

Scenario 0508 (2.0)

# Mode Analysis of Laser Ring Resonator

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**Requirements:** VirtualLab 6.2 – Starter & Laser Resonator Toolbox

# Abstract

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- This scenario shows the mode analysis of a laser ring resonator using the Fox&Li Algorithm.
- Therefore a single resonator round trip is built up in the Light Path Diagram of VirtualLab.
- Then the external module

`Sc508_ModeAnalysis_LaserRingResonator_2_Module_Fox-Li.cs`

is applied to calculate the most dominant transversal resonator eigenmode.

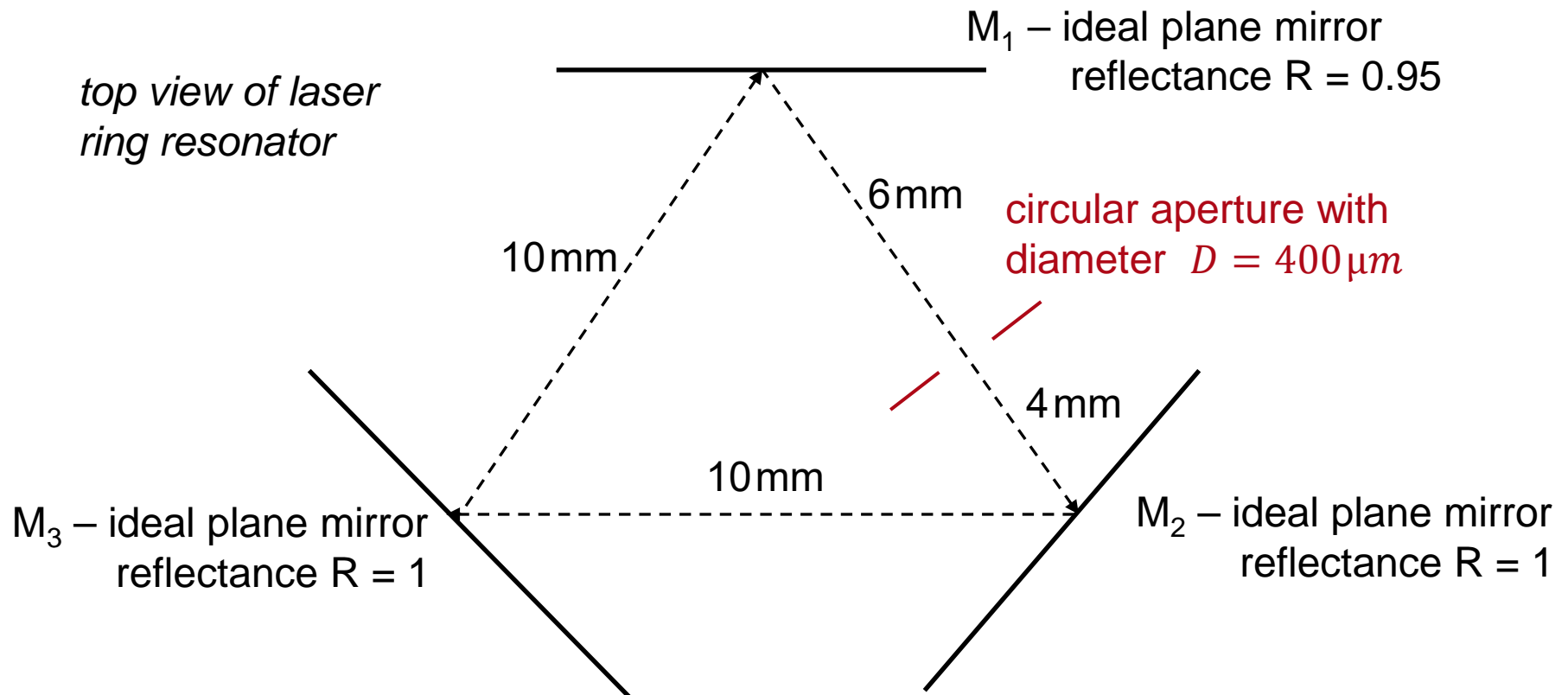
# Important Notes

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- Please note that you are running VirtualLab in **administrator mode**. Otherwise the external module will not work.
- Please ensure that all files, which are involved in the calculation are stored in the same folder.

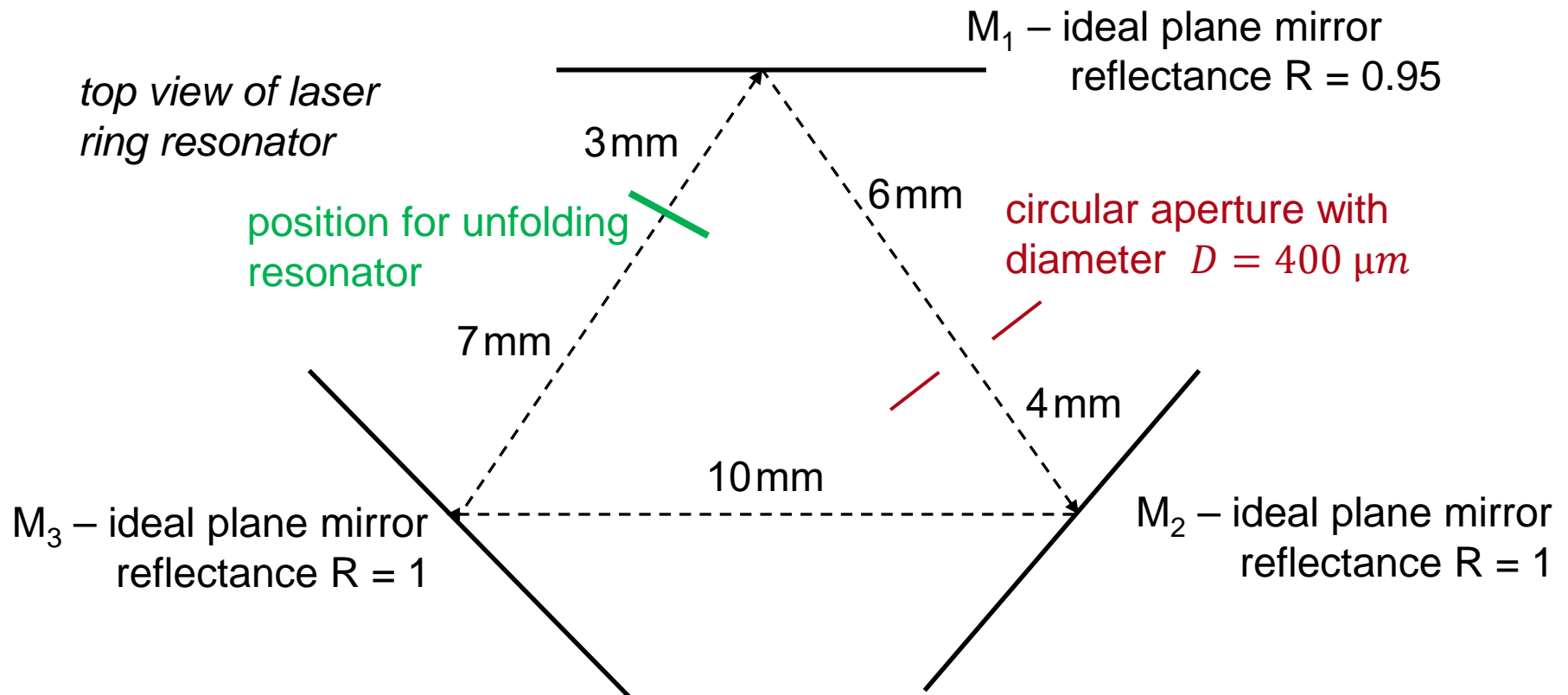
# The Simulation Task

- Calculation of the most dominant transversal eigenmode of the following laser ring resonator.



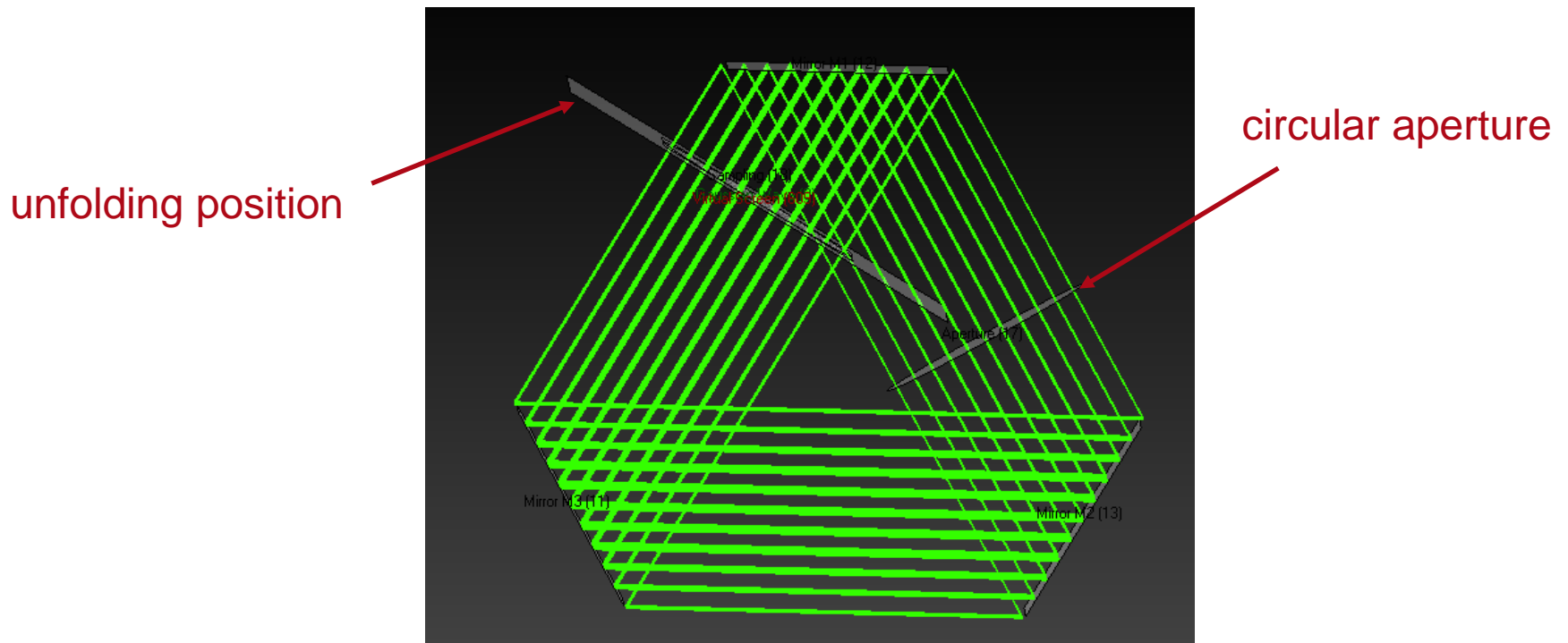
# The Simulation Task

- To build up a single resonator round trip we have to unfold the ring resonator setup at the position we like to calculate the eigenmode.



# Building Up Single Resonator Round Trip

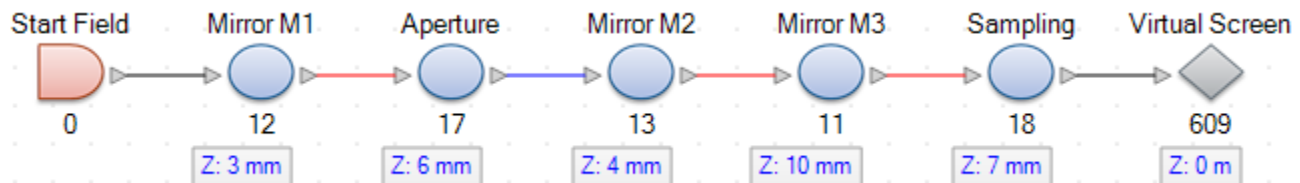
- To build up a single resonator round trip we have to unfold the ring resonator setup at the position where we like to calculate the eigenmode.



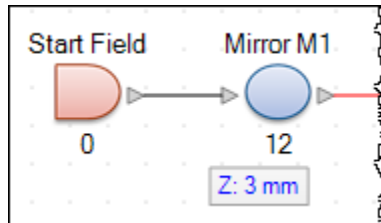
*top view of ray trace through ring resonator*

# Building Up Single Resonator Round Trip

- In the Light Path Diagram (LPD) the single round trip is looks like the below depicted screenshot.
- After the first round trip the field obtained in the Virtual Screen will be stored in the start field component by the Fox-Li module and the next round trip will be calculated.  
**This step will be repeated iteratively.**



# Start Field

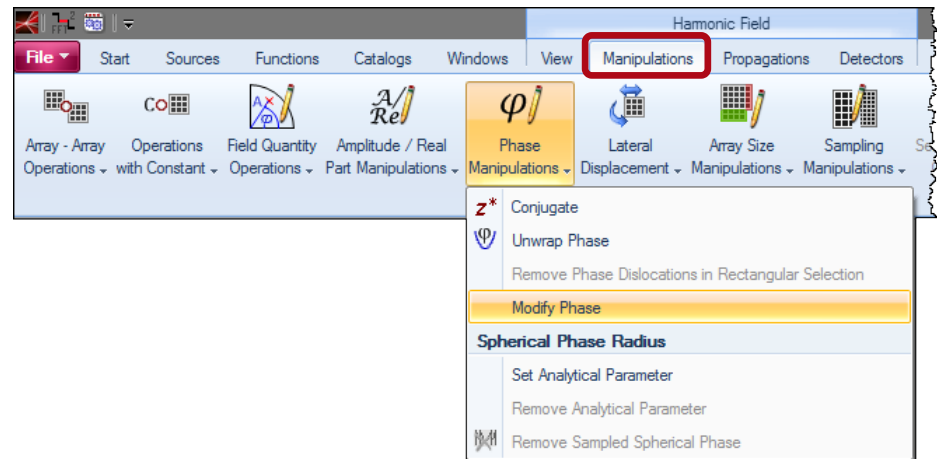
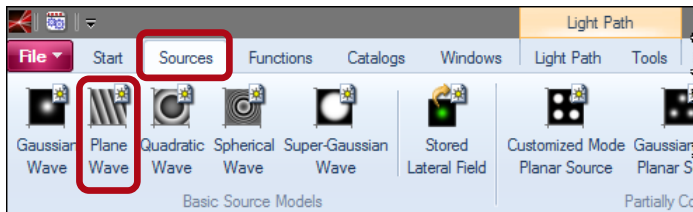


- Any monochromatic light source which is available in the light path diagram can be used as the starting condition of the Fox&Li algorithm.
- To ensure fast convergence of the eigenmode a good initial guess should be used. This guess can be e.g. the expected dominant eigenmode of the resonator system.



# Advanced Start Fields

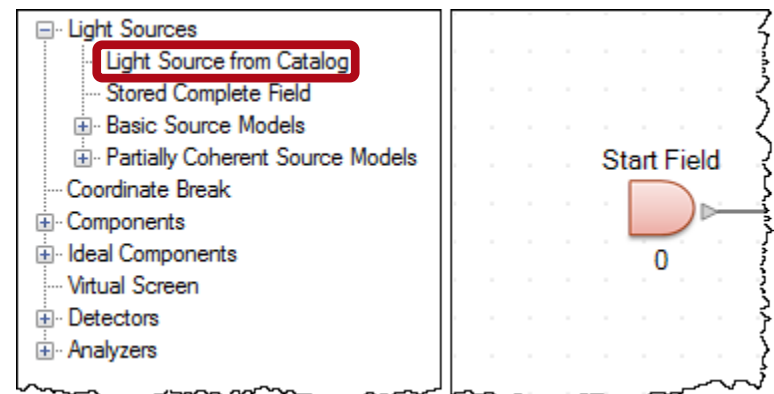
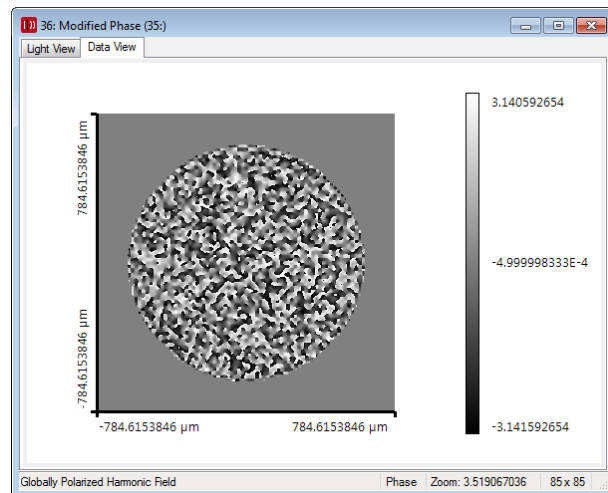
- For plenty of optical resonators also a plane wave multiplied with a random phase-only transmission function is a good starting field.
- You can create such field by clicking on **Sources > Basic Source Models > Plane wave**.
- Random phase-only transmission function can be multiplied by clicking on **Manipulation (see red box) > Phase modification > Modify Phase > Random Phase**



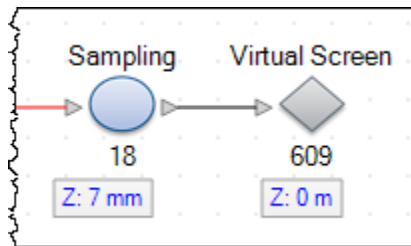
# Advanced Start Fields

- Random phase field can be loaded in the Light Path Diagram using the Stored Complete Field Light Source.

*Phase of plane wave multiplied with random-phase only transmission function*



# Sampling of Round Trip Operator



- To ensure a correct sampling please always place directly in front of the Virtual Screen a sampling component and manually choose a sufficient sampling distance and computational domain size.

# The Fox-Li Algorithm

Load the module `sc508_ModeAnalysis_LaserRingResonator_2_Module_Fox-Li.cs`. The following parameters can be chosen in the module:

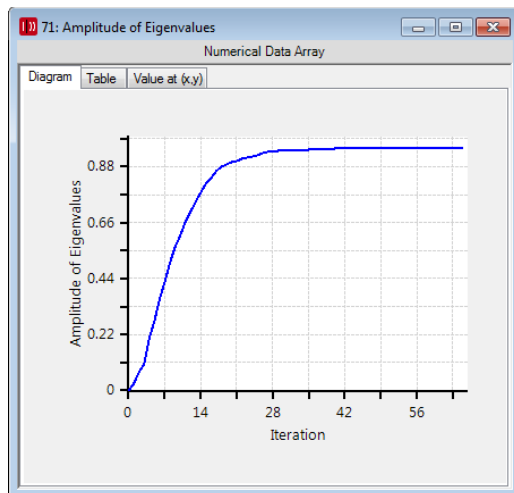
Parameter	Description
MaximumIteration	Gives the maximum number of iterations for the Fox-Li-Algorithm
Tolerance	Gives an convergence criteria of the eigenvalue amplitude when the iterations of the Fox-Li-Algorithm are stopped
normalizeField_power	If true: enables normalization of field before each iteration. In the absence of amplifying media, this is necessary to avoid that the field energy inside the resonator drops to zero due to resonator round trip losses.
roundtripPower_on	If true: enables logging of output power. In the absence of amplifying media, this parameter should be switched to false.
IncrementStoredField	Gives the number of subresults to be shown. For example 5 means that after every 5 <sup>th</sup> iteration the intermediate result will be shown in a separate window.

The parameters *Simulation.InstableAnalysis* and *Simulation.ShowLPDForUnstableAnalysis* will be explained in an upcoming application scenario. Default values should be false for both parameters.

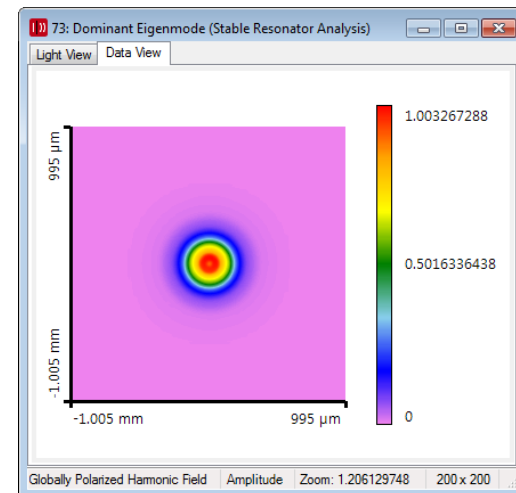
# Results

- After executing the Fox-Li algorithm module by pressing the **GO!** - button, VirtualLab calculate the most dominant eigenmode.
- Please note that we have chosen as a start field a fundamental Hermite Gaussian Mode.

*evolution of eigenvalue amplitude*



*most dominant transversal eigenmode of ring resonator setup*



# Summary

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- VirtualLab can do a wave-optical simulation of laser ring resonators using a Fox-Li algorithm.
- Therefor the resonator round trip operator can be easily build up in the Light Path Diagram.
- The field tracing concept allows plenty of different propagation techniques for the calculation of the round trip operator.