



---

## Material Properties

- **Catalog** displays a list of material catalogs supported in *LightTools*.

**See also:**

[Using the Special Materials Catalog](#)

[Using the Plastics Catalog](#)

- **Glass Map** displays a graphical representation of materials plotted on a grid based on dispersion (Vd) and index (Nd) values. In the current version of *LightTools*, Schott, Ohara, and Hoya catalogs are supported in the glass map view.
- **Material** is the name of the material from one of the major commercial glass catalogs, fictitious glass, plastics, or your own user-defined material. You can also specify a material name from the Special Materials Catalog provided with *LightTools*. These materials are "special" in the sense that most of them are used for optical systems operating over spectral bands beyond the normal visible wavelengths, either the UV or IR.
- **User Material**. You can access commonly used materials from the material library and glass catalogs provided with *LightTools*. If you require additional materials, however, you can use the User Materials option to create, load, export and, edit materials.

- **Volume Scattering**

These options are available only when the material for the object has been defined as a User Material with volume scattering:

- Disable Volume Scattering** temporarily turns off the volume scattering capability to observe the behavior of light in the model without considering the volume scattering.
- Number of Volume Scattering Events per Ray**. This value is the maximum number of scattering events a ray will have in a given solid before *LightTools* stops tracing it. The default value is 100.
- Volume Interface Name**. This field allows you to assign to the volume interface a unique, meaningful name. This name is important when defining a filter on a receiver, for example, to admit rays that intersect a specific volume interface.

See also:

[Defining Volume Scattering Type](#)



**OPTICAL  
RESEARCH  
ASSOCIATES**

---

<http://www.opticalres.com>  
Voice: (626) 795-9101  
Fax: (626) 795-0184  
[service@opticalres.com](mailto:service@opticalres.com)

## Using the Special Materials Catalog

The Special Materials catalog (SPECIAL) provides data for materials from a variety of sources (not just one

manufacturer); these materials are "special" in the sense that most of them are used for optical systems operating over spectral bands beyond the normal visible wavelengths, either the UV or IR.

Using the SPECIAL catalog may pose some complications. The data used in the SPECIAL catalog come from various literature sources, and often these data were taken at temperatures other than 20°C.

The following table lists each Special Materials Catalog name, along with its material, temperature, and spectral range.

**Table 2-1. Special Materials Catalog  
Name, Temperature, and Spectral Range of Index of Refraction Fit**

Material Name	Material	Temp (°C)	Spectral Range (μ)
AMTIR1	AMTIR-1	20	7.60 to 11.70
ARTRI	Arsenic Trisulfide	25	0.58 to 11.90
BAF	Barium Fluoride	25	0.26 to 10.30
CDTE	Cadmium Telluride-IRT6	24.34	2.00 to 30.00
CAFL	Calcium Fluoride	24	0.23 to 9.72
CSI	Cesium Iodide	24	0.30 to 53.10
GERMLW	Germanium Poly. Long	27	4.87 to 13.02
GERMMW	Germanium Poly. Mid	27	2.10 to 5.50
SCGERMLW	Germanium Sin. Crystal Long	27	4.87 to 13.02
SCGERMMW	Germanium Sin. Crystal Mid	27	2.10 to 5.50
IRT1	IRTRAN 1 Poly. MgF <sub>2</sub>	25	1.01 to 6.24
IRT2	IRTRAN 2 Poly. ZnS	25	1.01 to 13.00
IRT6	IRTRAN 6 Poly. CdTe	25	1.01 to 10.00
PBF2	Lead Fluoride	19.5	0.29 to 11.90
LIF	Lithium Fluoride	23.6	0.50 to 6.00
MGF2O	Magnesium Fluoride O	19	0.20 to 7.00
MGF2E	Magnesium Fluoride E	19	0.20 to 7.00
MGO	Magnesium Oxide	23.3	0.36 to 5.35
KBR	Potassium Bromide	22	0.40 to 25.10
KCL	Potassium Chloride	--	0.18 to 17.70
SAPHIR	Sapphire	24	0.26 to 5.58
SILICA	Silica, Fused	20	0.21 to 3.71
SILICN	Silicon	26	1.36 to 5.50
NACL	Sodium Chloride	20	0.59 to 22.30
NAF	Sodium Fluoride	18	0.18 to 1.01
KRS5	Thallium Bromide Iodide	19	0.58 to 39.40
WATER	Water	20	0.41 to 0.70
ZNSE	Zinc Selenide (Raytran)	20	0.54 to 18.20



**OPTICAL  
RESEARCH  
ASSOCIATES**

<http://www.opticalres.com>  
Voice: (626) 795-9101  
Fax: (626) 795-0184  
[service@opticalres.com](mailto:service@opticalres.com)

**Using the Plastics Catalog**

The list of plastics available in *LightTools* includes polycarbonate, PMMA, and more. To access the plastics catalog:

1. In your *LightTools* model, right-click the object that you want to define as a plastic.
2. On the shortcut menu, choose **Properties**.  
The Properties dialog box is displayed.
3. Select the entity (e.g., Cube\_1), in the navigation tree.
4. Click the Material tab.
5. In the Catalog field, click the down-arrow to display the list of available catalogs. Click Plastic.
6. In the Material field, click the down-arrow to display the list of plastics. Click the desired plastic.
7. Click OK to apply the plastic to the selected object.



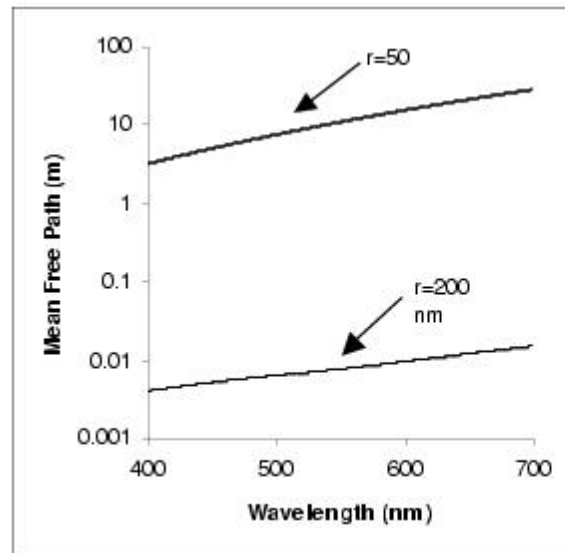
<http://www.opticalres.com>  
Voice: (626) 795-9101  
Fax: (626) 795-0184  
[service@opticalres.com](mailto:service@opticalres.com)

## Defining Volume Scattering Type

Using the User Material capability, you can create materials in which you can simulate the scattering of light in the volume of a material, not just on the surface. This capability enables you to analyze how light behaves in different media such as a diffusing plate, a plate of glass with imperfections (bubbles), or a dusty atmosphere, for example.

**Note:** You can filter the rays collected by a receiver to include only those that encounter a volume interface (i.e., that undergo scattering in the material) or those that do not.

For the Mie scattering type, you specify the density of particles (units =  $\text{mm}^{-3}$ ). For the user-defined volume scatterer, you specify the Mean Free Path, which is the average (statistical) distance a ray will travel before encountering a scattering particle. For Mie scattering, this distance varies as a function of wavelength, refractive index of the media, and the particle radius, refractive index, and density. For non-absorbing particles smaller than the wavelength of light, the Mean Free Path is generally proportional to the wavelength raised to the fourth power ( $\lambda^4$ ). This phenomena is illustrated in the following figure for water droplets in air. For particles the same size or larger than the wavelength, the behavior is more complicated. (See *Absorption and Scattering of Light by Small Particles* by Bohren and Huffman, Wiley, 1988, Chapter 4.)



OPTICAL  
RESEARCH  
ASSOCIATES

<http://www.opticalres.com>  
Voice: (626) 795-9101  
Fax: (626) 795-0184  
[service@opticalres.com](mailto:service@opticalres.com)

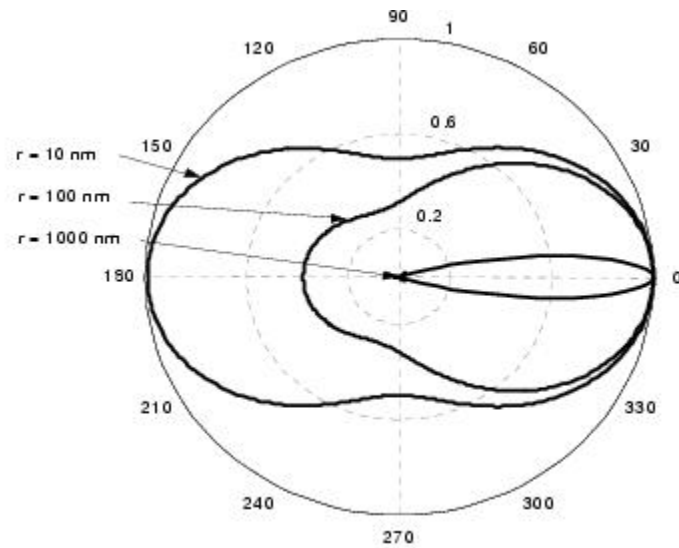
## Mie Volume Scattering

The Mie scattering option allows you to define the volume scattering properties of a material by specifying the radius, complex refractive index, and density of particles inside it. The equations that relate the angular distribution of scattered light to these parameters were first derived by Gustav Mie in 1908 by solving Maxwell's equations at the boundary of a spherical particle. Only spherical particles are considered in the *LightTools* model. Mie scattering theory can be used to explain a wide variety of natural phenomena, from blue skies to sunsets to the observed colors of interstellar dust. (See *Absorption and Scattering of Light by Small Particles* by Bohren and Huffman, Wiley, 1988, for a description of some of these phenomena.)

The computations for Mie scattering can be intensive, so many of them are performed in *LightTools* prior to raytracing to improve raytracing speed. For instance, the angular intensity distribution for a Mie scatterer is precomputed and stored in memory. These computations are performed whenever a Mie scatterer is first defined, or whenever a new spectral region is defined for a system with a Mie scatterer. The computations can take longer for continuous spectral regions than for discrete ones, and may take a significant amount of time; for this reason, *LightTools* displays a warning message while performing them.

If the particle size is much smaller than the wavelength of incident light, then the Rayleigh equations are used instead of the Mie equations. The Rayleigh equations are a degenerate case of the Mie equations that neglect higher-order terms in some series expansions. They are considerably simpler than the Mie equations and, thus, they compute faster. In *LightTools*, the Rayleigh equations are used if the radius of the particle is .1 times the size of the wavelength or smaller.

Another general property of Mie scattering is the amount of light that is scattered forward increases as the size of the particle increases. For particles much smaller than the incident wavelength (i.e., in the Rayleigh regime), an equal amount of light is scattered forward and backward. This phenomenon is illustrated below.



The implementation of Mie scattering in *LightTools* does not track polarization effects. All scattered rays are unpolarized.



**OPTICAL**  
**RESEARCH**  
**ASSOCIATES**

<http://www.opticalres.com>  
Voice: (626) 795-9101  
Fax: (626) 795-0184  
[service@opticalres.com](mailto:service@opticalres.com)