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Aberrations

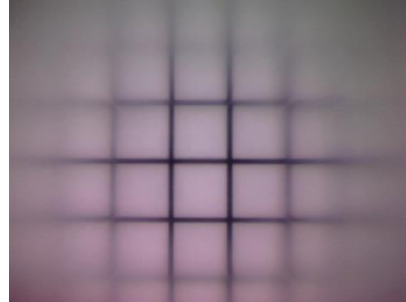
1. Imaging with a plan-convex lens for different orientations

Make three images at different de-focalization positions (-300, 0, 300 micron) for each orientation of the lens (object curvature - landscape) and place them in the report.

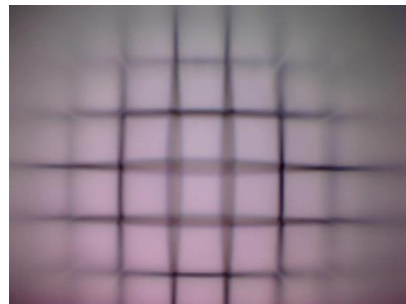
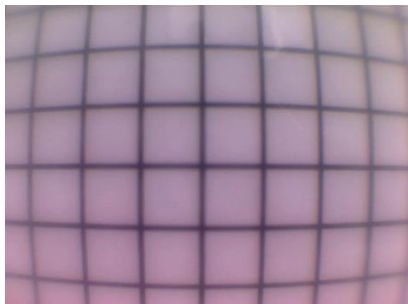
Landscape orientation



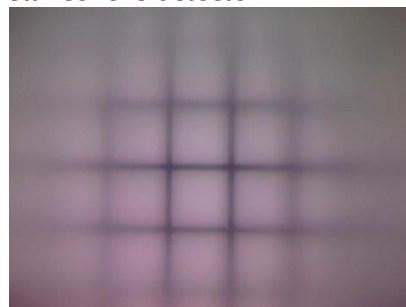
Object curvature orientation



In focus



-300 micron – smaller distance lens detector



+300 micron – larger distance lens detector

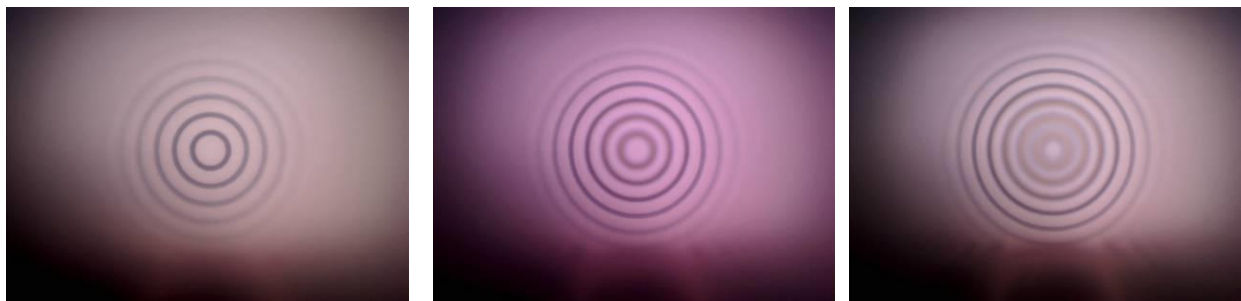
Comment what you see (image quality, focalization over the field of view, aberrations...)

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2. Direct measurement of the field curvature by defocusing of a test image

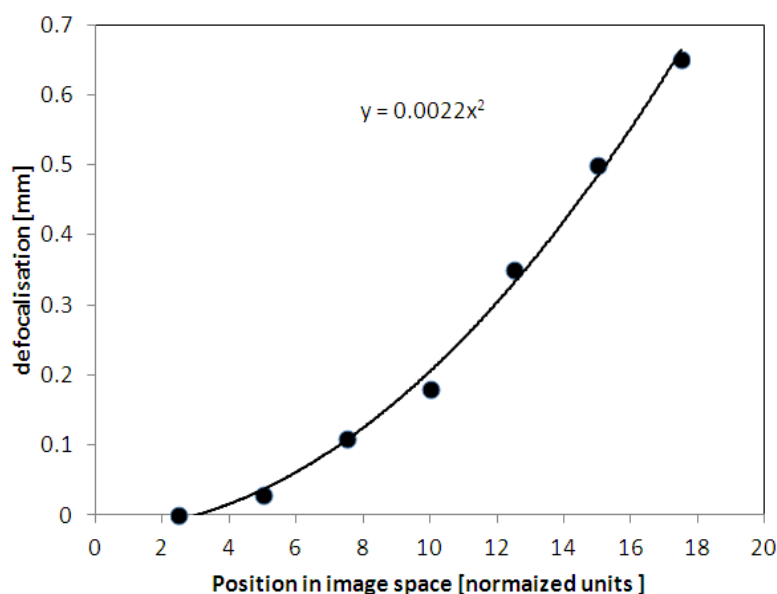
Show three images (for instance focusing of rings 1,3,5). Measure the field curvature resulting in de-focalization for a minimum of 7 rings. Plot the de-focalization distance (to be read at the linear stage) as a function of the position in the image (to be read in the image).



The diameter of each ring is doubled for advancing ring number on the card. To get the right scaling, you need to MEASURE the first ring diameter in the image and calculate all the others.

Measured diameter of first ring in image: $d_0 = \dots$ mm

Ring No	Radius	Calculated theoretical Radius in image space (mm)	Absolute Focus position on linear stage (mm)	Relative distance in mm
1	$d_0/2$			0
2	$d_0/2 + d_0/2$			
3	$d_0/2 + d_0$			
4	$d_0/2 + 3d_0/2$			
5	$d_0/2 + 2d_0$			
6	$d_0/2 + 5d_0/2$			
7	$d_0/2 + 3d_0$			



NOTE: the plot for the report needs to be done in mm and not in normalized units!!

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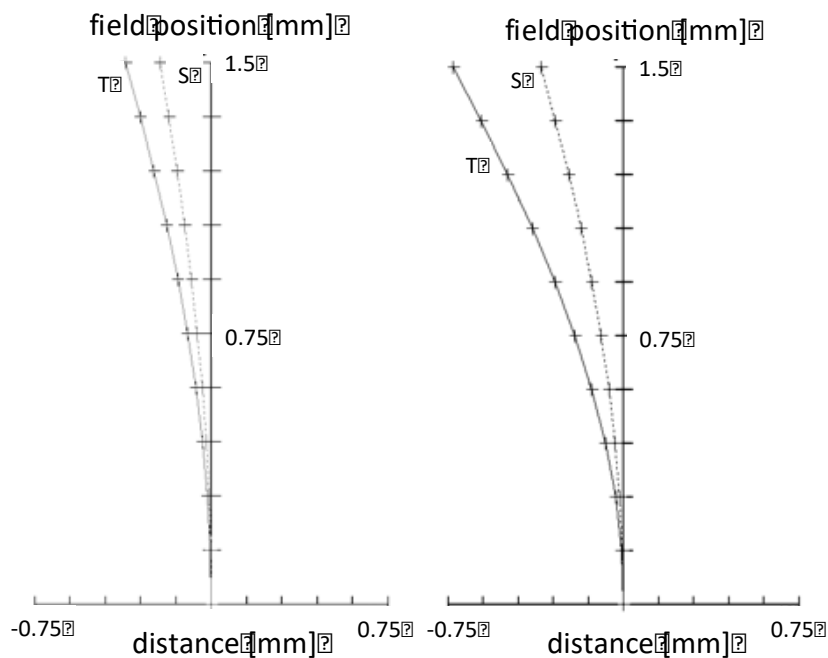
Calculate the radius of curvature at the center (0,0) of your data. This can be done by fitting a function $y=ax^2$ on the curve and calculate the radius of curvature with the equation $R=1/(2a)$.

Radius of curvature: $R = \dots \text{mm}$

Compare it with the Petzval curvature of the lens: $R_p = f/n$ (f-focal lengths, n-refractive index of the lens)

Petzval curvature: $R_p = f/n = \dots \text{mm}$

Comment on why the Petzval radius is so different from your measurement?



Simulated field curvature for the planoconvex lens used in the experiments. On the left, in landscape orientation, the maximum field curvature is smaller than 0.5 mm and on the right values larger than 0.75 mm could be found. (T – tangential, S – sagittal)

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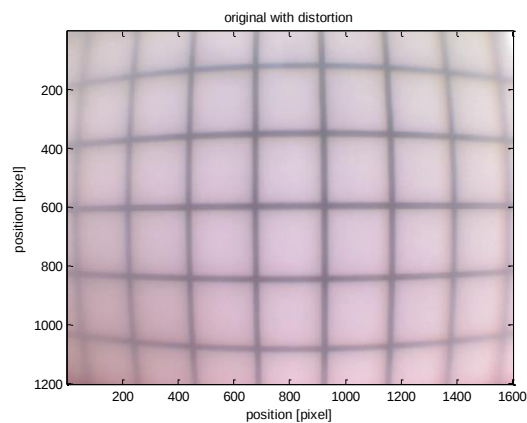
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Compare your result also with data given in the figure above!

3. Distortion and its correction by coordinate transformation

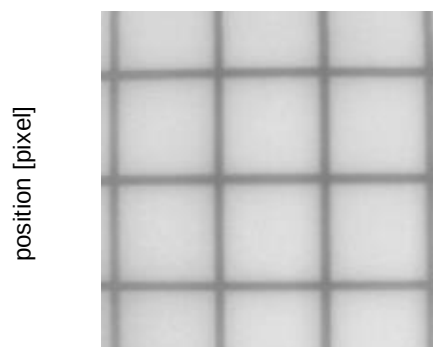
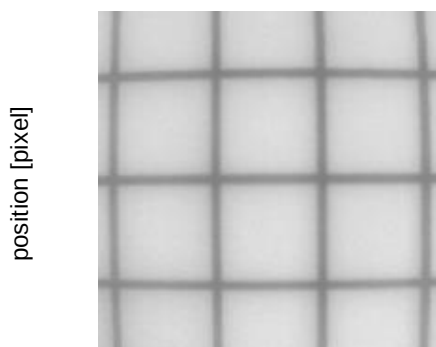
Show a series of images as given below. Try to find the best correction and **give the following values:**

- Position of the center of the transformation (called center_point_x; center_point_y in the matlab script)
- value of the correction (called "a" in the matlab script).



region of interest

distortion corrected



position [pixel]

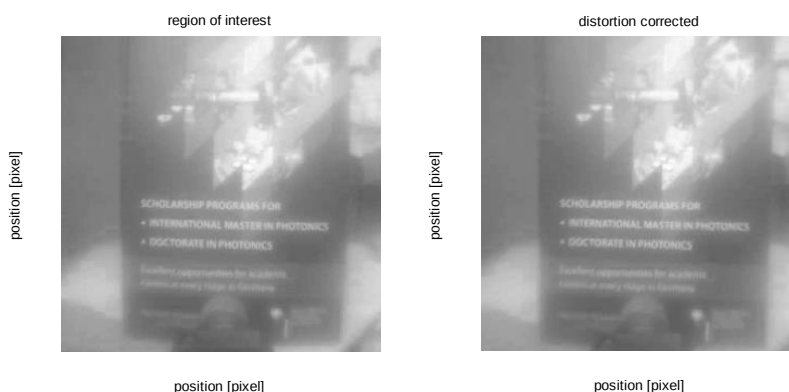
position [pixel]

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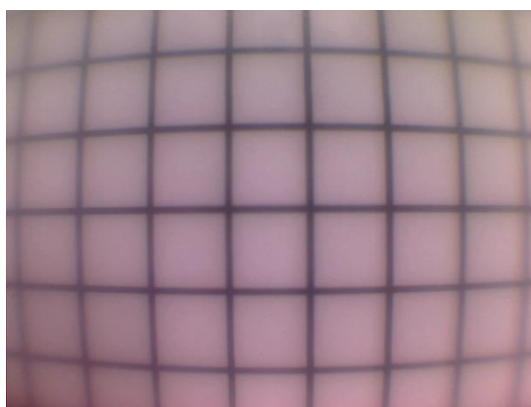
Comment on the meaning of the sign of the correction value.

Give a real image example by taking an image of a scene and make the correction.



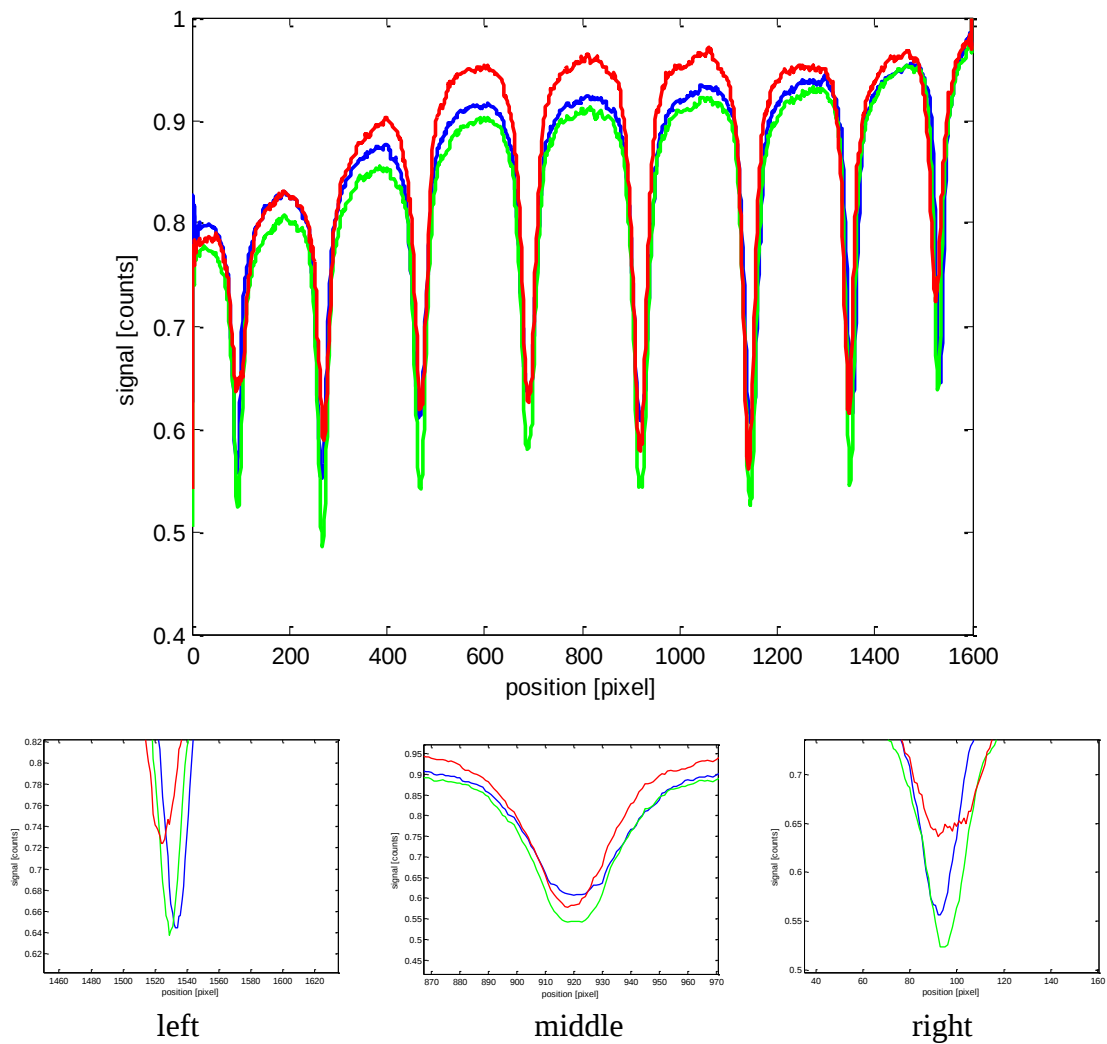
4. Observation of transversal chromatic aberrations for large field of views

Present two images and show transversal aberrations. Choose a convenient position in the image (middle) and plot the normalized line plot as given below. Use averaging to improve the quality of the measurement. Demonstrate the shift of the peaks for two positions (peaks) within the field of view by showing two graphs. Present a table that gives the peak positions for red, green and blue.



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NOTE: Your images might look different!!!

direction	Blue peak pixel position	Green peak pixel position	Red peak pixel position	Blue peak relative to position of center peak	Green peak relative to position of center peak	Red peak relative to position of center peak
left						
right						

Interpret your results!

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5. Example from the web

Find an image taken with a fisheye lens and print it into your report. Print also an image of the lens model as shown below so that one can read the parameters of the lens! Cite correctly!

**(Optional) Personal feedback:**

Was the amount of work adequate?

What is difficult to understand?

What did you like about it?

How can we do better?