

Mode matching - first try

Mirror configuration



Parameter

- Radius of curvature of mirror R1: $R_1 = 1 \text{ m}$
- Radius of curvature of mirror R2: $R_2 = \text{infinity}$ (Incoupling side)
- Wavelength: $\lambda = 1.55 \times 10^{-6} \text{ m}$
- Length between the resonator mirrors: $L = 485 \text{ mm}$
- Beam radius at waist: w_0
- Beam radius at mirror: w_1, w_2
- Stability parameter of the resonator: g_1, g_2
- Distance between mirror and the waist: t_1, t_2

Beam waist calculation from resonator

Step 1: Calculate the stability parameters

$$g_1 = 1 - \frac{L}{R_1} \quad ; \quad g_2 = 1 - \frac{L}{R_2}$$

Step 2: Calculate the beam waist radii on the mirrors

From thesis of Sana:

- Beam Radii, $1/e^2$ of the intensity

$$w_1 = \sqrt{L \cdot \frac{\lambda}{\pi}} \cdot \left(\frac{g_2}{g_1 \cdot (1 - g_1 \cdot g_2)} \right)^{1/4}$$

$$w_2 = \sqrt{L \cdot \frac{\lambda}{\pi}} \cdot \left(\frac{g_1}{g_2 \cdot (1 - g_1 \cdot g_2)} \right)^{1/4}$$

Alternative from rom Appl. Opt. 5, 1550 (1966):

$$w_1 = \sqrt{\frac{\lambda \cdot R_1}{\pi}} \cdot \left(\frac{(R_2 - L) \cdot L}{(R_1 - L) \cdot (R_1 + R_2 - L)} \right)^{1/4}$$

$$w_2 = \sqrt{\frac{\lambda \cdot R_2}{\pi}} \cdot \left(\frac{(R_1 - L) \cdot L}{(R_2 - L) \cdot (R_1 + R_2 - L)} \right)^{1/4}$$

$$w_0 = \sqrt{\frac{\lambda}{\pi}} \cdot \left(\frac{L \cdot (R_1 - L) \cdot (R_2 - L)}{(R_1 + R_2 - 2 \cdot L)^2} \right)^{1/4}$$

In our case:

$$w_2 = w_0$$

Step 3: Calculate the distance of beam waists on the mirrors and focus

Position of the beam waist on the two mirrors:

$$t_1 = L \cdot \frac{R_2 - L}{R_1 + R_2 - 2 \cdot L} \quad t_2 = L \cdot \frac{R_1 - L}{R_1 + R_2 - 2 \cdot L}$$

In our case: $L = t_1 + t_2$ and $t_2 \approx 0$

Step 4: Calculate the focal length of your collimator

Take the radii on the plane $w_2 = w_0 = 496.567 \mu\text{m}$ and curve mirror $w_1 = 691.95 \mu\text{m}$ and calculate the focal length f : $f = D \cdot \left(\frac{\pi \cdot w}{4 \cdot \lambda} \right)$ D is the beam waist diameter of the collimated beam after the collimator and w is mode beam diameter of the fiber output. In our case is: $D = 2 \cdot w_0$ The diameter from the light, which comes out of the fiber (1550 nm) is $w = 10.5 \pm 0.5 \mu\text{m}$. That gives us a focal length $f = 5.32044 \text{ mm}$.

Step 4b

We did the calculation wrong. 😞 We used $D = w_0$ and got $f = 2.66022 \text{ mm}$.

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