Diffraction effects in infrared interferometry

PRECISION-OPTICAL ENGINEERING

IF 004

Application Note

Diffraction effects in infrared interferometry

Some of the experimental conditions for infrared interferometry are rather different to those in the visible region, so special care must be taken in the setting up of the measurement, and the results analysed in as rigorous a manner as possible. Infrared optical systems are being produced with smaller optical apertures than previously for reasons of weight, cost and configurability. This trend has been aided by improvements in the detector technology. The result is that the IR lens for a camera system may have an aperture comparable in size to a visible camera system. However the wavelength in the IR system may be as much as twenty times greater than in the visible band. This makes the effects of diffraction much more dominant in IR interferometry, requiring that optical pupils are well focused onto the interferometers camera sensor surface.

Optimising the configuration

Because of the double pass nature of most commercially available interferometers, the aperture is ‘seen’ twice by the interferometer - if the two images of the optical aperture are not conjugate with one another then some diffraction is inevitable. The effects of this must be minimised to enable accurate analysis. This is highlighted in Figure 1 which shows two ways of analysing a lens with an interferometer.

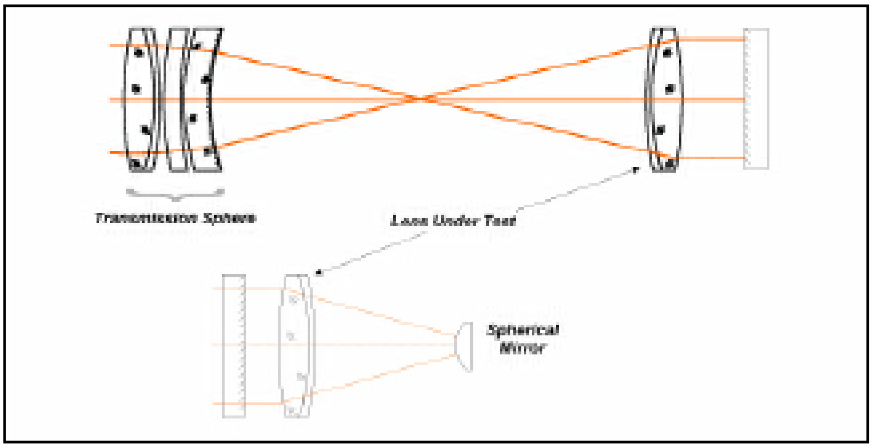

Figure 1

One test uses a spherical reference mirror while the other uses a flat reference mirror but requires an additional high quality focusing lens (or reference sphere) in order to make the measurement. From the point of view of diffraction the measurement using the reference sphere is preferred, since the return mirror can be very close to the pupil of the lens under test, therefore the pupil and its image via the mirror can both be very close to focus on the interferometer's camera faceplate. This is not possible using the other arrangement, and diffraction will be present especially if the spherical mirror radius is small so that it is physically far from the lens under test. It is important that any analysis of the interferograms takes into account the limitations of the method. Figure 2 shows the effect of diffraction on the pupil imagery in the interferometer. In the unfocused case, diffraction rings can clearly be seen inside the pupil. This has the effect of breaking up the interference pattern such that the fringes are discontinuous or vary in width

PRECISION-OPTICAL ENGINEERING

Wilbury Way, Hitchin, Hertfordshire, SG4 OTP, United Kingdom.

Tel: +44 (0)1462 440328 Fax: +44 (0)1462 440329
Website: www.p-oe.co.uk
P-OE is a business centre of MBDA UK Limited

Diffraction effects in infrared interferometry

due to contrast changes. Any automatic fringe analysis program must be used with caution when analysing such fringes. In these cases the peak to valley wavefront aberration reported will be worse than the actual aberration for the lens under test.

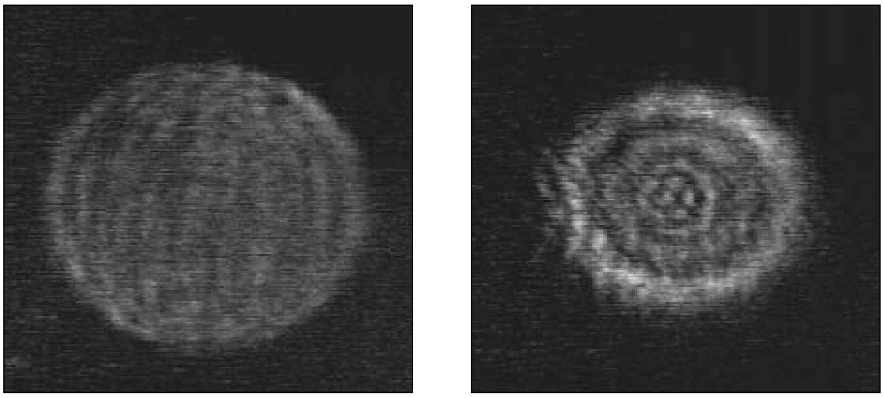

Figure 2

While Figure 2 shows the effect of diffraction within the optical pupil, the other common case is when the diffracted radiation appears outside the pupil. This has the effect of blurring the pupil edge so its size is uncertain and, because the diffracted radiation has a different curvature to the main beam, any interference fringes will curve within this zone. The effect is very similar to that seen with Spherical Aberration especially that of higher order and if not corrected can lead to a large departure in measured vs. actual performance. This situation is shown schematically in Figure 3.

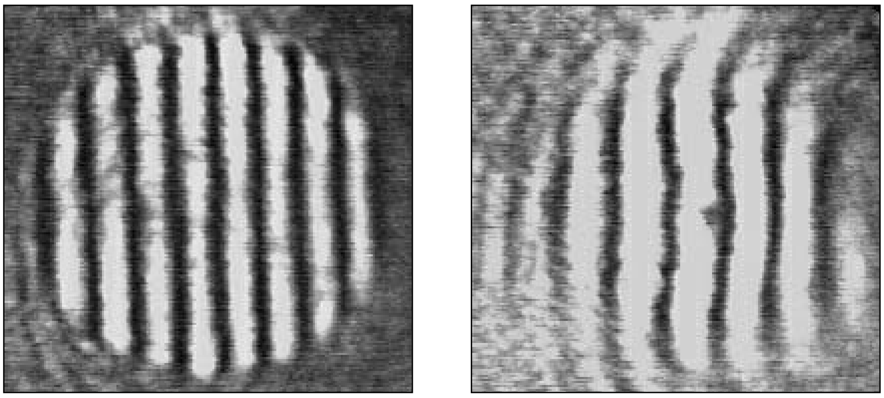

Figure 3

Here, if information is known about the size of the pupil within the interferogram, it is possible to mask out much of the effects of diffraction simply by ignoring those parts outside the pupil. There will be cases where it is impossible to achieve good pupil imagery without going to great expense. In such circumstances, double pass interferometry can still provide a confidence test on system performance, but ultimate proof may require a single pass test, either by interferometry or by non coherent broad band MTF testing or similar.

PRECISION-OPTICAL ENGINEERING

Wilbury Way, Hitchin, Hertfordshire, SG4 OTP, United Kingdom.

Tel: +44 (0)1462 440328 Fax: +44 (0)1462 440329
Website: www.p-oe.co.uk
P-OE is a business centre of MBDA UK Limited