

The optical design and engineering package OPTOLAB©

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A not yet commercially available optical design and engineering software, developed in Visual Fortran, is presented. It is composed of OPTOLAB main program and many important ancillary ones which can be opened independently, like Database, Layout, Point, Optimize, Ghost. A major feature is immediate and automatic update of output windows at any change in database

1 Introduction

A skilled optical engineer analyses and designs a system even if no appropriate software tools are available off-the-shelf and has to be capable to face extemporary problems. The best solution for such a highly skilled fellow is *developing his own software!* Once one has at disposal routines and functions (employed in normal activities), by having access to the sources of a complex software such as OPTOLAB, it is easy to assemble new applications. Many problems can then be solved in a very competitive and well-timed way. Of course bugs may exist, but this should not be a problem since a true optical engineer must be able to understand a program output and validate its results.

OPTOLAB applications have been implemented following a criterion of priority on the contingencies. OPTOLAB is based on more than 30 years of experience of the 1st author in optical engineering, design, teaching and software analysis & development. The language is Visual Fortran, taking advantage from Win32 and OpenGL libraries. Applications speed is equal to that developed in Visual C++. This software is not yet commercially available.

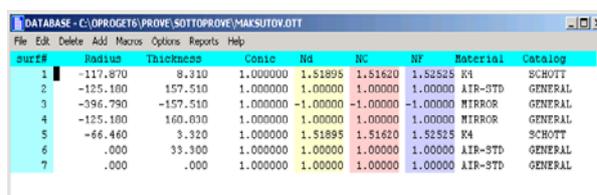
2 Main features

The following sections provide a very fast overview of the most important OPTOLAB features.

2.1 Applications

OPTOLAB basically consists of a main program (named OPTOLAB), which allows to browse and create folders and working files, and to call a set of specialized applications, which can run also as stand-alone, by clicking the proper icons on the desktop. The applications are of two kinds:

- Modifiers (applications able to change the working file): OPTOLAB, DATABASE (Fig. 1), MODIFY, OPTIMIZE.
- Analyzers (applications reading the file without changing it): LAYOUT (Fig. 2), POINT, GHOST, TOLERANCES, other tools.



Surf#	Radius	Thickness	Conic	Nd	Nc	Nf	Material	Catalog
1	-117.870	8.310	1.000000	1.51895	1.51620	1.52525	K4	SCHOTT
2	-125.100	157.510	1.000000	1.000000	1.000000	1.000000	AIR-STD	GENERAL
3	-396.790	-157.510	1.000000	-1.000000	-1.000000	-1.000000	MIRROR	GENERAL
4	-125.100	160.030	1.000000	1.000000	1.000000	1.000000	MIRROR	GENERAL
5	-66.460	3.320	1.000000	1.51895	1.51620	1.52525	K4	SCHOTT
6	.000	33.300	1.000000	1.000000	1.000000	1.000000	AIR-STD	GENERAL
7	.000	.000	1.000000	1.000000	1.000000	1.000000	AIR-STD	GENERAL

Fig. 1. An example of DATABASE application.

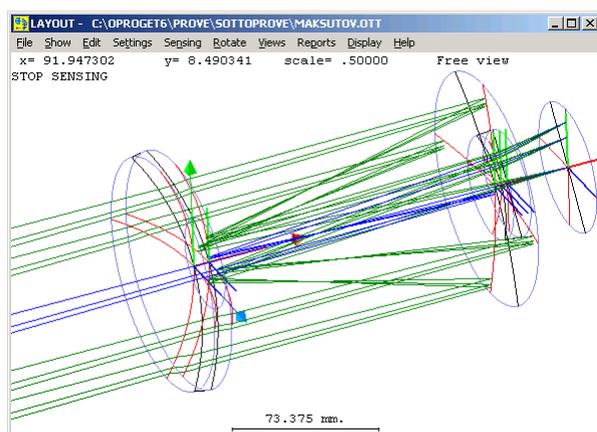


Fig. 2. The 3D LAYOUT application, related to data of Fig. 1.

For instance, POINT is the application dedicated to analyze the image quality. It provides single, multi-field and/or multi-colour spot diagrams. Also, it allows to compute and display 3D solid PSF (Fig.3) (by means of three different method: Pupil Function Autocorrelation, Fraunhofer or Kirchoff-Fresnel (Huygens) formula) [1,2,3,4,5,6], polychromatic MTF weighted with spectral efficiencies, through-focus Strehl ratios.

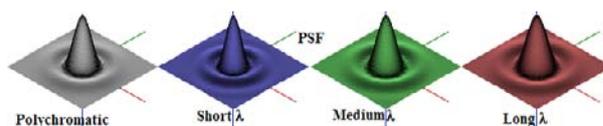


Fig. 3. Polychromatic weighted PSF and monochromatic components (related to files of Fig.1). Note the different diameters of the 1st ring over the wavelengths.

2.2 Pupil definition

OPTOLAB can define both real and virtual entrance pupils, making possible to disassemble an optical system into groups of elements and to optimize them separately. The single groups shall be corrected not by minimizing all aberrations, but only by reaching aberrations values which compensate those of the other groups. This way allows minimizing the number of surfaces, with reduction of manufacturing costs. It allows to easily model and understand optical systems, by automatic updating of LAYOUT and other output windows when changing database.

2.3 Decentering (shifts and tilts)

The system of decentring, with tilts based on an alto-azimuth angular method, is user-oriented and easy to understand. The following kinds of decentring can be applied:

- Single: only the single surface is decentred.
- Extended: the decentring is applied to the surface and to all the following ones.
- Refracted/Reflected (on diopters/mirrors): the reference axis is refracted or reflected according to the surface nature. Vertices and axes of the following surfaces are referred to the reference axis.
- Inverse: similar to Refracted/Reflected, but the surface is tilted so that the output reference axis exits from the surface with the tilt direction applied to it.
- Absolute: the surface tilt is applied with respect to the object reference system.

2.4 Special data

Apart from the ordinary parameters defined for each surface, such as radii, thicknesses, conic constants, materials etc., it is possible, up to now, to define 24 kinds of "Special" features for each surface, the most important being:

AXIs: for rotating groups of surfaces around an user defined axis; BORder: defines a surface border for graphics; BIFresnel: an alternate Fresnel surface, an invention of the 1st author; CUBe: cube corner prism; EDGe: refractive, non sequential lens edge; FILter map of absorption; FREsnel surface; GRAting: diffractive grating; GRIn: gradient index; HOE&DOE: holographic & diffractive surfaces; POLarizer: for a polarizing element; ROOf: roof prism; SLIt: diffractive slit of spectrometers; STOp: allowing to model almost whatever stop shape, with obstruction, beams and so on; THInlens: Gauss I order lens; TORic surface; WINston cone; ZERNike polynomial distortion of a surface; ZONal annular surface made of rings of different curvature radii.

2.5 Working and surface numbers

There are no limits for the number of zoom positions, fields of view, wavelengths, surfaces and groups of surfaces.

2.6 Optimizations

Optimisation is based on *Damped Least Square Levenberg-Marquardt* method [7], and works on 6 kinds of aberrations sets: Seidel, Spot (in betatest) and (in progress) Strehl Ratios, Generalised Seidel, MTF and Zernike polynomials of wavefront.

2.7 Others

OPTOLAB performs analyses of Ghost and Narcissus and allows tolerances evaluation with Montecarlo method. Moreover it allows to access a set of tools for peculiar physical optics analysis, such as: Scattering – grating efficiency evaluation – 1 order optical system modelling and baffles design – scanning devices – theoretical MTF – polarisation analyses – search of materials – refractive index fitting...

3 Conclusions

Although many new developments are in progress, such as Non Sequential modelling and ray tracing and thermal and structural analyses, the current version of OPTOLAB successfully works and is being used in many occasions for raytrace and analysis of various optical designs and devices.

Some references

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