Problems in laser physics

Sheet 5

Handed out on 30. 11. 17 for the Tutorial on 11. 1. 18

Problem 13: Laser resonators and Gaussian beams (4P)

The stability of laser resonators can be explained by a simple geometrical argument on the radii of curvature (ROC) of the mirrors.

(a) Find out if the following resonators are stable (1P):

- A 100 mm ROC concave mirror and a 300 mm ROC convex mirror separated by 50 mm.
- Two 1 m ROC concave mirrors separated by 2.5 m.
- A flat mirror directly followed by a $f = 1$ m lens and a 400 mm ROC concave mirror separated by 300 mm.

Therein, ”concave” and ”convex” always refers to the interior of the cavity.
(b) Find the diameter and the position of the fundamental mode waist in a resonator consisting of two concave mirrors with $R_1 = 1$ m and $R_2 = 3$ m ROC separated by 0.8 m at a wavelength of 632.8 nm (1P).
(c) What are the beam diameters on the two resonator mirrors in (b)? (2P)

Problem 14: Resonators (4P)

For a Nd^{3+}:YAG laser ($\lambda = 1064$ nm) a confocal resonator with a mirror distance of 300 mm and a mirror diameter of 12.6 mm is used.

(a) Calculate the Fresnel number (1P).

(b) Calculate the diffraction losses for the fundamental mode and the first higher-order mode (1P).

(c) When we assume that the mirrors have a reflectivity of 99.8%, what is the resonance line width of that resanator and what is its finesse? (2P)

Problem 15: Laguerre-Gaussian beams (2P)

In the case of a confocal resonator with circular symmetric mirrors, the electric field distribution of the eigenmodes is given by the Laguerre-Gaussian modes. Their radially Gaussian shape is modulated by the Laguerre polynomials $L_p^l(x)$, which are given by the relation

$$L_p^l(x) = \frac{1}{p!} x^{-l} e^x \frac{d^p}{dx^p} (x^{p+l} e^{-x}) \; . \tag{1}$$

(a) Calculate the first three Laguerre polynomials $L_0^l(x)$, $L_1^l(x)$ and $L_2^l(x)$ (1P).
(b) Sketch the field distribution $\psi(x)$ and the intensity distribution $I(x) \propto |\psi(x)|^2$ for the circular symmetric $(0,p)$ modes TEM_{00}, TEM_{01} and TEM_{02} as a function of the radial coordinate.