Solutions to exam in Optical Physics 080114

1

The objective is aperture stop (and entrance pupil) and the field lens is field stop. The exit pupil is found by imaging the AS first through the eye lens:

$$s'_2 = \frac{s_2 f_2}{s_2 - f_2} = \frac{200\text{mm} \cdot 25\text{mm}}{175\text{mm}} = 28{,}57\text{mm} \Rightarrow s_3 = -8{,}57\text{mm} \quad \mathrm{M}_2 = \frac{1}{7}$$

$$s_3' = pss = -6{,}00\text{mm} \quad \mathrm{M}_3 = \frac{7}{10} \Rightarrow \mathrm{M}_{\text{tot}} = \frac{1}{10}$$

Exit pupil lies 6 mm after the eye lens and has a diameter of 0,4 mm.
To find the field of view we have to calculate the working distance

$$s_1' = 200\text{mm} \Rightarrow s_1 = \frac{s_1' f_1}{s_1' - f_1} = 5{,}13\text{mm och} \quad \frac{h_{field}}{h_{fieldlens}} = \frac{s_1}{s_1'} \Rightarrow h_{field} = 0{,}205\text{mm}$$

2

The plane at the working distance is obviously the front focal plane. The angle of the ray touching the rim of the AS is u=arctan (2 mm / 5,13 mm). If this ray is followed through the system it will have a distance of 0,2mm to the symmetry axis. The elongation of this ray intersects with the “rim ray” 0,513 mm outside (!) the focal plane. The system focal length is -0,513mm, and the magnification calculated with the loupe formula is 487.
Calculated with conventional microscope formulae

$$M_{obj} = \frac{200}{5{,}13} = 38{,}986 \quad M_{eye} = \frac{250mm}{20mm} = 12{,}5 \Rightarrow M_{tot} = 487$$

Nice!

3

Rayleigh on NA: $d = s_1 \frac{1{,}22\lambda}{D_1} = 1{,}57\lambda$

The exit pupil only gives an angle as the final image is in infinity, but we can always check what distance, d’, this corresponds to in the intermediate image.

$$\alpha = \frac{1{,}22\lambda}{D_{exitp}} \Rightarrow d' = \frac{f_{eyep} 1{,}22\lambda}{D_{exitp}} = 61\lambda \Rightarrow \frac{d'}{d} = 38{,}986 = M_{obj}$$

4-5

In the 0° and 90° cases light only goes in one of the arms and no interference can take place (visibility =0). In the 45° case the two beams that are rejoined in the beamsplitter have orthogonal polarizations and hence they do not interfere either: But the polarizer takes one component from each beam that are parallel with each other and have equal amplitude and the visibility is one

6

Paraxial rays (black)

$$\frac{n}{\infty} + \frac{1}{s'} = \frac{1-n}{-r} \Rightarrow s' = 2{,}43r$$

The most peripherical ray is the one borderlining to TIR (blue)

$$\sin(I_{\max}) = \frac{1}{n}$$

$$d = \frac{r}{\cos(I_{\max})} = \frac{r}{\sqrt{1 - \frac{1}{n^2}}} = 1{,}24r$$

Pretty large difference!