Solutions to exam in Optical Physics 081020

1

The eye is obviously the Aperture Stop and then the lens must be the Field Stop.
The field stop is not in an intermediate image plane and therefore there is vinjetting. The easiest thing is then to define the field of view with the ray that limits half illumination. This is the ray from the rim of the FS to the middle of the AS (chief ray). The angle of this ray to the symmetry axis is 20 mm / 200 mm = 100 mrad. All rays from the border point at the object are parallel between the lens and the eye, and also have the same angle as the ray from the border point to the center of the lens. The field of view is a circle with radius r = 80 mm x tan (100 mrad)=8 mm

2

The intermediate image is at infinity which situates the final image at z= 0 (same position as the object. It is magnified 4 times. Ray sketch required.

3-4

The stated wavelength spread gives a longitudinal coherence length of

$$L_{coh} = \frac{\lambda^2}{\Delta\lambda} \approx 130\lambda \approx 83\mu m$$

This creates restrictions but is not detrimental.
Considering longitudinal coherence, it can cause problems because the collimated field will everywhere contain plane waves with different directions (+- 200 µrad). This will cause the fringe pattern to vary frpm different points in the source, erasing all fringe structures denser than 2 x 200 µrad x path length = 0,5 mm (order of magnitude). If this would be unuseful the real Michelsson could be used, meaning a lens is placed after the recombination of the beams and the fringe pattern is observed in the back focal plane of the lens.

5

Even though the problem has circular symmetry it is bar far easiest to calculate in Cartesian coordinates

$$E_{far} \propto \iint_{startplane} \exp\left[-\left(x^2+y^2\right)/r_0^{\,2}\right] \exp i\frac{k}{L}\left(x\xi + y\eta\right)dxdy$$

Which can be separated in to a product of two integrals, one in x-direction and one in y

$$\text{Using } F\wedge(\exp(-at^2)) = const.\exp(-\omega^2/4a)$$

We get

$$E(\xi) = F\wedge(-\frac{x}{x_0^{\,2}}^{2}) = const\cdot\exp\left(-\frac{\kappa^2 x_0^{\,2}}{4}\right) = const\cdot\exp\left(-\frac{\pi^2\xi^2 x_0^{\,2}}{\lambda^2 L^2}\right) \Rightarrow$$

$$\xi_0 = \frac{\lambda L}{\pi x_0} \Rightarrow \theta = \frac{\xi_0}{L} = \frac{\lambda}{\pi x_0}$$

6

For 550 nm the phase difference is 2π giving no change in the state of polarization so no light of that wavelength passes the second polarizer (this part gives 0,2 p)
For 440 nm the phase difference is 5π/2 giving circular polaisation, and hence the transmittance is 0,5.