Fundamentals of Optical Sciences

WS 2017/2018 **1. Exercise sheet** **19.10.2017**

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Deliver your answers on 27.10.2017; discussed in the exercise on 01.11.2017.

Problem 1: Gaussian Beam

A Gaussian beam with $w_0 = 1$ cm is focused by a thin lens of focal length $f = 2$ cm. The lens is placed at the focus of the original Gaussian beam. Assume an optical wavelength of $\lambda = 1.0$ μm.

a) At what distance from the lens does the new focus occur?

b) What is the spot size at the new focus? Give numbers for both an ideal and a realistic lens.

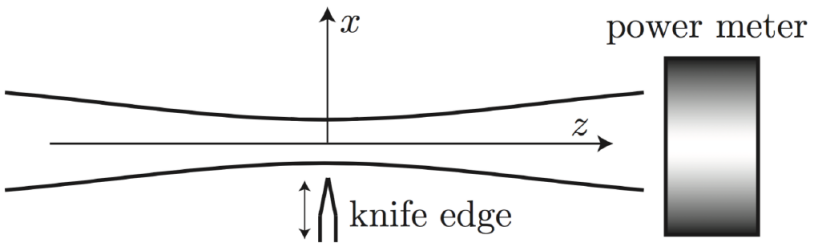
c) What is the far-field expansion angle?

Problem 2: Knife method

A common technique in the laboratory for measuring the beam waist parameter of a Gaussian beam is illustrated in the diagram. A Gaussian beam is incident on an optical power meter, which registers the total power of the incident beam. A knife edge can be translated in the transverse direction to block part of the beam (i.e., if the position of the knife edge is x_{knife}, then the part of the beam in the region $x < x_{\text{knife}}$ is blocked from reaching the power meter). The "10-90" rule is to measure the knife edge position $x_{10\%}$ where the power meter reads 10% of the total beam power, and then the position $x_{90\%}$ where the power meter reads 90% of the total beam power. Then the beam radius $w(z)$ at the knife-edge location z along the beam is given by

$$w(z) = \alpha \, |x_{10\%} - x_{90\%}|$$

where α is a constant factor. Calculate the numerical value of α.



Problem 3: ABCD method

Refraction at a spherical boundary

a) Derive the ABCD matrix for a refractive spherical boundary.

b) Find the determinant of the matrix.

Focussing a beam with a sphere

c) Use the spherical boundary matrix to find the focal length for glass bead. At what distance f is a ray parallel to the optical axis at $y = 0.8$ mm focussed behind a glass bead with diameter $d = 2$ mm?