

Application note:

Camera lens testing with the SHSInspect RL module

1 Introduction

This application note describes how camera objectives can be tested with Optocraft's SHSInspect RL module in a double pass ("2Xpass") configuration. Using a simple optical setup, the wave aberrations and imaging quality of a 50mm f/1.8 camera lens are tested. With a slightly extended set-up, also the measurement of chromatic effects and field effects is possible. The accuracy which can be achieved with such a set-up can be in the range of $\lambda/20$ (pv).

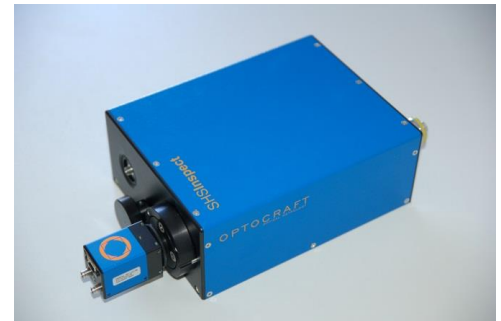


Fig.1: SHSInspect RL module with SHSCam HR

2 Experimental

Figure 2a) shows the experimental setup. A multi-mode fibre coupled LED ($\lambda=530\text{nm}$) is collimated and directed via a beam splitter towards a null lens. Thus, a spherical wave is formed that illuminates the test sample. The numerical aperture of the null lens is chosen such that it matches the numerical aperture of the test sample. This way, the entire pupil of the test sample is illuminated. By adjusting the axial position, the test sample is positioned such that it collimates the incident light and forms a defocus-free wave that propagates towards the plano reference mirror (surface flatness $<\lambda/20$). After reflection, the wave-front passes the test sample and the null lens a second time and is finally imaged to the Shack-Hartmann wave-front sensor via a Kepler-type telescope. In this setup, a SHSCam HR-110-GE with a lateral resolution of 60×80 microlenses is used.

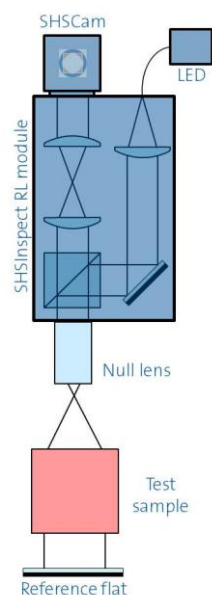
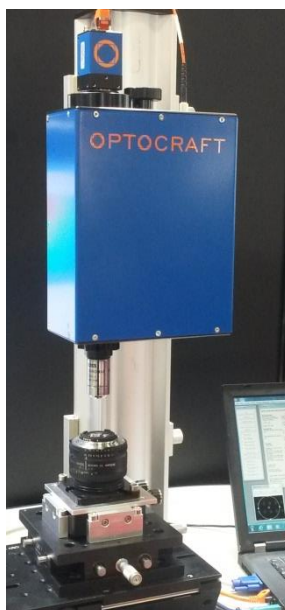
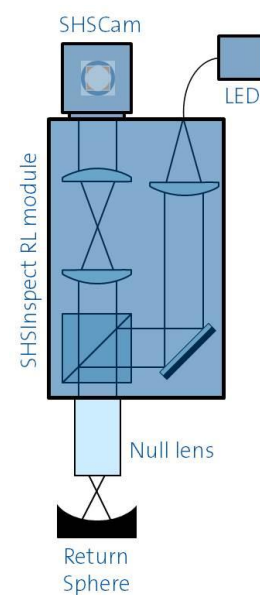


Fig. 2a) Setup for camera lens testing



b) calibration with spherical mirror

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In order to calibrate the system, the test sample and the plano reference mirror are replaced by a spherical mirror with high optical quality. It is positioned such that it reflects the spherical wave emitted by the null lens back into itself, see figure 2b). In this configuration a reference measurement is taken by the software SHSWorks which is subsequently subtracted during the measurements.

3 Results

In the example described here, a 1.8/50mm camera lens is placed onto the sample holder and adjusted as described above. With the aperture completely opened (F/1.8), a first measurement is taken. Then the aperture is closed to F/2.8 and to F/4 and measurements are taken in each situation. The results are shown in figure 3.

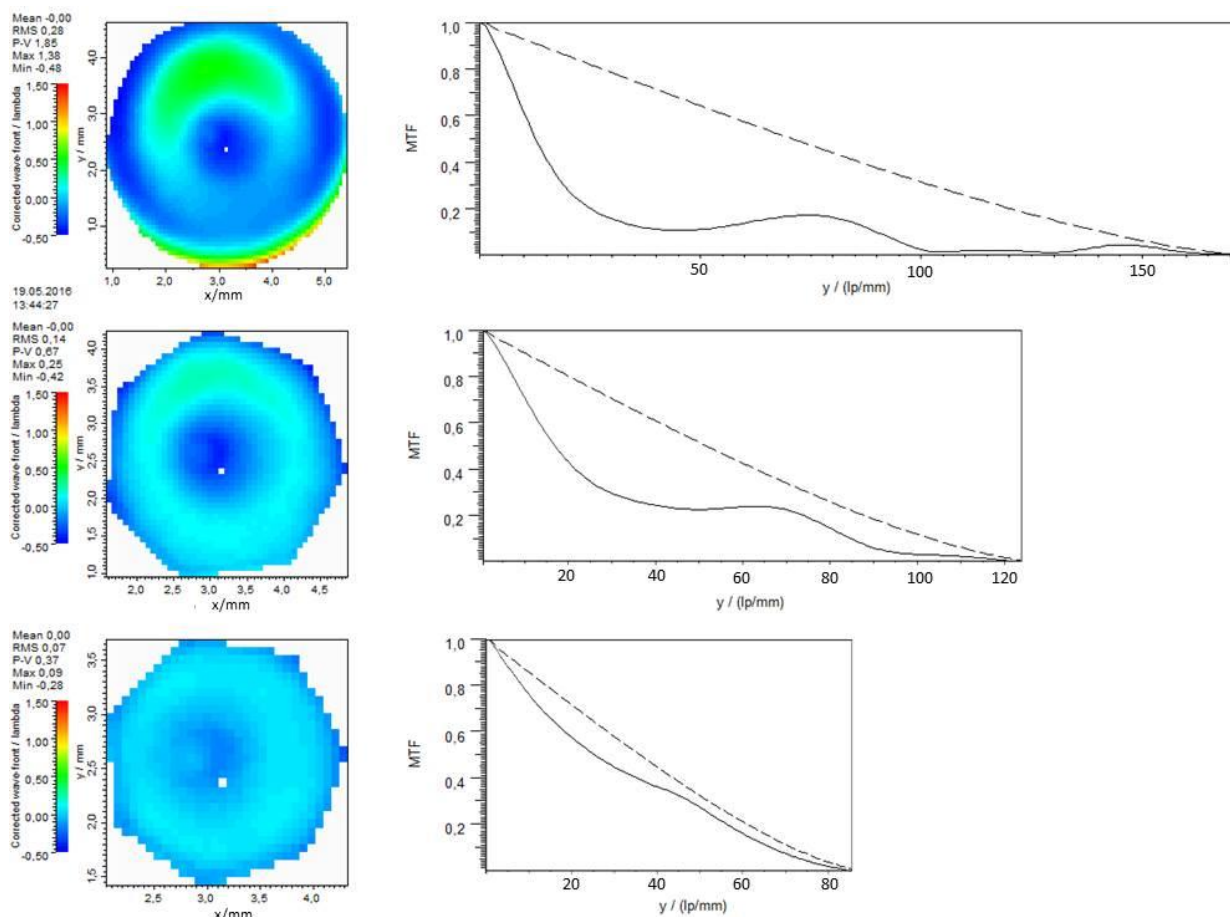


Fig. 3) Corr. wave-front and MTF for open aperture (F/1.8, above) and for aperture closed by two steps (F/4, below). In the MTF-charts, the dashed line indicates the MTF for the corresponding ideal, diffraction-limited system.

Closing the aperture reduces the number of spots available for the measurement, but still leaves us with >20 spots across the pupil diameter which is sufficient for a reliable wave-front reconstruction. The peak-to-valley value of the corrected wave-front is 2.2 lambda when the aperture is completely open, and decreases to 0.6 lambda and 0.3 lambda for F/2.8 and F/4, respectively. Corresponding Strehl ratios are 0.12, 0.51 and 0.88. The corresponding MTF, too, shows that by closing the aperture to F/4, the tested 50mm lens shows a near diffraction-limited behaviour.