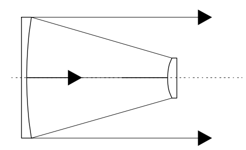
LASERS

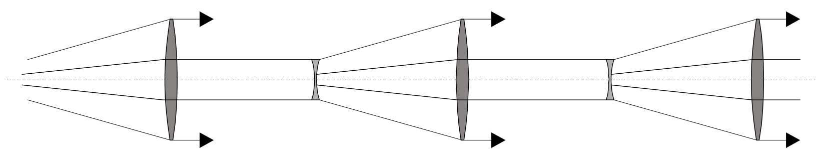
Empty hard-edge unstable laser resonator.

Introduction

$mrad \equiv 10^{-3} \cdot rad$ $\qquad$ $nm \equiv 10^{-9} \cdot m$

The unstable resonator can be simulated starting with an arbitrary field that circulates between the mirrors towards a steady state solution. In this example we simulate a positive branch, confocal unstable resonator. In stead of mirrors, we use a lens-guide of alternating positive and negative lenses, separated a distance, L, the resonator length.





Unstable confocal resonator and its equivalent lens guide.

The simulation

$$
F := \left|
\begin{array}{l}
K \leftarrow LPBegin\left(\frac{size}{m}, \frac{\lambda}{m}, N\right) \\
K \leftarrow LPRandomIntensity(8, K) \\
K \leftarrow LPRandomPhase(13, 1, K) \\
\text{for } i \in 0..n \\
\quad \left|
\begin{array}{l}
K \leftarrow LPRectAperture\left(\frac{R}{m}, \frac{R}{m}, 0, 0, 0, K\right) \\
K \leftarrow LPLensForvard\left(\frac{f_1}{m}, \frac{L}{m}, K\right) \\
K \leftarrow LPLensForvard\left(\frac{f_2}{m}, \frac{L}{m}, K\right) \\
K \leftarrow LPTilt\left(\frac{t_x}{rad}, \frac{t_y}{rad}, K\right) \\
K \leftarrow LPNormal(K) \\
Norm_i \leftarrow K_{N,6} \\
K \leftarrow LPInterpol\left(\frac{size}{m}, N, 0, 0, 0, 1, K\right) \\
F_i \leftarrow K
\end{array}
\right. \\
\begin{pmatrix} F \\ Norm \end{pmatrix}
\end{array}
\right.
$$

Extract the results, calculate the output intensity and phase distributions

Here we extract the calculated fields and the normalisations of the field from the solution structure, F:

$i := 0 .. n \qquad Field := (F_0) \qquad Normal := F_1$

After the field inside the resonator has been calculated we convert to normal coordinates and screen the field with a rectangular screen to calculate the outcoupled (near) field:

$Field_i := LPConvert(Field_i) \qquad Field_i := LPRectScreen\left(\frac{R}{m}, \frac{R}{m}, 0, 0, 0, Field_i\right)$

Calculation of the near-field intensity for each round trip:

$I_i := LPIntensity(2, Field_i)$

Simulation parameters

The simulation has been done using the following parameters:

number of grid points: $N \equiv 100$

grid size: $size \equiv 32 \cdot mm$

wavelength (XeCl excimer laser) $\lambda \equiv 308 \cdot nm$

focal length negative lens (concave mirror): $f_1 \equiv -1.5 \cdot m$

size of the convex, rectangular mirror: $R \equiv 8 \cdot mm$

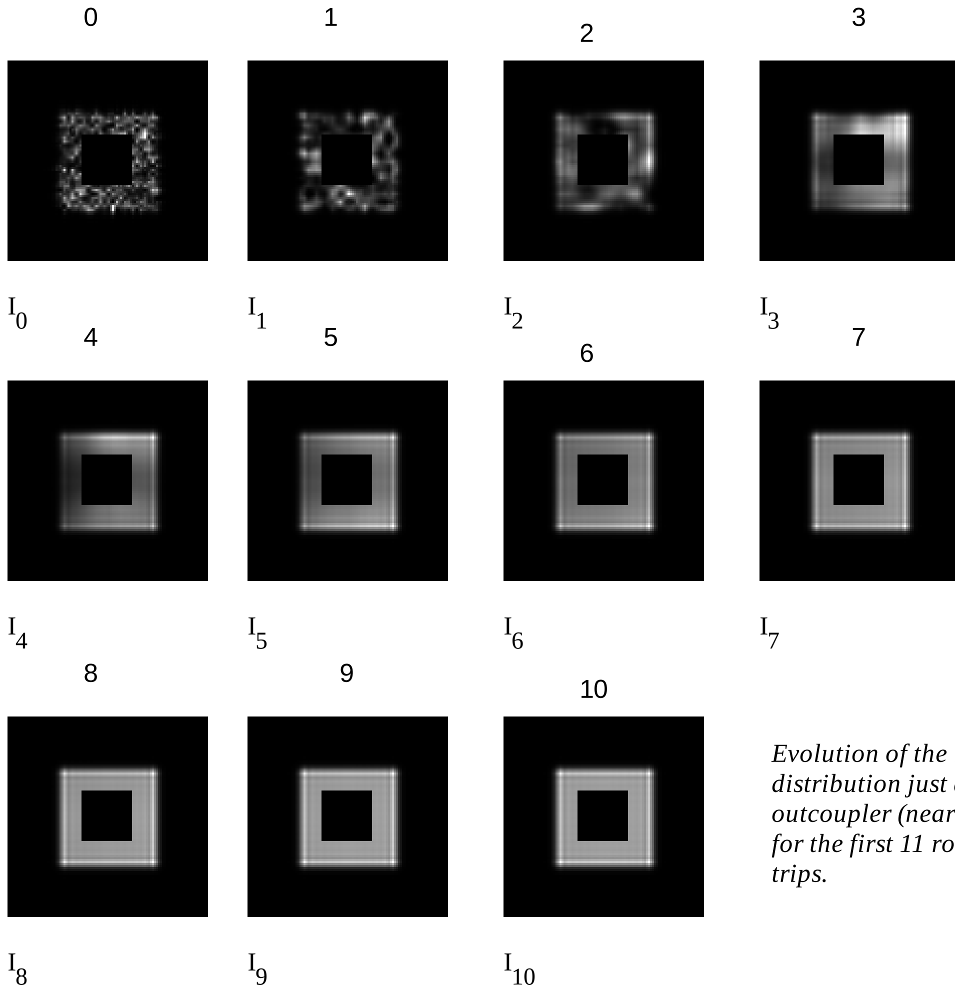
focal length positive lens (convex mirror): $f_2 \equiv 3 \cdot m$

resonator length: $L \equiv 1.5 \cdot m$

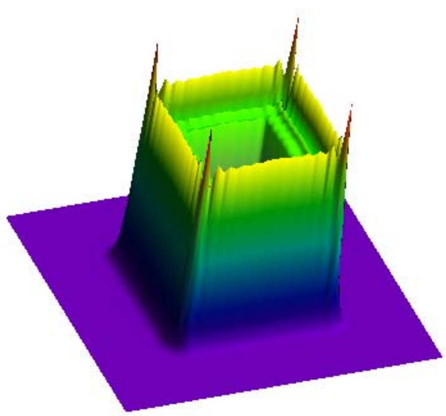
number of roundtrips calculated: $n \equiv 30$

mirror mis-alignment: $t_x \equiv 0.0 \cdot mrad$, $t_y \equiv 0.0 \cdot mrad$

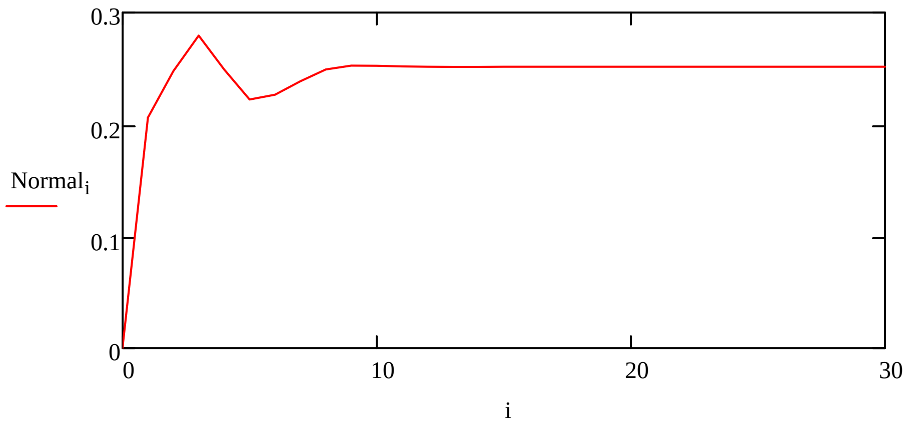
Results



Evolution of the intensity distribution just after the outcoupler (near field) for the first 11 round trips.



Intensity distribution just after the outcoupler.



Normalisation coefficient as a function of the number of round trips.

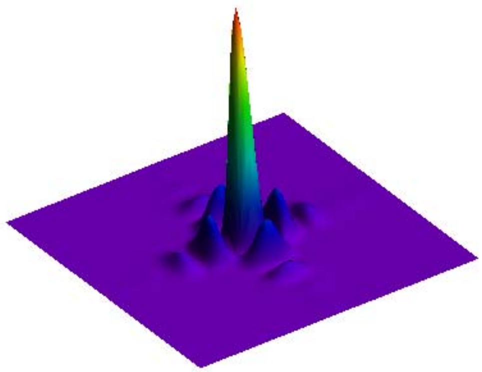
Calculation of the far field

Here the trick with coordinate transfer is used: first we define the field in a "small" region then we apply a weak positive lens then we apply coordinate transfer equivalent to a weak negative lens (resulting in a plane wave in divergent coordinates and then we propagate it. As the coordinates are divergent, the output field is wide enough to to match the diffracted pattern Without this trick the input grid would be too coarse

$f := 150m$

$Field_i := LPLens\left(\frac{f}{m}, 0, 0, Field_i\right)$ $Field_i := LPLensFresnel\left(-\frac{500f}{m}, \frac{f}{m}, Field_i\right)$

$I := LPIntensity\left(2, Field_n\right)$



Calculation of the far field using spherical coordinates