11.5.3 Use of lateral shear interferometer to measure the OTF

H. H. Hopkins was the first to show that a lateral shearing interferometer can be used to measure the OTF of an optical system. (Ref: H. H. Hopkins, Opt. Acta 2, 23 (1955).)

The one-dimensional OTF of an optical system \( H[f_x] \) is given by the autocorrelation of the pupil function

\[
H[f_x] = \frac{1}{c} \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} P\left[ x + \frac{s}{2}, y \right] P^*\left[ x - \frac{s}{2}, y \right] \, dx \, dy
\]

If \( z_i \) is the image distance, \( D \) is the pupil diameter, and \( \lambda \) is the wavelength

\[
f_x = \frac{s}{\lambda z_i} = \frac{s}{D \cdot \lambda z_i} = \frac{s}{D \cdot \lambda f_x^H}
\]

For simplicity let the two interfering beams in a lateral shear interferometer have the same intensity. Let \( \delta \) be the phase difference between the two sheared interfering wavefronts due to path difference in the interferometer. Generally \( \delta \) is made to vary linearly with time, i.e. \( \delta = \omega t + \phi_0 \).

Then the total flux in the interference pattern is

\[
F(\delta, s) = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} \text{Abs} \left[ P\left[ x + \frac{s}{2}, y \right] + P\left[ x - \frac{s}{2}, y \right] e^{-i\delta} \right]^2 \, dx \, dy
\]

\[
= 2 \int \int \text{Abs} \left[ P\left[ x + \frac{s}{2}, y \right] \right]^2 \, dx \, dy + \int \int P\left[ x + \frac{s}{2}, y \right] P^*\left[ x - \frac{s}{2}, y \right] e^{i\delta} \, dx \, dy + \text{complex conjugate}
\]

\[
= 2c \left( 1 + \text{Abs}[H[f_x]] \right) \cos(\delta - \Theta[f_x])
\]

\( 2c \) is the average amount of flux in the two interfering wavefronts.