqrt{3}}\,\frac{I_1 - I_3}{2I_2 - (I_1 + I_3)}$$

A–2: $0, \frac{\pi}{3}, \frac{2\pi}{3}$

In this algorithm, the initial phase is taken 0 and the phase step is retained as $\pi/3$. The phase $\delta(x,y)$ is obtained as

$$\tan \delta(x,y) = \frac{1}{\sqrt{3}} \frac{2(I_1 - I_2) + (I_3 - I_2)}{I_2 - I_3}$$

As has been pointed out earlier, the phase $\delta(x,y)$ can be computed using the expression for algorithm A-1, but the phase obtained will then be $[\delta(x,y) - \pi/3]$ rather $\delta(x,y)$.

A–3: $-\frac{\pi}{2}, 0, \frac{\pi}{2}$

The phase of the reference wave is shifted by $\pi/2$ with the initial phase taken as $-\pi/2$. The phase $\delta(x,y)$ is obtained as

$$\tan \delta(x,y) = \frac{I_1 - I_3}{2I_2 - (I_1 + I_3)}$$

A–4: $0, \frac{\pi}{2}, \pi$

This algorithm also uses the phase step of $\pi/2$ but the initial phase is taken as 0. The phase $\delta(x,y)$ is obtained as

$$\tan \delta(x,y) = \frac{(I_1 + I_3) - 2I_2}{I_1 - I_3}$$

A-5: $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}$

This algorithm is a variation of A-4 algorithm, in which the phase-steps are offset by $\pi/4$ resulting in the phase steps as $\frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}$. The phase $\delta(x,y)$ is obtained as

$$\tan \delta(x,y) = \frac{I_3 - I_2}{I_1 - I_3}$$

This algorithm was proposed by Wyant [6]. This is a neater expression. If this expression is used for calculating the phase using the phase steps 0, $\pi/2$, π, then the phase $\delta(x,y)$ should be replaced by $[\delta(x,y) + \pi/4]$.

A-6: $-\frac{2\pi}{3}, 0, \frac{2\pi}{3}$

In this algorithm, the phase step is $2\pi/3$ and the initial phase of the reference wave is taken as $-2\pi/3$. The phase $\delta(x,y)$ is obtained as

$$\tan \delta(x,y) = \sqrt{3} \frac{I_1 - I_3}{2I_2 - (I_1 + I_3)}$$

A-7: $0, \frac{2\pi}{3}, \frac{4\pi}{3}$

In this algorithm also, the phase step is $2\pi/3$ but the initial phase of the reference wave is taken 0. The phase $\delta(x,y)$ is obtained as

$$\tan \delta(x,y) = \sqrt{3} \frac{I_3 - I_2}{2I_1 - (I_2 + I_3)}$$

Both A-6 and A-7 algorithms give the expressions with similar structure. However, if the data is collected using algorithm A-7, and the phase $\delta(x,y)$ is calculated using expression for algorithm A-6, the calculated phase $\delta(x,y)$ is replaced by $[\delta(x,y) - 2\pi/3]$.

A–8: $0, \frac{\pi}{3}, \pi$

Another interesting algorithm is due to Wizinowich [7], which also uses three interferograms. The phase steps at 0 and π are used to get the average irradiance in the interferogram. The phase $\delta(x,y)$ is obtained as

$$\tan \delta(x,y) = \frac{I_{av} - I_2}{I_1 - I_{av}}$$

where $I_{av} = (I_1+I_3)/2$ is the average irradiance of two π phase-shifted interferograms. This algorithm can be used in the presence of vibrations.

B: Four-step algorithms

All four-step algorithms can be derived from Carre' algorithm [8]. Elegance of this algorithm lies in the fact that the phase step need not be known but the phase steps must be equal: the phase step can be obtained from the irradiance measurements. Since under this situation, there are four unknowns and hence four irradiance measurements are needed to obtain the values of all unknowns that include the phase step and the phase of the aberrated wave.

B-1: Carre' algorithm –3α/2, –α/2, α/2, 3α/2

The irradiance distributions corresponding to four phase steps –3α/2, –α/2, α/2, 3α/2 of the reference wave are expressed as

$$I_1 (x,y) = a(x,y) + b(x,y) \cos[\delta(x,y) - 3\alpha/2]$$

$$I_2 (x,y) = a(x,y) + b(x,y) \cos[\delta(x,y) - \alpha/2]$$

$$I_3 (x,y) = a(x,y) + b(x,y) \cos[\delta(x,y) + \alpha/2]$$

$$I_4 (x,y) = a(x,y) + b(x,y) \cos[\delta(x,y) + 3\alpha/2]$$

The phase $\delta(x,y)$ is obtained as

$$\tan \delta(x,y) = \tan(\alpha/2)\,\frac{(I_2 - I_3) + (I_1 - I_4)}{(I_2 + I_3) - (I_1 + I_4)}$$

with

$$\tan^2 (\alpha/2) = \frac{3(I_2 - I_3) - (I_1 + I_4)}{(I_2 - I_3) + (I_1 - I_4)}$$

Combining them, we obtain

$$\tan \delta(x,y) = \frac{\sqrt{[3(I_2 - I_3) - (I_1 - I_4)][(I_2 - I_3) + (I_1 - I_4)]}}{(I_2 + I_3) - (I_1 + I_4)}$$

or

$$\delta(x,y) = \tan^{-1}\left[\frac{\sqrt{[3(I_2 - I_3) - (I_1 - I_4)][(I_2 - I_3) + (I_1 - I_4)]}}{(I_2 + I_3) - (I_1 + I_4)}\right]$$

The conversion of the result of the arc tangent is not quite straight-forward due to the square root appearing in the numerator. On the other hand tan (α/2) can be computed with measured intensities and since the value of α is expected to be less than or equal to π/2, the ambiguity in the sign of sine is avoided.

B-2: 0, α, 2α, 3α

However, when the phase of the reference wave is stepped up in multiples of α with initial phase 0, the equation for tan $\delta(x,y)$ is very complicated and involved. However, a neater expression results as

$$\tan [\delta(x,y) - 3\alpha/2] = \tan(\alpha/2)\,\frac{(I_2 - I_3) + (I_1 - I_4)}{(I_2 + I_3) - (I_1 + I_4)}$$

It means that we can use the expression for phase as given by Carre's algorithm but the phase measured will be $[\delta(x,y) - 3\alpha/2]$.

Almost all the 4-step algorithms can be obtained from Carre's algorithm. Some of them are given herewith.

B–3: $-\frac{3\pi}{4}, -\frac{\pi}{4}, \frac{\pi}{4}, \frac{3\pi}{4}$

When the phase of reference wave is stepped up by π/2 starting with an initial phase of −3π/4, the phase $\delta(x,y)$ is obtained as

$$\tan\delta(x, y) = \frac{(I_2 - I_3) + (I_1 - I_4)}{(I_2 + I_3) - (I_1 + I_4)}$$

In all the algorithms where the phase step is π/2, the term tan (α/2) becomes unity.

B–4: $-\frac{\pi}{4}, \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}$

When the phase of the reference wave is stepped by π/2 starting with an initial phase of −π/4, the phase $\delta(x,y)$ is obtained as

$$\tan\delta(x, y) = \frac{(I_1 + I_4) - (I_2 + I_3)}{(I_2 - I_3) + (I_1 - I_4)}$$

B–5: $0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}$

However when the initial phase of the reference wave is taken 0, and the phase is stepped up by π/2, the phase $\delta(x,y)$ is obtained as

$$\tan\delta(x, y) = \frac{(I_4 - I_2)}{(I_1 - I_3)}$$

This is a neater expression. This may be considered as the best algorithm under 4-step algorithms.

C: Five-step algorithms

C–1: −2α, −α, 0, α, 2α

Realizing some issues with the Carre' algorithm, Hariharan proposed 5-step algorithm in which the phase of the reference wave is taken as −2α, −α, 0, α, 2α and the corresponding irradiance distributions are written as [9]

$$I_1 (x, y) = a(x, y) + b(x, y) \cos[\delta(x,y) - 2\alpha]$$

$$I_2 (x, y) = a(x, y) + b(x, y) \cos[\delta(x,y) - \alpha]$$

$$I_3 (x, y) = a(x, y) + b(x, y) \cos\delta(x,y)$$

$$I_4 (x, y) = a(x, y) + b(x, y) \cos[\delta(x,y) + \alpha]$$

$$I_5 (x, y) = a(x, y) + b(x, y) \cos[\delta(x,y) + 2\alpha]$$

The phase $\delta(x, y)$ is obtained as

$$\tan\delta(x, y) = 2\sin\alpha \frac{(I_2 - I_4)}{2I_3 - (I_1 + I_5)}$$

with 2 sin α given by

$$2\sin\alpha = \frac{\sqrt{4(I_2 - I_4)^2 - (I_1 - I_5)}}{(I_2 - I_4)}$$

Since the phase-step can be chosen at will, we can determine the value of α for which the calculated phase $\delta(x, y)$ will have the minimal error. Mathematically

$$\frac{d}{d\alpha}\left[\frac{\tan\delta(x,y)}{2\sin\alpha}\right] = 0$$

This yields

$$\frac{d\delta(x,y)}{d\alpha} = \frac{\cos\alpha}{2\sin\alpha}\sin 2\delta(x,y)$$

When the phase-step is chosen 90º, the phase error in computed values of phase is zero.

C–2: $-\pi, -\frac{\pi}{2}, 0, \frac{\pi}{2}, \pi$

The phase of the reference wave is stepped up by π/2 and the initial phase is taken as −π. Since sin α= 1, the phase $\delta(x,y)$ is given by

$$\tan\delta(x, y) = \frac{2(I_2 - I_4)}{2I_3 - (I_1 + I_5)}$$

This algorithm can also be obtained using averaging technique [3]. Further, since $I_1 = I_5$, this algorithm takes even a much simpler form as

$$\tan\delta(x, y) = \frac{I_2 - I_4}{I_3 - I_1}$$

C–3: $0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}, 2\pi$

From application point of view, stepping the phase of reference wave by π/2 from its initial value 0 is convenient. The phase $\delta(x, y)$ is obtained as

$$\tan\delta(x, y) = \frac{I_2 - I_4}{I_3 - I_1}$$

Though the initial phases are different under *C–2* and *C–3*, the algorithms are identical. This is due to the periodicity of the tan θ function, which is π radian. This is the difference between the initial phases.

D: Six-step algorithms

D–1: $0, \frac{\pi}{3}, \frac{2\pi}{3}, \pi, \frac{4\pi}{3}, \frac{5\pi}{3}$

The phase of the reference wave is taken as $0, \frac{\pi}{3}, \frac{2\pi}{3}, \pi, \frac{4\pi}{3}, \frac{5\pi}{3}$ and the corresponding irradiance distributions are written as

$$I_1(x,y) = a(x,y) + b(x,y)\cos\delta(x,y)$$

$$I_2(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{\pi}{3}\right]$$

$$I_3(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{2\pi}{3}\right]$$

$$I_4(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \pi\right]$$

$$I_5(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{4\pi}{3}\right]$$

$$I_6(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{5\pi}{3}\right]$$

The phase $\delta(x, y)$ is obtained as

$$\tan\delta(x,y) = \frac{1}{\sqrt{3}}\frac{(I_5 + I_6) - (I_2 + I_3)}{2(I_1 - I_4) - (I_2 + I_6) + (I_3 + I_5)}$$

D–2: $0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}, 2\pi, \frac{5\pi}{2}$

The phase of the reference wave is taken as $0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}, 2\pi, \frac{5\pi}{2}$ and the corresponding irradiance distributions are written as

$$I_1\,(x,y) = a(x,y) + b(x,y)\cos\delta(x,y)$$

$$I_2\,(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{\pi}{2}\right]$$

$$I_3\,(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \pi\right]$$

$$I_4\,(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{3\pi}{2}\right]$$

$$I_5\,(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + 2\pi\right]$$

$$I_6\,(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{5\pi}{2}\right]$$

The phase $\delta(x, y)$ is obtained as

$$\tan\delta(x,y) = \frac{(I_4 - I_6) + (I_4 - I_2)}{(I_1 - I_3) + (I_5 - I_3)}$$

Since $I_1 = I_5$ and $I_2 = I_6$, this can also be recast as

$$\tan\delta(x,y) = \frac{(I_4 - I_6) + 3(I_4 - I_2)}{(I_1 - I_3) + 3(I_5 - I_3)}$$

The later formula is obtained by phase averaging. It however, places more emphasis on irradiances I_2, I_3, I_4 and I_5 as compared to I_1 and I_6.

E: Seven-step algorithms

E–1: $-3\alpha, -2\alpha, -\alpha, 0, \alpha, 2\alpha, 3\alpha$

The phase of the reference wave is taken as -3α, -2α, $-\alpha$, 0, α, 2α, 3α and the corresponding irradiance distributions are written as

$$I_1\,(x,y) = a(x,y) + b(x,y)\cos[\delta(x,y) - 3\alpha]$$

$$I_2\,(x,y) = a(x,y) + b(x,y)\cos[\delta(x,y) - 2\alpha]$$

$$I_3\,(x,y) = a(x,y) + b(x,y)\cos[\delta(x,y) - \alpha]$$

$$I_4\,(x,y) = a(x,y) + b(x,y)\cos\delta(x,y)$$

$$I_5\,(x,y) = a(x,y) + b(x,y)\cos[\delta(x,y) + \alpha]$$

$$I_6\,(x,y) = a(x,y) + b(x,y)\cos[\delta(x,y) + 2\alpha]$$

$$I_7\,(x,y) = a(x,y) + b(x,y)\cos[\delta(x,y) + 3\alpha]$$

From these we, can obtain the following equations

$$\tan\delta(x,y) = \frac{1 - \cos\alpha}{\sin\alpha}\,\frac{I_3 - I_5}{2I_4 - (I_3 + I_5)}$$

$$\tan\delta(x,y) = \frac{1 - \cos 2\alpha}{\sin 2\alpha}\,\frac{I_2 - I_6}{2I_4 - (I_2 + I_6)}$$

$$\tan\delta(x,y) = \frac{1 - \cos 3\alpha}{\sin 3\alpha}\,\frac{I_1 - I_7}{2I_4 - (I_1 + I_7)}$$

Further,

$$\tan(\alpha/2) = \sqrt{\frac{6I_4 + (I_2 + I_6) - 4(I_3 + I_5)}{2I_4 - (I_2 + I_6)}}$$

Then the averaging can be used before unwrapping the phase.

E–2: $0, \frac{\pi}{3}, \pi, \frac{3\pi}{3}, 2\pi, \frac{5\pi}{2}, 3\pi$

The phase of the reference wave is taken as $0, \frac{\pi}{3}, \pi, \frac{3\pi}{3}, 2\pi, \frac{5\pi}{2}, 3\pi$ and the corresponding irradiance distributions are written as

$$I_1(x,y) = a(x,y) + b(x,y)\cos\delta(x,y)$$

$$I_2(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{\pi}{2}\right]$$

$$I_3(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \pi\right]$$

$$I_4(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{3\pi}{2}\right]$$

$$I_5(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + 2\pi\right]$$

$$I_6(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + \frac{5\pi}{2}\right]$$

$$I_7(x,y) = a(x,y) + b(x,y)\cos\left[\delta(x,y) + 3\pi\right]$$

The phase $\delta(x, y)$ is obtained as

$$\tan\delta(x,y) = \frac{(I_4 - I_6) + (I_4 - I_2)}{(I_1 - I_3) + (I_5 - I_7)}$$

Since $I_1 = I_5$, $I_2 = I_6$ and $I_3 = I_7$, this can also be recast as

$$\tan\delta(x,y) = \frac{4(I_4 - I_6) + 4(I_4 - I_2)}{(I_1 - I_7) + 7(I_5 - I_3)}$$

This algorithm is obtained by least square method [2]. General approaches to design algorithms have been put forward by Larkin and Oreb [10], Surrel [11] and Hibino *et al* [12].

3 Conclusions

Many of the algorithms can be derived from their respective generalizations. In practice, the phase of the reference wave is stepped up from the initial phase. Hence the simplified forms of algorithms get accordingly modified. If the simplified form is to be used with the phase stepped from its initial value taken as 0 phase, the calculated phase is to be appropriately shifted. This shift does not impact the strain values but needs to be taken into consideration where actual phase is used like in length interferometry, Profilometry etc. This paper may also be considered as tutorial on various phase- algorithms. No attempt is made to study their relative insensitivities to various external factors.

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Prof. Sirohi worked in Germany as a Humboldt Fellow and an Awardee. He was a Senior Research Associate at Case Western Reserve University, Cleveland, Ohio, and Associate Professor, and Distinguished Scholar at Rose Hulman Institute of Technology, Terre Haute, Indiana. He was ICTP (International Center for Theoretical Physics, Trieste Italy) Consultant to Institute for Advanced Studies, University of Malaya, Malaysia and ICTP Visiting Scientist to the University of Namibia. He was Visiting Professor at the National University of Singapore and EPFL, Lausanne, Switzerland.

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Prof. Sirohi has received the following awards from various organizations:

Humboldt Research Award (1995) by the Alexander von Humboldt Foundation, Germany; Galileo Galilei Award of International Commission for Optics (1995); Amita De Memorial Award of the Optical Society of India (1998); 13th Khwarizmi International Award, IROST (Iranian Research Organisation for Science and Technology (2000); Albert Einstein Silver Medal, UNESCO (2000); Dr. YT Thathachari Prestigious Award for Science by Thathachari Foundation, Mysore (2001); Pt. Jawaharlal Nehru Award in Engineering & Technology for 2000, (awarded in 2002) by MP Council of Science and Technology; NRDC Technology Invention Award on May 11, 2003; Sir CV Raman Award: Physical Sciences for 2002 by UGC (University Grants Commission); Padma Shri, a national Civilian Award (2004); Sir CV Raman Birth Centenary Award (2005) by Indian Science Congress Association, Kolkata; Holo-Knight (2005), inducted into Order of Holo-Knights during the International Conference-Fringe 05-held at Stuttgart, Germany; Centenarian Seva

Ratna Award (2004) by The Centenarian Trust, Chennai; Instrument Society of India Award (2007); Gabor Award (2009) by SPIE (The International Society for Optical Engineering) USA; UGC National Hari OM Ashram Trust Award - Homi J. Bhabha Award for Applied Sciences (2005) by UGC; Distinguished Alumni Award (2013) by Indian Institute of Technology Delhi; Vikram Award 2014 by SPIE (The International Society for Optical Engineering) USA.

Prof. Sirohi was the President of the Optical Society of India during 1994-1996. He was also the President of Instrument Society of India for three terms (2003-06, 2008-12). He was on the International Advisory Board of the Journal of Modern Optics, UK and on the editorial Boards of the Journal of Optics (India), Optik, Indian Journal of Pure and Applied Physics. He was Guest Editor to the Journals “Optics and Lasers in Engineering” and “Optical Engineering”. He was Associate Editor of the International Journal “Optical Engineering”, USA during (1999-Aug.2013), and currently is its Senior Editor.

Prof. Sirohi has 456 papers to his credit with 244 published in national and international journals, 67 papers in Proceedings of the conferences and 145 presented in conferences.He has authored/co-authored/edited thirteen books including five milestones for SPIE. He was Principal Coordinator for 26 projects sponsored by Government Funding Agencies and Industries, has supervised 25 Ph.D. theses, 7 M.S. theses and numerous B.Tech., M.Sc. and M.Tech. theses.

Prof. Sirohi’s research areas are Optical Metrology, Optical Instrumentation, Laser Instrumentation, Holography and Speckle Phenomenon.