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Laser Technology – Exercise Sheet 1

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1 Photons in a laser cavity

From an optical laser resonator (depicted in Fig. 1) of length L, light is outcoupled through the right mirror with a power reflection coefficient R. The outcoupled light has a power P_{out} and a wavelength λ. The gain medium inside the cavity has a refractive index n. The reflection coefficient R is formed by the interface between the semiconductor and air (n = 1), and thus obtained as $R = (n-1)^2 / (n+1)^2$.

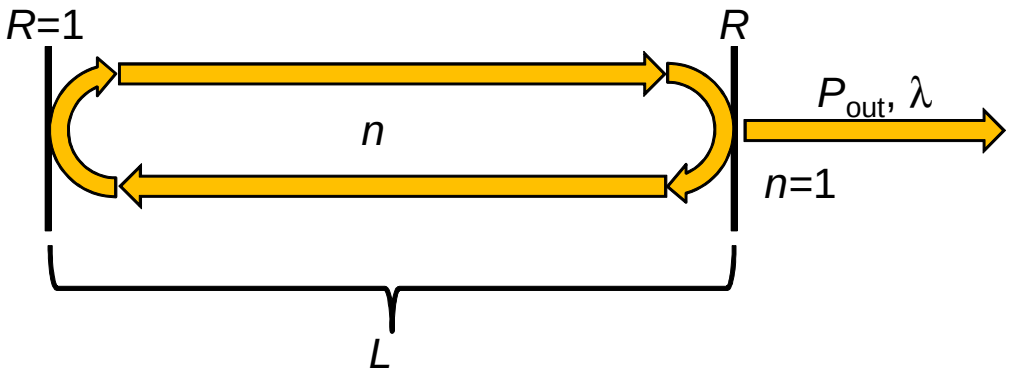

Figure 1 Schematic representation of the laser cavity.

a) How many photons per second are outcoupled from the cavity?

b) How many photons are in the cavity? Assume for the calculation that $(1-R) \ll 1$, and thus the power within the cavity can be assumed to be constant at different positions in the cavity.

c) Calculate these quantities for typical values of a semiconductor laser, L = 1 mm, λ = 670 nm, P_{out} = 5 mW, n = 3.3.

2 Gain saturation

The power dependent roundtrip gain is often modeled by $G = G_0 / (1 + P/P_{\mathrm{sat}})$, where G_0 is the small signal gain, P is the intracavity power and P_{sat} is the saturation power. The laser setup is as shown in Fig. 1, i.e., with outcoupling at the right side with a reflection coefficient R, and given G_0 and P_{sat}. The outcoupled power is P_{out}.

a) How big is P and P_{out} as a function of R? What is the maximum obtainable P_{out}, and for which R is it obtained? What is the maximum obtainable P, and for which R is it obtained?

b) Plot P_{out} as a function of R for typical values of a semiconductor laser, G_0 = 100, P_{sat} = 2 mW.