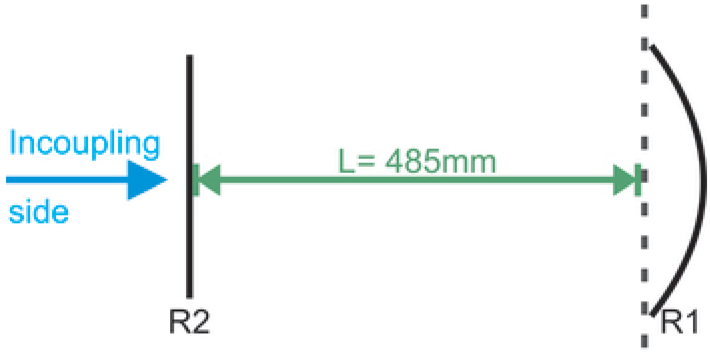
Mode matching

Literature



- Laser Beams and Resonators
  H. Kogelnik et al., Applied Optics **5**, 1550 (1966)
- Determination and optimization of mode matching into optical cavities by heterodyne detection
  G. Mueller et al., Optics Letters, Vol. **25**, No. 4 (2000)

Mirror configuration

Parameter

- Radius of curvature of mirror R1: R1= 1 m
- Radius of curvature of mirror R2: R2= infinity (Incoupling side)
- Wavelength: λ= 1.55×10^-6 m
- Length between the resonator mirrors: L= 485 mm
- Beam radius at waist: w0
- Beam radius at mirror: w1, w2
- Stability parameter of the resonator: g1, g2
- Distance between mirror and the waist: t1, t2

Beam waist calculation from resonator

Step 1: Calculate the stability parameters
$$g_1=1-\frac{L}{R1} \;\text{and}\; g_2=1-\frac{L}{R2}$$

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 R1}{\pi}}\cdot \left(\frac{(R2-L)\cdot L}{(R1-L)\cdot(R1+R2-

L)}\right)^{1/4}$$ $$w_2 = \sqrt{\frac{\lambda\cdot R2}{\pi}}\cdot \left(\frac{(R1-L)\cdot L}{(R2-L)\cdot(R1+R2-L)}\right)^{1/4}$$ $$w_0 = \sqrt{\frac{\lambda}{\pi}}\cdot \left(\frac{L\cdot(R1 - L)\cdot(R2 - L)\cdot(R1 + R2 - L)}{(R1 + R2 - 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{R2 - L}{R1 + R2 - 2\cdot L}$$ $$t_2 = L\cdot\frac{R1 - L}{R1 + R2 - 2\cdot L}$$
In our case: $$L=t_1+t_2$$ and t_2 is ≈0

Step 4: Calculate the focal length of your collimator

Take the radii on the plane w_2=w_0=496.567µm and curve mirror w_1=691.95µm and calculate the focal length f: $$f=D\cdot \left(\frac{\pi\cdot w}{4\lambda}\right)$$ 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+/-0.5µm. That gives us a focal length f= 5.32044mm.

Step 4b

We did the calculation wrong. We used D=w_0 and got f=2.66022mm.