A Quick Tour of LASCAD™

This Quick Tour is guiding you through the main features of LASCAD. It shows how fast a resonator can be configured by the use of the GUI, and how to experiment with different cavity parameters. It is helping to get started, but it does not replace the manual, which is found in the directory "Documentation" on the CD-ROM, or in the subdirectory "Documentation" of the LASCAD application directory after installation. For limitations of the demo version, please open the item "Help/Demo Limitations" in the LASCAD main menu, or refer to the last section of the manual.

After starting LASCAD the window **"Select Working Directory"** is popping up asking you to define a working directory. Click okay and then click the item **"File / New Project"** in the LASCAD main menu or alternatively the left most button in the tool bar, or just press the "ENTER" key. A dialog appears in which you can define the type of simulation and the number of elements. For the present purpose let it unchanged and click **"OK".**

Two windows are popping up. The upper one is showing the gaussian mode shape for a simple 2 mirror resonator, the lower one a field with the parameters of the resonator. The type of analysis, in the present case "Standing Wave Resonator", is indicated in the caption of the upper window. To get a nice graphical appearance the mode shape is visualized by 5 lines, the top line is related to the scale to the left of the plot.

The optical elements, presently just 2 mirrors, are represented by vertical lines and the following symbols:

mirrors	filled rectangular triangles
dielectric interfaces	open rectangular triangles
lenses	filled isosceles triangles

Click on one of the vertical lines - but not on the number box - and drag the line to a desired new position. After releasing the mouse button the new mode shape is computed and plotted immediately.

Horizontal extension and position of the mode plot can be changed by the use of controls arranged below the mode plot window.

The "**Shrink and Stretch**" buttons change the horizontal extension of the plot.

The "**Scroll Bar"** moves the mode plot to the left or right hand side.

The "**Adjust Length**" box at the lower left corner of the mode plot window fits the diagram to the lengths of the picture box. Uncheck this box to switch off automatic horizontal adjustment. The vertical extension of the plot can be adjusted by checking the "**Adjust Diameter**" box. Unchecking this box prevents automatic adjustment of the plot to the height of the picture box.

To **insert an additional element**, press the **"SHIFT"** key and click into the mode plot between two vertical lines. The dialog **"Insert Element"** is shown. Into the boxes of this dialog you can enter parameters of the new element. In addition to the parameters describing the element itself also the parameters of the medium at the left hand side of the element can be defined. The pull down box in the first row allows for selecting from different types of elements. The present version is offering lens, mirror, and dielectric interface. Choose "lens" and click the "OK" button. After clicking "OK" a lens element with a focal length of 21 mm is inserted between the 2 mirrors.

To change the focal length of the inserted lens click the second box in the row **"Type-Param.:"** of the window **"Parameter Field"**, enter a new focal length, and click the **"Apply"** button or press the **"Enter"** key. The replotted mode shape reflects the effect of the changed focal length. Like the other elements also the inserted lens element can be dragged to a new position by the use of the mouse. The **"Type Parameter"** depends on the type of the element; it corresponds to the radius of curvature in the case of a mirror or a dielectric interface, or to the focal length in the case of a lens.

Instead of using numerical input a parameter also can be changed by the use of the **slider** being found below the mode plot box. When a box in the parameter field is clicked on, the related parameter for instance the focal length of the lens is connected to this slider, and can be changed by moving the slider. The name of the parameter is specified in the box left most of the slider, its value in the yellow box next to the right. The third box to the right determines a percentage range within which the parameter can be modified. By default, it is set to ±50% of the original parameter value, but another value can be entered. While moving the slider you can watch the actual value of the parameter in the yellow box. After releasing the mouse button the mode shape corresponding to the changed parameter value is plotted. Clicking into the parameter or the percentage box centers the slider at the actual value of the parameter.

Click the tab **"y-plane parameters"** in the window **"Parameter Field"** to show parameters of the y-z-plane of the cavity. For all of them **astigmatism** can be set. As an example a cylindrical lens can be defined by entering a big value into the box for the y-plane focal length. After confirmation with the "Enter" key, the background of the corresponding box becomes blue, and the mode plot box splits up into two boxes. The upper one is showing the x-z-plane mode shape, the lower one the y-z-plane mode shape. For an astigmatic parameter the y-plane value remains unchanged, when the x-plane value is changed, otherwise it follows the x-plane value. To **remove astigmatism** of a parameter **press the "CTRL" key**, and click into the related blue box. This resets the y-z-plane value back to the x-z-plane value.

To **clear an element** press the **"CTRL"** key and click with the mouse on the corresponding vertical line – not the number box.

To insert elements outside the cavity, reduce in advance the horizontal scale of the plot or shift it to the left or right hand side.

Click the tab **"Spot Size Results"** to show the gaussian spot sizes at the positions of the optical elements. According to common use, the gaussian spot size is the distance from the beam axis where the intensity is dropping to $1/e^2$.

A Green or red background of the boxes is distinguishing spot sizes belonging to the wave front propagating from left to right or from right to the left, respectively. If no gain is present the shapes of the beams propagating in opposite directions are identical. If however a value different from zero is entered into one of boxes "Gain Parameters" in bottom row of the window "Parameter Field" the curvature of the wave front is modified dependent on the direction of propagation. Therefore, also the results for the spot sizes depend on the propagation direction. A non-vanishing gain parameter prevents the cavity from becoming unstable, a property which is useful when you are playing with different configurations.

To show spot sizes at arbitrary positions, click in the mode plot window the menu item **"Show Additional Items/ Beam Parameters"** to open the window **"Beam Parameters ..."**, and drag the magenta vertical bar from the right end over the mode plot. In addition to the spot size, parameters like size of virtual beam waist and divergence are shown at the position of the drag bar.

Additionally click the menu item **"Show Additional Items/Transverse Gaussian Mode Profile"** to open the window **"Mode Profile"** which shows the mode profile at the actual position of the drag bar. The UpDown-controls **Mode TEM**

n0 and **Mode TEM 0m** found in the lower right corner allow for showing higher order Hermite–Gaussian modes.

To show the mode shape for a beam quality parameter $M^2 > 1$ click the Tab **"Miscellaneous"** in window "Parameter Field" and enter a new value into the related number box. Alternatively, you can click the tab **"Apertures"** to define apertures, and then check the box **"Use x(y)-plane apertures ..."** to determine the maximum M^2 possible within the defined apertures.

In addition to the mode inside the resonator you can show the beam leaving the resonator through the right mirror by checking the option button **"Mode + External Beam"** below the mode plot window. Like inside the resonator also outside additional elements can be inserted into the propagation path of the beam. The option button **"External Beam only"** allows showing the external beam only.

To insert a thermally lensing crystal into the resonator, crystal dimensions, material parameters etc. must be defined first. Click the item **"FEA / Parameter Input & Start of FEA Code"** in the LASCAD main menu to open the window **"Crystal, Pump Beam, ..."**. This window is showing six tabs, which can be opened to define dimensions of the crystal, pumping and cooling configuration, and to control the Finite Element Analysis (FEA) as described in detail in sections 4.2. and 6.10. of the manual.

For the present purpose we use the default settings for an end pumped cylindrical Nd:YAG crystal. To have a look at the pump profile click the tab **"Pump Light"** and then the button **"Show Pump Light Distribution"** to open the graphics window **"Pump Beam Profile"** which is showing the absorbed power density. To start the FEA press the button **"Apply & Run FEA"** . A window is popping up showing the progress of computation. With the button **"Skip"** thermal or structural analysis can be stopped after the actual iteration step in order to proceed to structural analysis or to finish the computation, respectively. If at the end of the computation the message "FEA finished successfully" appears, press **"OK"** to close the dialog.

For graphical visualization of the FEA results click **"FEA / 3D Visualizer"** in the LASCAD main menu to open the related window. Use the dropdown button leftmost in the toolbar of this window to select a physical quantity like heat load, temperature etc. to be shown. The other buttons of the toolbar, which are almost self-explaining, are described in the manual. Objects can be rotated, shifted, and zoomed by the use of the three mouse buttons, but also use of a 2-button mouse is possible in combination with the toolbar. The results of FEA are stored in files in the subdirectory **"FEA"** of the working directory.

To use the FEA results with the ABCD matrix code the temperature distribution is multiplied by the derivative of the refractive index versus temperature. The obtained thermally induced distribution of the refractive index is being fitted parabolically at right angles to the optical axis using the finite element mesh subdivisions. Similarly, a fit of the deformed end facets of the crystal must be carried through. Click **"FEA / 2D Data Profiles and Parabolic Fit"** in the main menu to open the dialog **"2D Data Profiles and Parabolic Fit"**. This window is showing diagrams displaying the temperature distribution at different cross sections perpendicular to crystal axis. To show other items please refer to section 6.13 of the manual for further instructions.

Click **"Refresh & Fit"** to carry through the parabolic fit. A graphical representation of the fit is being shown now, and simultaneously, a yellow information window is popping up. According to the instructions given in this window, **press the "ALT"** key and click in the mode plot into the field where the crystal shall be inserted. A yellow-ocher colored symbol for the thermally lensing crystal is being inserted. The length of the field is adjusted to the length of the crystal as defined in tab **"Models"** of the window **"Crystal, Pump Beam, ..."**. The elements at both ends of the field are transformed into the end faces of the crystal. Like the other elements also the crystal can be dragged with the mouse to an other position. To **clear the thermal lens** press the "CTRL" key and click into the crystal.

For cases where parabolic approximation and ABCD matrix code are not sufficient the **FEA results can alternatively be used as input for a physical optics code** based on the beam propagation method (BPM). This code provides full 3D simulation of the interaction of a propagating wave front with the hot, thermally deformed crystal, without using parabolic approximation. The mode structure of the resonator is computed by the use of a Fox and Li type iteration procedure, which propagates a wave front in small steps iteratively between the end mirrors of the resonator. To get started with this code click the item **"BPM / Run BPM"** in the LASCAD main menu. It opens the window **"Beam Propagation Method"** where you can define several parameters controlling the execution of the BPM code as described in section 6.16 of the manual. For the present purpose use the default values, and click the button **"Run BPM"** to start the BPM code. A window is popping up asking you if input files needed by the BPM Code shall be overwritten or not. After clicking "yes" or "no" the window **"BMP"** is opened, which has its own menu and several child windows as explained in section 7 of the manual. If a thermally lensing crystal is present in the cavity, first the FEA results are interpolated with respect to the BPM grid. After interpolation is finished a Fox and Li type iteration starts, which is being recorded in the child window **"BPM_Output"**. After the first iteration a 2D Array Visualizer window is opened*) showing a plot of the intensity profile at the right end mirror. The profile is redrawn periodically after every round trip of the wave front. In addition, the window **"Convergence of Beam Radius with Cavity Iteration"** is shown, which is a child of the LASCAD main window. It shows the spot size at the right mirror as it develops with increasing number of cavity iterations. All files created by the BPM code are stored in the subdirectory **"BPM"** of the working directory.

To show intensity and phase distribution after the BPM is finished click the item **"BPM / Show Beam Profile"** in the LASCAD main menu as described in section 6.18. of the manual.

According to the intention to give a short introduction, not all features of LASCAD could be described in this Quick Tour. The reader is referred to the manual or to the tutorials which can be found in the directory "Tutorials" on the CD-ROM. Examples are provided into the directory "Examples" on the CD-ROM. The directories "Tutorials" and "Examples" also are being copied to the LASCAD application directory during installation.

Additional information can be found in the Power Point file "introduction.pdf" on the CD-ROM.

And now, please enjoy working with LASCAD!

*) If you have problems running the Array Visualizer showing the intensity distribution, please refer to "readme.txt" in the subdirectory “Documentation” of the LASCAD application directory.