

# Micro-optics

Winter semester 07/08

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## Exercise 12

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Discussion sections: Feb 06 & 07 2008

### 1 End-fire coupling (40)

Consider a small light source (e.g., a semiconductor laser) and a fiber. The fiber core has a diameter larger than the size of the emitting surface of the light source. The light source has an intensity of  $I_0$  and an angular emission characteristic described by  $I(\theta) = \frac{1}{\pi} I_0 \cos \theta$ .

#### 1.1 Small gap

The light source is mounted near the end facet of the fiber with a small air gap in between. Calculate the intensity collected by the fiber, and describe your result in terms of characteristic quantities of the source and the fiber!

#### 1.2 Butt coupling

Now, the source is bonded to the fiber core (i.e., without an air gap between source and fiber core). The refractive indices are  $n_g = 1.460$  and  $n_c = 1.455$  for the fiber and  $n_0 = 3.5$  for the light source.

Calculate the numerical aperture and the acceptance angle of the fiber and the intensity ratio between accepted and emitted intensity for both cases.

### 2 Fiber attenuation (15)

Given a fiber with losses of 0.17 dB/km; how far does a signal propagate until its intensity drops to half of its initial value?

### 3 Mode number (15)

The number of modes of a step index fiber may be approximated by

$$N_m = \frac{\pi^2}{2} \left( \frac{d \cdot \text{NA}}{\lambda_0} \right)^2.$$

Evaluate  $N_m$  for a fiber with  $n_c = 1.456$  and  $n_g = 1.460$  and a diameter of the core of  $d = 6.25 \mu\text{m}$  if the light is emitted by a LED with a center wavelength of  $\lambda_0 = 850 \text{ nm}$ . Compare the result to the respective number of an uncladded core.

### 4 Children's question (30)

Why does the sky appear blue? Why can we observe a red sky in the morning and in the evening?

Is celestial light polarized? If so, how and why?

**A task out of competition:** Conceive an experiment showing the same physical phenomenon using a glass, milk (Why milk? What does milk consist of?), water, and a white light source (e.g. halogen lamp). Do the experiment at home!

