How to Work with the Programmable Medium and Example (Thermal Lens)
Abstract

Providing maximum versatility is one of our most fundamental objectives. A key aspect of this aim is to provide a flexible-enough definition mechanism of the refractive index, in order to achieve a realistic characterization of the matter which composes an optical system. In VirtualLab Fusion this role is left to Materials and Media: the first deal with the dependence of the refractive index on wavelength (dispersion), the second group take care of the dependence on position. Here we bring you a tutorial that explains how to program your own custom media.
Where to Find the Programmable Medium: Catalog

Note that the Programmable Material is also accessible at any point during the construction of a system when a medium must be entered for the configuration!
Writing the Code

- The panel on the right shows a list of available independent parameters.
- **BaseMaterial** refers to the material which is used to define the dispersion (wavelength-dependence) of the refractive index of the medium.
- **Temperature** and **Pressure** are parameters whose value is fixed in the configuration of the optical system.
- **x**, **y** and **z** span the volume of the medium. Any inhomogeneity in the medium will be simulated by programming a function which depends on at least one of these three parameters.
- The parameter **Wavelength** permits the user to access the value of the wavelength.

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```c
double realPart = 0.0;
double imaginaryPart = 0.0;

/**************************** INSERT YOUR CODE HERE ****************************/

return new Complex(realPart, imaginaryPart);
```

**Hint:** the Global Parameters, Snippet Help, Advanced Settings tabs and other aspects of the interface work equivalently to those of other programmable elements in VirtualLab.
Change the Base Material (subsequently accessible in the code of the Programmable Medium) here. Use a Material from the Catalog, a constant value of \( n \), or a custom material!

The option Index Modulation adds the value of the refractive index of the Base Material to the value computed by the current snippet. Index Distribution directly defines the value of the refractive index.

Ticking the option Use Periodization activates additional global parameters in the snippet!
Programming a Thermal Lens
Thermal Lens

![Diagram of thermal lens](image)

**Fundamental Gaussian mode**

- **wavelength**: 632.8 nm
- **polarization**: linear in x-direction
- **waist radius**: 760 μm
- **input power** $P_{in}$: 8 to 20 kW

**Thermal lens refractive index distribution**

$$n(x, y) = n_0 - \frac{\eta P_{in}}{4K\pi d} \cdot \frac{\delta n}{\delta T} \cdot \frac{r^2}{r_0^2}$$

- $r_0$: 0.31 cm
- $K$: 11.1 W/(cm°C)
- $\eta$: 0.05
- $\delta n/\delta T$: $7.3 \times 10^{-6}$°C$^{-1}$

**Tasks**

1. **Task 1**: evaluation of the variation of focal length with varying $P_{in}$
2. **Task 2**: evaluation of the variation of beam size with varying $P_{in}$

---

1. **beam waist**
2. **input plane**
3. **focal plane**
4. **300 cm**
5. **d = 7.5 cm**
Note that the Programmable Material is also accessible at any point during the construction of a system when a medium must be entered for the configuration!
Programmable Medium: Global Parameters

- Once you have triggered open the Edit dialogue, go to the Global Parameters tab.
- There, Add and Edit two global parameters:
  - `double P = 8 kW (0W, 1MW)`: the input power of the laser.
  - `double r0 = 3.1mm (0mm, 1m)`: \( r_0 \) in the equation (see slide with basic theory).
- Use the button with the small “notes” icon to add some explanation to your custom global parameters.

Hint: it is possible to add some clarifying text to each global parameter to facilitate use of the snippet for other users!
Programmable Medium: Snippet Help

• **Optional**: you can use the Snippet Help tab to write instructions, clarifications, and some metadata associated to your snippet.

• This option is very helpful to keep track of your progress with a programmable element.

• It is especially useful when the programmable element is later disseminated to be handled by other users!
Programmable Medium: Snippet Help

Thermal Lens (Programmable Medium)

**Version**: 1.0  
**Last Modified**: Tuesday, November 14, 2017

Custom medium which replicates the behaviour of thermal lensing effect. This sample has been extracted from an application use case previously published by LightTrans.

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<td>Input power.</td>
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<tr>
<td>r₀</td>
<td>r₀ in equation (see accompanying slides).</td>
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Programmable Medium: Writing the Code (1)

Export Snippet to save your work!

Default global parameters/variables

Global parameters defined by user in Global Parameters tab

Eq.

Are there errors in your code?

Declare output
Save the Custom Medium to the Catalog

Hint: if you used the Catalog to define your custom medium, you will be automatically prompted to save your work to the catalog.
Test the Code!

**Main Function**

```csharp
// Declare output:
double realPart = 0.0;
double imaginaryPart = 0.0;

// Implement equation from theory:
double ita = 5E-2;
double K = 0.111E2;
double L = 7.5E-2;
double dndT = 7.3E-6;
double n0 = 1.823;
double r = Math.Sqrt(x * x + y * y);
double c1 = (-1.0) * ita * P / (4.0 * K * Math.PI * L) * dndT;
realPart = n0 + c1 * (r * r / r0 / r0);

// Return output:
return new Complex(realPart, imaginaryPart);
```
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| further reading | - **How to Work with the Programmable Material and Example (Linear Dependence)**  
- **Gaussian Beam Focused by a Thermal Lens** |