ZemaxGlassReader user manual

(08-Jul-13)

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To illustrate how to use the library, here are several examples, all of which come up by running `python ZemaxGlassReader.py`. In all of the examples below, it is assumed that the Zemax glass library object has already been initialized, such as with

```
glasslib = ZemaxGlassLibrary()
```

where, without an input directory, the code assumes that the `*.agf` files are all in the same directory as the main Python file, which is how the repository is structured.

Figure 1 shows the dispersion curves for Schott glasses N-BK7 and SF66, obtained by running the commands

```
glasslib.plot_dispersion('N-BK7', 'schott')
glasslib.plot_dispersion('SF66', 'schott', polyfit=True, fiterror=True)
```

If the minimum and maximum wavelengths (`wavemin` and `wavemax`) are not specified as keywords in the initializer, then they are assumed to be specify the standard visible wavelength range (400–700 nm).

Figure 2 shows two examples of "dual property disagrams", in which one set of glass properties is plotted against another, for one glass catalog or for the entire glass library. These figures shown are obtained by running

```
glasslib.plot_catalog_property_diagram('all', prop1='vd', prop2='nd')
glasslib.plot_catalog_property_diagram('all', prop1='nd', prop2='dispform')
```

If the degree of the polynomial fit is not set using the `degree` keyword in the initialization, then the default polynomial used for approximating the curve is 3rd degree.

[talk about fitting the dispersion curves with polynomials, and plotting polynomial approximations to "exact" curves (constant, linear, quadratic, cubic, etc).]

[talk about culling the library, using `pprint`, using `find_catalog_for_glassname`, `simplify_schott_catalog`, `cull_library`]

The general format of the Zemax glass catalog (`*.agf`) file is

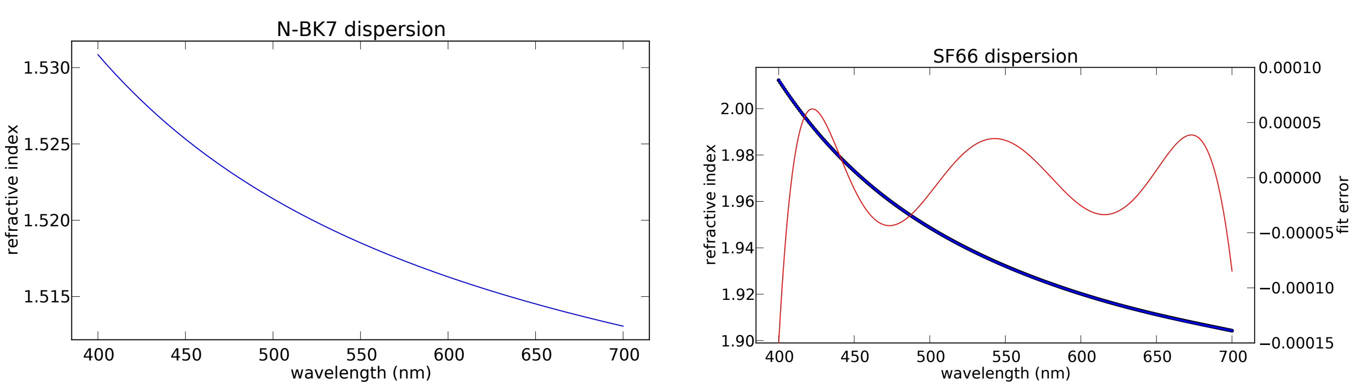

Figure 1: (*Left*) The dispersion of N-BK7 glass. (*Right*) The dispersion of SF66 glass, with the glass' dispersion model shown with a blue line, the 3rd-degree polynomial approximation shown as black circles, and the approximation error with a red line.

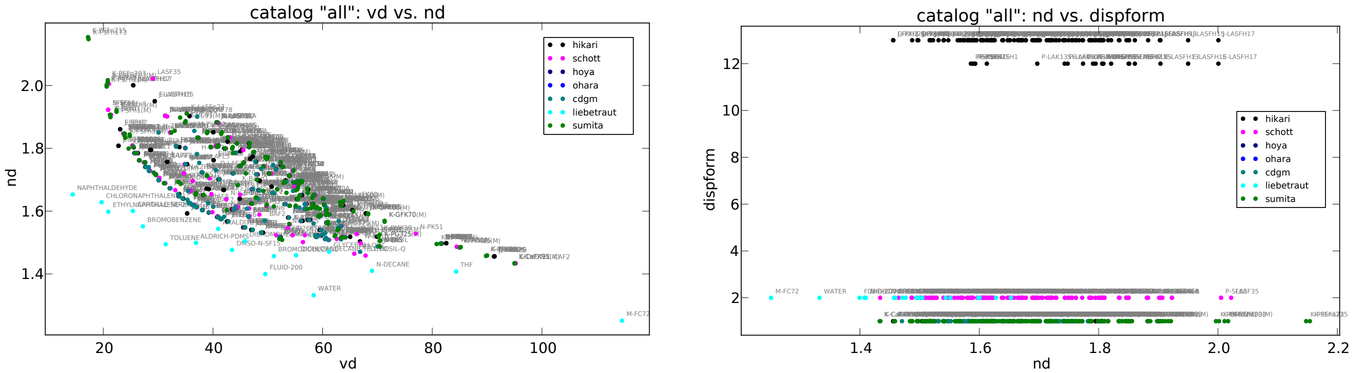

Figure 2: (*Left*) A plot of the glass index n_d versus the Abbé number v_d. (*Right*) A plot of the glass index n_d vs. the type of dispersion formula used. Note that each glass property is labelled with a glass name.

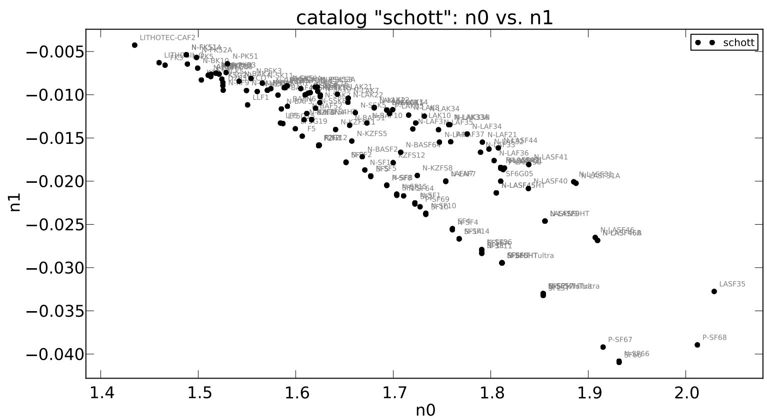

Figure 3: A "dual property diagram" of n_0 vs. n_1 — the zeroth and first order polynomial coefficients for describing the dispersion specrtrum.

```
CC <Catalog_comment>
NM <glass_name> <dispersion_formula_number> <MIL> <N(d)> <V(d)> <Exclude_sub> <status> <melt_freq>
GC <Individual glass comment>
ED <TCE_(-30_to_70)> <TCE_(100_to_300)> <density> <dPgF> <Ignore_thermal_exp>
CD <dispersion_coeffs>
TD <D0> <D1> <D2> <E0> <E1> <Ltk> <Temp>
OD <rel cost> <CR> <FR> <SR> <AR> <PR>
LD <min lambda> <max lambda>
IT <lambda> <transmission> <thickness>
IT <lambda> <transmission> <thickness>
... multiple IT lines may follow
```

The expressions for the 12 different dispersion formulae used by Zemax are:

Formula		*Expression*
#	*Name*	
1	Schott	$n^2 = c_0 + c_1\lambda^2 + c_2\lambda^{-2} + c_3\lambda^{-4} + c_4\lambda^{-6} + c_5\lambda^{-8}$
2	Sellmeier1	$n^2 = 1 + \frac{c_0\lambda^2}{\lambda^2 - c_1} + \frac{c_2\lambda^2}{\lambda^2 - c_3} + \frac{c_4\lambda^2}{\lambda^2 - c_5}$
3	Herzberger	$n = c_0 + c_1 L + c_2 L^2 + c_3\lambda^2 + c_4\lambda^4 + c_5\lambda^6$, where $L = 1/(\lambda^2 - 0.028)$
4	Sellmeier2*	$n^2 = 1 + c_0 + \frac{c_1\lambda^2}{\lambda^2 - c_2^2} + \frac{c_3\lambda^2}{\lambda^2 - c_4^2}$
5	Conrady	$n = c_0 + c_1\lambda^{-1} + c_2\lambda^{-7/2}$
6	Sellmeier3	$n^2 = 1 + \frac{c_0\lambda^2}{\lambda^2 - c_1} + \frac{c_2\lambda^2}{\lambda^2 - c_3} + \frac{c_4\lambda^2}{\lambda^2 - c_5} + \frac{c_6\lambda^2}{\lambda^2 - c_7}$
7	Handbook of Optics 1	$n^2 = c_0 + \frac{c_1}{\lambda^2 - c_2} - c_3\lambda^2$
8	Handbook of Optics 2	$n^2 = c_0 + \frac{c_1\lambda^2}{\lambda^2 - c_2} - c_3\lambda^2$
9	Sellmeier4	$n^2 = c_0 + \frac{c_1\lambda^2}{\lambda^2 - c_2} + \frac{c_3\lambda^2}{\lambda^2 - c_4}$
10	Extended	$n^2 = c_0 + c_1\lambda^2 + c_2\lambda^{-2} + c_3\lambda^{-4} + c_4\lambda^{-6} + c_5\lambda^{-8} + c_6\lambda^{-10} + c_7\lambda^{-12}$
11	Sellmeier5	$n^2 = 1 + \frac{c_0\lambda^2}{\lambda^2 - c_1} + \frac{c_2\lambda^2}{\lambda^2 - c_3} + \frac{c_4\lambda^2}{\lambda^2 - c_5} + \frac{c_6\lambda^2}{\lambda^2 - c_7} + \frac{c_8\lambda^2}{\lambda^2 - c_9}$
12	Extended2	$n^2 = c_0 + c_1\lambda^2 + c_2\lambda^{-2} + c_3\lambda^{-4} + c_4\lambda^{-6} + c_5\lambda^{-8} + c_6\lambda^4 + c_7\lambda^6$

* Note that this formula is untested. (Zemax's user manual does not provide the order in which the coefficients in the glass files map to coefficients in the formulae).

A. Nomenclature:

AR (alkali resistance class) The ability of a glass to resist contact with warm, alkaline liquids. Values range from 1 (very resistant) to 4 (very vulnerable).

CR (climatic resistance class) The ability of a glass to resist climatic effects such as humidity and high temperature. Values can range from 1 (very resistant) to 4 (very vulnerable).

D (distance between two glasses) $D = \left[w_{\mathrm{n}}(n_{\mathrm{d},1} - n_{\mathrm{d},2})^2 + w_{\mathrm{a}}(v_{\mathrm{d},1} - v_{\mathrm{d},2})^2 + w_{\mathrm{p}}(\Delta P_{\mathrm{g,F},1} - \Delta P_{\mathrm{g,F},2})^2\right]^{1/2}$ where the w_i's are weight terms, with default values $w_{\mathrm{n}} = 1.0$, $w_{\mathrm{a}} = 1.0 \times 10^{-4}$, and $w_{\mathrm{p}} = 1.0 \times 10^{2}$.

Density the density of the glass in units of g/cc.

Dispersion_formula an integer indicating which dispersion formula to use (see Table).

dPgF (differential partial dispersion) is $\Delta P_{\mathrm{g,F}} = P_{\mathrm{g,F}} - (0.6438 - 0.001682 v_{\mathrm{d}})$.

Exclude_substitution an integer flag, indicating 0:no, 1:yes. If yes, then this glass will not be selected during global optimization, converted from model to real glasses, or be considered by the RGLA optimization operand.

FR (stain resistance class) The ability of a glass to resist stain formation under the influence of slightly acidic water. Values range from 0 (very resistant) to 5 (very vulnerable).

Ignore_thermal_expansion an integer flag, indicating 0:no, 1:yes.

IT (internal transmittance) the transmittance of a material after removing the effects of Fresnel reflections.

LD (lambda data) the wavelength range over which the dispersion coefficients provide an accurate estimate of the dispersion curve.

melt_freq (mel frequency) how commonly a glass is manufactured. Values range from 1 (melted very frequently) to 5 (melted infrequently).

MIL (military glass number) the military number was once a common method for describing glasses using a six-digit integer, such as 517640 for BK7. The first three integers are given by $1000 \cdot (n_{\mathrm{d}} - 1)$, while the second three integers are given by $10 \cdot (v_{\mathrm{d}})$.

n (refractive index) n_{d} is the refractive index at λ_{d}.

P (partial dispersion) $P_{\mathrm{g,F}} = \frac{n_{\mathrm{g}} - n_{\mathrm{F}}}{n_{\mathrm{F}} - n_{\mathrm{C}}}$.

PR (phosphate resistance class) The ability of a glass to resist washing solutions (detergents) that contain phosphates. Values range from 1 (very resistant) to 4 (very vulnerable).

Relative_cost the approximate relative cost of the glass as compared to BK7 (*i.e.* 3.5 indicates a glass that costs about 3.5 times as much as BK7 per kg).

SR (acid resistance class) The ability of a glass to resist damage due to acid exposure. Values range from 1 (very resistant) to 5 (vulerable), with values 51, 52, and 53 indicating increasing vulerability beyond that of class 5.

status the "status" of a glass, where 0:standard, 1:preferred, 2:obsolete, 3:special, 4:melt.

TCE (thermal coefficient of expansion) dn/dT in units of $10^{-6}\,\mathrm{K}^{-1}$.

v (dispersion, or Abbé number).

The special wavelengths used here are:

$$
\begin{aligned}
\lambda_{\mathrm{g}} &= 435.8\,\mathrm{nm} \\
\lambda_{\mathrm{F}} &= 486.1\,\mathrm{nm} \\
\lambda_{\mathrm{d}} &= 587.6\,\mathrm{nm} \\
\lambda_{\mathrm{C}} &= 656.3\,\mathrm{nm}
\end{aligned}
$$